Rensselaer Catalog
2013–2014

Undergraduate, Graduate, and Professional Programs
### DEGREES OFFERED

#### SCHOOL OF ARCHITECTURE

<table>
<thead>
<tr>
<th>Field</th>
<th>Degree(s)</th>
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<tbody>
<tr>
<td>Architecture</td>
<td>B.Arch., M.Arch.</td>
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<tr>
<td>Architectural Sciences</td>
<td>M.S., Ph.D.</td>
<td>0202</td>
</tr>
<tr>
<td>Lighting</td>
<td>M.S.</td>
<td>0299</td>
</tr>
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</table>

#### SCHOOL OF ENGINEERING

1. All Engineering bachelor’s degree programs are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, except for the Engineering Science program, which is intended to serve educational desires that do not coincide with the standard professional engineering curricula. Correspondingly, this degree is not, nor is it intended to be, accredited for professional engineering practice.

<table>
<thead>
<tr>
<th>Field</th>
<th>Degree(s)</th>
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<tr>
<td>Aeronautical Engineering</td>
<td>B.S., M.Eng., M.S., D.Eng., Ph.D.</td>
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<tr>
<td>Biomedical Engineering</td>
<td>B.S., M.Eng., M.S., D.Eng., Ph.D.</td>
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<td>Chemical Engineering</td>
<td>B.S., M.Eng., M.S., D.Eng., Ph.D.</td>
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<tr>
<td>Civil Engineering</td>
<td>B.S., M.Eng., M.S., D.Eng., Ph.D.</td>
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<tr>
<td>Computer and Systems Engineering</td>
<td>B.S., M.Eng., M.S., D.Eng., Ph.D.</td>
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</tr>
<tr>
<td>Decision Sciences and Engineering Systems</td>
<td>Ph.D.</td>
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<tr>
<td>Electric Power Engineering</td>
<td>M.Eng., M.S., D.Eng., Ph.D.</td>
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<tr>
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<tr>
<td>Engineering Physics</td>
<td>M.S., D.Eng., Ph.D.</td>
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<tr>
<td>Engineering Science</td>
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<td>Environmental Engineering</td>
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<td>Industrial and Management Engineering</td>
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<tr>
<td>Mechanical Engineering</td>
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<td>Mechanics</td>
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<tr>
<td>Nuclear Engineering</td>
<td>B.S., M.Eng., M.S., D.Eng.</td>
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<tr>
<td>Nuclear Engineering and Science</td>
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<tr>
<td>Systems Engineering and Technology Management</td>
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<tr>
<td>Transportation Engineering</td>
<td>M.Eng., M.S., D.Eng., Ph.D.</td>
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<thead>
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<tbody>
<tr>
<td>Cognitive Science</td>
<td>B.S., M.S., Ph.D.</td>
<td>0499</td>
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<tr>
<td>Communication</td>
<td>B.S.</td>
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<tr>
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<tr>
<td>Design, Innovation, and Society</td>
<td>B.S.</td>
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<tr>
<td>Ecological Economics</td>
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<td>0517</td>
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<tr>
<td>Ecological Economics, Values, and Policy</td>
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<tr>
<td>Economics</td>
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<tr>
<td>Electronic Arts</td>
<td>B.S., M.F.A., Ph.D.</td>
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<tr>
<td>Electronic Media, Arts, and Communication</td>
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<td>0605</td>
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<tr>
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<tr>
<td>Science and Technology Studies</td>
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<tr>
<td>Sustainability Studies</td>
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<tr>
<td>Technical Communication</td>
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#### SCHOOL OF MANAGEMENT

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<td>Business Analytics</td>
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<tr>
<td>Business and Management</td>
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<tr>
<td>Financial Engineering and Risk Analytics</td>
<td>M.S.</td>
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<tr>
<td>Management</td>
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<td>Technology, Commercialization and Entrepreneurship</td>
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#### SCHOOL OF SCIENCE

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<td>Applied Science</td>
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<tr>
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<tr>
<td>Biology</td>
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<tr>
<td>Biochemistry and Biophysics</td>
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</tr>
<tr>
<td>Bioinformatics and Molecular Biology</td>
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<tr>
<td>Chemistry</td>
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<tr>
<td>Computer Science</td>
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#### INFORMATION TECHNOLOGY AND WEB SCIENCE

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<tr>
<td>Information Technology</td>
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</tr>
<tr>
<td>Information Technology and Web Science</td>
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<td>0702</td>
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</table>
Rensselaer Catalog is an official publication of Rensselaer Polytechnic Institute for its students, alumni, and friends. It is published by Strategic Communications & External Relations, Rensselaer Polytechnic Institute, 110 8th St., Troy, NY 12180-3590.

Notice Regarding Changes  All information in this catalog pertains to the 2013-2014 academic year and is correct to the extent that the information was available on the catalog preparation date. However, Rensselaer reserves the right to change the course offerings, tuition, fees, rules governing admission, requirements for graduation and the granting of degrees, and any other regulations affecting its students. Such changes are to take effect whenever the administration deems necessary whether or not there is actual notice to individual students.

NOTICE PURSUANT TO THE “CAMPUS SEX CRIMES PREVENTION ACT” AND CAMPUS CRIME REPORTING AND STATISTICS

In accordance with Federal and State law, the following notice is provided: The Advisory Committee on Campus Safety will provide upon request all campus crimes statistics as reported to the United States Department of Education. The U.S. Department of Education Web site address for campus crime statistics is www.cope.ed.gov/security/search.asp.

The phone number for the Department of Public Safety, the designated college campus contact authorized to provide such statistics for the Institute, is (518)276-8527.

In addition, information about sex offenders, if any, living or working at Rensselaer, will be available at the Department of Public Safety. For more information about and access to New York’s “Sex Offender Registry,” go to: http://criminaljustice.state.ny.us/NSOR/index.htm.

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Academic Calendar

Fall Term 2013

August 9
Fall tuition and fees due.

August 21
Residence halls and apartments open for upperclass and new graduate students.

August 22
Resident dining halls open with breakfast.

August 25
Class of 2017 Convocation.

August 26
Classes begin.

August 30
Official date of August graduation; diplomas mailed to students after final clearance is completed in September. Degree recipients may take part in the May 2014 Commencement ceremony.

September 2
Labor Day. No classes. Staff holiday.

September 9
Last day for graduate and undergraduate students to add courses or change sections or to put courses on audit. Last day for completion of “NE” grade requirements for Spring 2013 courses.

September 20
Last day to file a Degree Application with Registrar’s Office for December graduates.

Nomination of Master’s Thesis Committee and Provisional Thesis Title & Degree Designation forms due to the Office of Graduate Education for December graduates.

October 4-6
Reunion and Homecoming 2013.

October 14
No classes.

October 15
Classes resume. Follow Monday class schedule.

October 18
Last day for undergraduate and graduate students to drop a course.

October 18-20
Family Weekend.

October 19
Honors Convocation.

October 21-November 1
Consultation weeks. Advisement for spring registration. Students should consult their faculty advisers.

November 4-18
Registration for all currently enrolled students for the spring semester.

November 8
Doctoral dissertations due to advisers.

November 15
Master’s theses and engineering projects due to advisers.

November 25
Master’s theses due in the Office of Graduate Education.

November 26
Thanksgiving recess begins after class. Resident Dining halls close after dinner. Last day for undergraduates to add or remove Pass/No Credit designation. Last day to defend doctoral dissertations.

November 27-29
No classes.

November 28-29
Staff holidays.

December 1
Resident dining halls open with dinner.

December 2
Classes resume.

December 6
Classes end after last evening class. Doctoral dissertations due in the Office of Graduate Education.

December 9
Registration begins for all currently enrolled students for the Summer 2014 semester.

December 9-10
No classes. Study-Review Days.

December 11
Add/Drop reopens for Spring 2014.

December 11-13 and 16-17
Final Examinations.

December 17
Resident dining halls close after dinner.

December 18
Residence halls close at noon. Winter recess begins.

December 23-25
Staff holidays.

December 26-31
Holiday Winter Break-Institute is closed.

December 31
Official date of December graduation; diplomas mailed to students after final clearance is completed in January. Degree recipients may take part in the May 2014 Commencement ceremony.

SPRING TERM 2014

January 1
Staff holiday.

January 3
Spring tuition and fees due.

January 17
Residence halls and apartments open for spring term at noon.

January 20
Resident dining halls open with dinner.

January 20
Martin Luther King Jr. Day. Staff holiday.

January 21
Classes begin.

February 3
Last day for graduate and undergraduate students to add courses or change sections or to put courses on audit.

February 7
Last day to file Degree Applications with Registrar’s office for May 2014 graduation. Nomination of Master’s Thesis Committee and Provisional Thesis Title and Degree Designation forms due to the Office of Graduate Education for May graduates.

February 17
President’s Day. No classes. Staff holiday.

February 18
Classes resume. Follow Monday class schedule.

March 7
Resident dining halls close with dinner.
Academic Calendar (continued)

March 10-14
Spring break.

March 16
Resident dining halls open with dinner.

March 17
Classes resume.

March 17-March 28
Consultation Weeks. Advisement for Fall 2014 registration. Students should consult their faculty advisers.

March 21
Last day for undergraduates and graduate students to drop courses.
Doctoral dissertations due to advisers.
Master’s theses and engineering projects due to advisers.

March 31-April 14
Registration for all currently enrolled students for the Fall 2014 semester.

April 4
Last day to defend doctoral dissertations.
Master’s theses due in the Office of Graduate Education.

April 4-April 11
Grand Marshal Week (Student Government Elections).

April 9
No classes.

April 18
Last day for undergraduates to add or remove Pass/No Credit designation.
Doctoral dissertations due in the Office of Graduate Education.

May 7
Classes end after last evening class.

May 8-9
No classes. Study-review days.

May 8
Graduation Status Check and post-graduation career plans.

May 12
Add/Drop reopens for Fall 2014.

May 12-16
Final Examinations.

May 16
Deadline for completion of “NE” grade requirements for Fall 2013 courses.
All Resident dining halls close after dinner.

May 17
Residence halls and apartments close at noon for all students not participating in Commencement.

May 19-August 8
Summer Session I (12 weeks).
No designated exam days.

May 19-June 27
Summer Session II (6 weeks).
No designated exam days.

May 23
ROTC Commissioning Ceremony.

May 24
Commencement.

May 25
All residence halls close by 11am.

May 26
Memorial Day. No Classes. Staff holiday.

SUMMER SESSION 2014

May 19
Classes begin. Courses will be scheduled for varying lengths of time during the summer session. Check the online Class Hour Schedule for specific information.
Summer Session I, May 19 – August 8 (12 weeks)
Summer Session II, May 19 – June 27 (6 weeks)
Summer Session III, June 30 – August 8 (6 weeks)

Summer Session 2014 Calendar

<table>
<thead>
<tr>
<th>Term</th>
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<th>Drop deadline</th>
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<td>1</td>
<td>May 30</td>
<td>July 11</td>
<td>June 18</td>
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<td>2</td>
<td>May 23</td>
<td>June 6</td>
<td>May 30</td>
</tr>
<tr>
<td>3</td>
<td>July 7</td>
<td>July 18</td>
<td>July 19</td>
</tr>
</tbody>
</table>

May 25
Residence halls and apartments open for summer.

May 26
Memorial Day. No classes. Staff holiday.

June 20
Last day to file degree application with Registrar’s Office for August 30, 2014 graduation.
Nomination of Master’s Thesis Committee and Provisional Thesis Title & Degree Designation forms due to the Office of Graduate Education for August graduates for August 2014 graduation.

July 4
No Classes. Staff holiday.

July 2
Master’s theses and engineering projects due to advisers.
Doctoral dissertations due to advisers.

July 11
Last day to defend doctoral dissertations.
Master’s theses due to the Office of Graduate Education.

July 25
Doctoral dissertations due to the Office of Graduate Education.

August 8
Last day of classes.

August 9
Residence halls and apartments close for summer.

August 29
Official date of August graduation; diplomas mailed to students after final clearance is completed in September. Degree recipients may take part in the May 2015 Commencement ceremony.

FALL 2014

August 8
Fall tuition and fees due.
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<tr>
<td>IHSS Interdisciplinary Humanities and Social Science Studies (HSSH)</td>
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<tr>
<td>ISCI General Interdisciplinary Courses (SOS)</td>
<td>476</td>
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<tr>
<td>ISYE Industrial and Systems Engineering (SOE)</td>
<td>477</td>
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<tr>
<td>ITWS Information Technology and Web Science</td>
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<tr>
<td>LANG Foreign Languages</td>
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<tr>
<td>LGHT Lighting (SOA)</td>
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<tr>
<td>LITR Literature (HSSH)</td>
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<tr>
<td>MANE Mechanical, Aerospace, and Nuclear Engineering (SOE)</td>
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<tr>
<td>MATH Mathematics (SOS)</td>
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<tr>
<td>MATP Mathematical Programming, Probability, and Statistics (SOS)</td>
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<td>Rensselaer Admissions</td>
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<tr>
<td></td>
<td>(518) 276-6216</td>
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<tr>
<td></td>
<td><a href="mailto:admissions@rpi.edu">admissions@rpi.edu</a></td>
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<tr>
<td><strong>Alumni Relations</strong></td>
<td>Office of Alumni Relations</td>
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<tr>
<td></td>
<td>(518) 276-6205</td>
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<tr>
<td></td>
<td><a href="http://www.alumni.rpi.edu">www.alumni.rpi.edu</a></td>
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<tr>
<td><strong>Dining</strong></td>
<td>Rensselaer Hospitality Services</td>
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<td></td>
<td>(518) 276-6277</td>
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<td><a href="mailto:mactut@rpi.edu">mactut@rpi.edu</a></td>
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<tr>
<td><strong>Disability Services for Students Information</strong></td>
<td>Dean of Students</td>
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<td>(518) 276-6266</td>
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<td></td>
<td><a href="mailto:smithm@rpi.edu">smithm@rpi.edu</a></td>
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<td><strong>Education for Working Professionals</strong></td>
<td>Hartford Campus and Groton Site Programs</td>
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<tr>
<td></td>
<td>(860) 548-2400</td>
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<td></td>
<td>(800) 433-4723</td>
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<tr>
<td><strong>Financial Aid</strong></td>
<td>Dean of Students Office</td>
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<td>(518) 276-6266</td>
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<tr>
<td><strong>General Student Advising</strong></td>
<td>Dean of Students Office</td>
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<td>(518) 276-6266</td>
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<tr>
<td><strong>Graduate Education</strong></td>
<td>Office of Graduate Education</td>
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<tr>
<td></td>
<td>(518) 276-6488</td>
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<td></td>
<td><a href="mailto:gradschool@rpi.edu">gradschool@rpi.edu</a></td>
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<tr>
<td><strong>Housing</strong></td>
<td>Residence Life</td>
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<td></td>
<td>(518) 276-6284</td>
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<td><a href="mailto:Res_life@rpi.edu">Res_life@rpi.edu</a></td>
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<tr>
<td><strong>International Student Information</strong></td>
<td>International Services for Students and Scholars</td>
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<td></td>
<td>(518) 276-6821</td>
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<td><a href="mailto:havisj@rpi.edu">havisj@rpi.edu</a></td>
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<tr>
<td><strong>Career Center</strong></td>
<td>Center for Career and Professional Development</td>
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<tr>
<td></td>
<td>(518) 276-6234</td>
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<td><a href="mailto:careerd@rpi.edu">careerd@rpi.edu</a></td>
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<tr>
<td><strong>Rensselaer Union</strong></td>
<td>(518) 276-6505</td>
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<tr>
<td><strong>Transcripts</strong></td>
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<td>(518) 276-6231</td>
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<td><a href="mailto:registrar@rpi.edu">registrar@rpi.edu</a></td>
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<td>Request form at: <a href="http://www.rpi.edu/web/trans">www.rpi.edu/web/trans</a></td>
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<td><strong>Tuition/Fees</strong></td>
<td>Bursar’s Office</td>
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<td>(518) 276-6610</td>
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<td><a href="mailto:bursar@rpi.edu">bursar@rpi.edu</a></td>
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<tr>
<td><strong>Undergraduate Academic Advising</strong></td>
<td>Advising and Learning Assistance Center</td>
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<td></td>
<td>(518) 276-6269</td>
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<tr>
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<tr>
<td><strong>Undergraduate Financial Aid and Graduate Loans</strong></td>
<td>Office of Financial Aid</td>
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<td>(518) 276-6813</td>
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</tbody>
</table>

**Undergraduate Transfer, Part-Time, and Non Matriculated Admissions**
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admissions@rpi.edu

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**Telephone**
(518) 276-6000

**World Wide Web**
http://www.rpi.edu

**Rensselaer at Hartford (Education for Working Professionals)**
275 Windsor Street
Hartford, CT 06120-2991
(860) 548-2400
info@ewp.rpi.edu
http://www.ewp.rpi.edu
Rensselaer in Brief

Overview

Rensselaer Polytechnic Institute is the nation’s oldest technological university. The university offers degrees from five schools: Engineering; Science; Architecture; Humanities, Arts, and Social Sciences; and the Lally School of Management and Technology; as well as an interdisciplinary degree in Information Technology and Web Science.

Institute programs serve undergraduates, graduate students, and working professionals around the world. The Institute’s long-standing reputation drew students from 49 states and 62 foreign countries in the fall of 2012.

Rensselaer offers more than 110 programs at the bachelor’s, master’s, and doctoral levels. Students are encouraged to work in interdisciplinary programs that allow them to combine scholarly work from several departments or schools. The university provides rigorous, engaging, interactive learning environments and campus-wide opportunities for leadership, collaboration, and creativity at its campuses in Troy, N.Y., and in Hartford, Conn., as well as at its Southeastern Connecticut regional site and at the Center for Architecture Science and Ecology in New York City.

During the course of almost two centuries, Rensselaer has built a reputation for providing an undergraduate education of undisputed intellectual rigor based on educational innovation in the laboratory, classroom, and studio. In more recent years, driven by talented, dedicated, and forward-thinking faculty, Rensselaer has expanded dramatically its research enterprise by leveraging existing strengths and focusing on five signature research areas: biotechnology and the life sciences; computational science and engineering; media arts; science and technology; energy, environment, and smart systems; and nanotechnology and advanced materials.

The Institute also has been a leader in the transfer of technology from the laboratory to the marketplace so that new discoveries and inventions benefit human life, protect the environment, and strengthen economic development.

The Rensselaer Plan

The Rensselaer Plan, conceived and led by President Shirley Ann Jackson, has been the blueprint for institutional transformation into a "fully realized technological university with global reach and global impact." The goal of offering a world-class educational experience to students includes building a robust research enterprise and creating an environment and community that nurture, support, and enable students to excel in all aspects of their lives.

Rensselaer continues to make significant strides in its transformation as a leader among technological research universities. We continue to recruit a talented and diverse student body, attracting record applicant pools. Investments in residence life include new living and learning communities, residence hall refurbishing, a new residence hall, and a major addition to athletic facilities. Since 2001 aggressive recruiting of leading faculty members has continued, including investments in constellation and new faculty positions. Research platforms developed under The Rensselaer Plan include the Center for Biotechnology and Interdisciplinary Studies, the Computational Center for Nanotechnology Innovations, and the Curtis R. Priem Experimental Media and Performing Arts Center.

Building on the original Rensselaer Plan, in 2013 the Institute launched The Rensselaer Plan 2024 to guide the campus through its next phase of growth leading to the university’s bicentennial in 2024.

Students

Rensselaer students have a well-deserved reputation as leaders and problem solvers. They truly fulfill the Institute’s vision and promise — to solve problems, to make a difference, and to change the world.

For the 2012–2013 academic year, Rensselaer enrolled 5,298 full-time undergraduates and 1,161 full-time graduate students in residence on the Troy campus, as well as 341 part-time in Hartford.

Self-identified underrepresented minorities account for 8 percent of the undergraduate student body and 4 percent at the graduate level. Twenty-nine percent of undergraduates are women, and 32 percent of full-time graduate students are women. It is an exceptionally bright and ambitious group: just over 66 percent of the members of the class of 2016 were in the top 10 percent of their high school classes.

Students operate the Rensselaer Union and control its annual budget. They belong to 23 NCAA intercollegiate teams (two, men’s and women’s ice hockey, compete at the Division I level, while all others compete in Division III), scores of intramural teams, and 200 clubs. About 30 percent of men are members of fraternities and 16 percent of women belong to sororities. Students publish a weekly newspaper and operate a 10,000-watt radio station.
Approximately 18 percent of Rensselaer graduates go on to graduate school within a year of graduating. The average starting salary for Rensselaer bachelor’s degree recipients in 2012 was $59,636, and $66,273 for master’s degree recipients, higher than the national averages. Rensselaer has been counted among the top 50 universities in the nation for nine consecutive years, according to U.S. News & World Report.

**Academic Approach and Educational Innovations**

Rensselaer is anchored by two vibrant roots:

- One root, written into the school’s founding documents, is “...the application of science to the common purposes of life.” This kept the focus on engineering solutions to national and international needs and challenges. Rensselaer graduates constructed the canals, roads, bridges, skyscrapers, and basic infrastructure of America, which helped to form the basis for 20th-century society.

- The second root, also built into the school’s origin, is the employment of unique educational strategies. In the earliest days, after initial instruction, students taught what they knew to each other — since teaching reinforces learning. Likewise, students performed scientific experiments — rather than watch faculty conduct them, as had been the common practice.

Today’s Rensselaer students are well-equipped not only to follow in the footsteps of their predecessors but also to blaze new paths. They are encouraged to pursue interdisciplinary studies and conduct research, even as undergraduates. And they have ample opportunities to develop as leaders, problem solvers, and doers—to do their part to fulfill the Institute’s promise and to change the world.

Rensselaer’s approach to education prepares students for leadership and for life. Students benefit from an innovative technological educational experience that extends beyond traditional classroom or campus boundaries. Comprehensive educational and research programs cut across academic disciplines, giving students the opportunity to learn and to grow into world leaders in their chosen fields.

**Faculty**

Rensselaer’s 500 faculty members are a collaborative community working in an atmosphere of interdisciplinarity. Rensselaer’s faculty members work directly with students — doing basic research, solving problems, teaching, and interacting.

The Rensselaer faculty includes National Science Foundation Faculty Early Career Development Award winners, members of the National Academy of Sciences and the National Academy of Engineering, and other eminent professionals.

Rensselaer faculty take pride in their dedication to teaching — demonstrating a commitment to excellence in teaching that always has been a hallmark of Rensselaer’s teacher-scholars. In coordination with the Anderson Center for Innovation in Undergraduate Education, the Rensselaer faculty devotes much thought and time to designing dynamic teaching methods, redesigning curricula, and transforming classrooms into interactive learning environments. Often Rensselaer’s faculty is organized into “constellations” or multidisciplinary teams that include senior faculty and early career faculty as well as graduate and undergraduate students.

**Research**

Basic science research is fundamental to addressing society’s greatest challenges: sustainability, better health and quality of life, renewable energy, safer infrastructure. At Rensselaer, key areas of emphasis include basic research in fundamental areas of biomedicine, drug discovery and development, regenerative medicine, and functional materials and devices, all of which build upon the fundamental disciplines of biochemistry, cell and developmental biology, biophysics, structural biology, systems biology, and computational biology. Rensselaer research programs also reach across the campus and beyond, linking together faculty and students, departments, schools, and interdisciplinary centers, and stimulating the integration of inquiry, new knowledge, and education.

The discovery of new scientific concepts and technologies, especially in emerging interdisciplinary fields, is the lifeblood of Rensselaer’s culture, and a core goal for faculty, staff, and students. Guided by The Rensselaer Plan, Rensselaer has created an extraordinary campus environment, leveraging unique research platforms such as the Curtis R. Priem Experimental Media and Performing Arts Center, the Computational Center for Nanotechnology Innovations, and the Center for Biotechnology and Interdisciplinary Studies. Rensselaer’s campus environment is extended by a broad set of research collaborations, alliances with the private sector, and partnerships with local, regional, national, and international institutions.

One of the hallmarks of a Rensselaer education is its commitment to intellectual partnerships between students, at all levels, and faculty. Opportunities are open to undergraduate students through the Undergraduate Research Program (in which students in all four class years can take part in formal research), in Rensselaer laboratories, through clubs, and as part of the curriculum. Graduate students are involved...
in myriad projects, from the development of life-saving treatments, to the design of sustainable built environments, to the exploration of the social and humanistic effects of technology.

Notice Regarding Intellectual Property All members of the Rensselaer community, including, but not limited to, graduate and undergraduate students, faculty, staff, administration, visiting scholars and scientists, and guests, are bound by the Rensselaer intellectual property policy. Go to: http://rpitechnology.com/files/ip_policy.pdf. For additional information about intellectual property at Rensselaer, refer to http://www.eship.rpi.edu/intellectual_property.php.

Entrepreneurship
Throughout its 190 years, Rensselaer has exhibited a unique strength in its ability to translate scientific discoveries into practical application, a process which is described as technological entrepreneurship. Historically and consistently, faculty, students, and alumni have developed technologies, created innovations, and formed business ventures to bring ideas into practice to create value.

Building on decades of successful efforts to nurture new businesses and bring ideas from classrooms and labs to the marketplace, Rensselaer recently launched a distributed incubation program to help young businesses grow and succeed.

The new program, called the Emerging Ventures Ecosystem (EVE), focuses on areas of Rensselaer’s signature research strengths and helps start up businesses take root in Troy and the Capital Region.

The Emerging Ventures Ecosystem builds on more than 30 years of the Institute’s previous incubator program, the nation’s first such program wholly sponsored and operated by a university. The new program utilizes an innovative distributed incubation model, working with each company to find an ideal matchup of space to enterprise in Troy and the surrounding area.

Today, the Emerging Ventures Ecosystem, Rensselaer Technology Park, and the Severino Center for Technological Entrepreneurship are national models, and the Office of Entrepreneurship provides leadership and coordination for student entrepreneurship in numerous ways: the office works closely with the provost, deans, and faculty to introduce new entrepreneurship courses into the various schools and to enhance existing courses independent of discipline. The program provides cocurricular activities for students, including entrepreneurial speakers in all disciplines, entrepreneurial workshops, a mentoring program, the “Change The World Challenge” student competitions, the Class of ‘51 Entrepreneurship Fund, and an “elevator pitch” competition. In addition, students can earn a Certificate of Achievement in Entrepreneurship and a personal letter of recommendation from the Vice Provost for Entrepreneurship by getting actively involved in the Exemplars Program, a program designed for those students who have a special interest in entrepreneurship.

Locations
Rensselaer’s historic main campus sits on a bluff overlooking the city of Troy and the Hudson River. The area offers a relaxed lifestyle with many cultural and recreational opportunities, with easy access to several major metropolitan centers.

Troy is 10 miles northeast of Albany, New York’s capital, and 150 miles north of New York City. The area is centrally located, with easy access to Boston (3 hrs.), Montreal (4 hrs.), and Niagara Falls (5 hrs.). Troy and the Capital Region (population 900,000) are home to many colleges, including Albany Medical College, Russell Sage, Siena, Skidmore, Union, and the University at Albany (SUNY).

The area offers a variety of recreational and social opportunities. The Adirondacks, the Berkshires, and the Catskills, all within an hour of Troy, offer hundreds of areas for camping, hiking, and skiing. Many clubs sponsored by the Rensselaer Union take full advantage of these natural resources.

Arts organizations of every description are also found in the area. The Troy Savings Bank Music Hall, considered by many experts to have the finest acoustics in America, is a short walk from campus, as is a downtown arts center. Nearby Saratoga Springs is the summer home to the New York City Ballet and the Philadelphia Orchestra. Albany’s Times Union Center hosts a wide array of top-name musical groups, sporting events, and other entertainment options.

Rensselaer’s Hartford campus features its own eight-story building on 15 landscaped acres in downtown Hartford, readily accessible from both Interstates 84 and 91. A regional site is in Groton, Connecticut.

The School of Architecture, in collaboration with architectural firm Skidmore, Owings & Merrill, operates the Center for Architecture Science and Ecology, an innovative collaborative in New York City that engages scientists, engineers, and architects from the professional and academic worlds toward a common goal of redefining how to build sustainable cities and environments. The joint effort allows Rensselaer students to be among the new generation of architects, thinkers, and planners developing sustainable and energy-efficient solutions to today’s environmental challenges in the global building sector.
Facilities

Rensselaer’s 276-acre Troy campus and its off-site facilities support the exploration, discovery, learning, and enrichment of our students and faculty. In the past decade, we have completed $750 million in new construction, renovation of facilities, and technology upgrades for research, teaching, and student life.

The Center for Biotechnology and Interdisciplinary Studies is a 218,000-square-foot facility that contains laboratories for molecular biology, analytical biochemistry, microbiology, imaging, histology, tissue and cell culture, proteomics, and scientific computing and visualization.

The Computational Center for Nanotechnology Innovations is among the most powerful supercomputers in the world. It advances semiconductor technology to the nanoscale, it enables key nanotechnology innovations, and it supports research in the fields of energy, biotechnology and the life sciences, new materials, arts, medicine, cognitive science, computer science, engineering design, and computational science and engineering.

The 220,000-square-foot Curtis R. Priem Experimental Media and Performing Arts Center is a platform for the largely unexplored territory where art, science, and technology come together in ways that empower the creation of entirely new work that cannot be done anywhere else. Its linkage to the Center for Biotechnology and Interdisciplinary Studies and to the Computational Center for Nanotechnology Innovations is propelling Rensselaer to the scientific, engineering, and artistic frontiers of the 21st century.

The East Campus Athletic Village supports Rensselaer students’ overall development and enhances the student experience. The complex includes a multipurpose stadium with seating for 5,200 spectators, a basketball arena with seating for 1,200, upgrades to the Houston Field House, and expanded and updated playing fields. A core component of The Rensselaer Plan, the facilities are designed to meet the needs of current students, more than 75 percent of whom participate in athletic activities on campus.

Indoor and outdoor athletic facilities include the Houston Field House, which is the home of the NCAA Division I men’s and women’s Engineers ice hockey teams. The Mueller Center, a 32,000-square-foot fitness center, houses more than 40 pieces of aerobic exercise equipment.

Institute residence facilities house up to 3,300 single students and 93 student families in a variety of living environments. The newest residence facility for undergraduates is the Howard N. Blitman, P.E. ’50 Residence Commons situated at the bottom of the Rensselaer Approach, the century-old granite staircase that symbolizes the connection between the city of Troy and the Institute. Blitman offers expanded housing options for Rensselaer undergraduates — specifically sophomores, juniors, and seniors — while bringing approximately 300 students downtown to engage in the vibrant community of Troy.

College Suites at City Station is a new housing community in Troy built exclusively for Rensselaer graduate students and graduate-level affiliates, located within walking distance of campus.

The 1,250-acre Rensselaer Technology Park is home to more than 60 companies and 2,300 employees, representing a wide diversity of technologies including physics, electronics, biotechnology, and software. Park tenants collaborate with faculty and students on research projects, making the site a “living laboratory.”

The mission of the Rensselaer Hartford campus is to anticipate and respond to the needs of individuals and organizations through the implementation of high-quality educational programs for working professionals. In support of this mission, the Rensselaer Hartford campus offers conference, training, and event facilities accommodating up to 100 guests.

Student Resources

The university has embarked on several new initiatives designed to elevate the undergraduate experience to a new level. The new student life model is based on the concept of “Clustered Learning, Advocacy, and Support for Students” (CLASS). The CLASS initiative is a comprehensive effort built around a time-based clustering and residential commons program. It builds upon our award-winning First-Year Experience with class deans, and extends learning across the spectrum of student residential life at Rensselaer. It is based on clusters of residence halls—or commons—with faculty deans within each of the commons, with live-in commons deans, upper-class and graduate student assistants, and individual class-year deans. Within the commons experience, the program incorporates student leadership opportunities and increases interaction with faculty and adult mentors. CLASS also includes plans to build the infrastructure to develop an international student experience, and a student life arts program.

The Rensselaer experience is complemented by resources that extend beyond traditional classroom and campus boundaries. These resources include: research libraries, academic and research computing, mobile computing program, O.T. Swanson Multidisciplinary Design Laboratory, Center for Career and Professional Development, cooperative education (co-op), exchange and study abroad programs, Archer Center for Student Leadership Development, Advising and Learning Assistance Center, and the Center for Initiatives in Pre-College Education.
To better prepare tomorrow’s leaders with the global perspective and multicultural sophistication that will be necessary to tackle the challenges facing the world in the 21st century, Rensselaer has created the Rensselaer Education Across Cultural Horizons program, or REACH. The program, one of the first of its kind in the nation, integrates an international experience into Rensselaer’s undergraduate curriculum.

A leading-edge integrated information environment is integral to teaching, learning, and research. Rensselaer is a leader in the use of computing to support education and research. The Division of the Chief Information Officer provides quality information solutions, bringing world-class services and support to the Rensselaer campus. Programs include the laptop program (requiring all entering freshmen to have a laptop computer for use both in and out of the classroom), support for interactive learning (including WebCT courses), state-of-the-art electronic information-retrieval services by the libraries, and online student and administrative services. The Institute’s robust computing infrastructure supports new applications in diverse areas of research such as bioinformatics, multimedia, modeling, and simulation.

**Alumni and Alumnae**

Rensselaer’s more than 95,000 living alumni and alumnae are active and influential in all facets of society. They are engineers, physicians, attorneys, architects, writers, inventors, and entrepreneurs. By contributing to scholarships and sharing their expertise with Institute leadership, they significantly enhance campus life.

The Office of Alumni Relations, supported by the Rensselaer Alumni Association, seeks to create and sustain mutually beneficial relationships among current students, alumni/ae, and the Institute. A full range of services are offered, including career assistance, regional and campus events, affiliate group programs, print and Internet communications, and sports programs. Student programs include the Red and White service organization, regional “fairs,” alumni speakers, and mentoring programs.

**Accreditation**

Rensselaer is accredited by the Middle States Commission on Higher Education and by a number of professional and academic societies. Undergraduate degree programs in chemistry are certified by the American Chemical Society; professional programs in architecture are accredited by the National Architecture Accrediting Board. The Lally School of Management and Technology is an accredited member of the Association to Advance Collegiate Schools of Business, an international accreditation. All engineering bachelor’s degree programs are accredited by the Engineering Accreditation Commission of the Board for Engineering and Technology. The exception is engineering science, which is not intended as preparation for professional engineering practice.

Rensselaer at Hartford is accredited by the Middle States Commission on Higher Education, by the Board of Governors for Higher Education of the State of Connecticut, and by a number of professional and academic societies. Rensselaer’s Hartford Department of the Lally School of Management and Technology is an accredited member of the Association to Advance Collegiate Schools of Business International.

Rensselaer admits qualified students without regard to age, race, color, gender, sexual orientation, religion, national or ethnic origin, veteran status, marital status, or disability.
Educational Programs and Resources

For more than 175 years, Rensselaer has offered a unique and innovative technological educational experience. As the Institute’s visionary leaders have long understood, ensuring the excellence of this experience requires learning opportunities that extend beyond traditional classroom or campus boundaries. Rensselaer’s students may choose from a broad range of distinctive advantages designed to fulfill their abundant desire for new challenges.

Especially appealing to Rensselaer’s highly motivated and intellectually talented students are opportunities to engage in leading-edge research. Rensselaer’s relatively small size enables faculty researchers to work closely with students, and they eagerly include both undergraduate and graduate students in their research work. Such opportunities are available to students in virtually every major offered through Rensselaer’s five schools—Engineering, Science, the Lally School of Management and Technology, Architecture, and Humanities, Arts, and Social Sciences.

Additional special opportunities include a variety of domestic and overseas student exchange programs, internships, and real-world work experience through the Cooperative Education Program. Conversely, the Vollmer W. Fries and other lecture series bring leading industrialists, governmental officials, authors, and outside educator-scholars to the Troy campus.

Recognizing the benefits of such beyond-the-classroom educational opportunities, leading industries and graduate and professional schools throughout the nation actively seek Rensselaer graduates.

Undergraduate Programs

Vice Provost and Dean: Vacant

Undergraduate programs leading to the Bachelor of Science degree are available in more than 30 fields listed in the Degrees Offered section of this catalog. All B.S. programs are normally completed in four academic years. Dual majors are also an option that generally can be completed within four academic years. For information on general degree requirements, refer to the Academic Information section of this catalog. The individual school sections provide detailed information on the specific curricula that each offers.

The Schools of Architecture and Engineering also offer professionally accredited degrees. These are the five-year Bachelor of Architecture degree program and the four-year Bachelor of Science in Engineering degree program. See the School of Architecture and School of Engineering catalog sections for more detailed information.

Additional special options available to undergraduates are described below.

Undergraduate Research Program

As a globally active research university committed to providing student research opportunities, Rensselaer offers undergraduates the opportunity to participate in research projects through the Undergraduate Research Program (URP). This program offers students real-world, hands-on research experience, in which they work directly with a faculty member on a bona fide research project for which they can earn either pay or course credit. There is a special summer program as well, in which the students can compete for funding that will allow them to spend a full summer working on a research project (SURP). Details on the programs are available at http://www.rpi.edu/dept/urp/ or in the Office of Undergraduate Education, Walker Lab, Room 4010.

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Study-Abroad and Exchange Opportunities

Study abroad has become an integral part of a well-rounded undergraduate experience. Students who spend time abroad will gain a deeper understanding not only of the culture in which they will be living, but also the culture of the U.S. and its place in today’s global society. A period of study abroad allows students to develop a broader perspective on their academic field of study while earning credit toward a Rensselaer degree.

Rensselaer offers a variety of study abroad and exchange opportunities at top universities and institutes around the world. Most semester opportunities require junior standing and a minimum GPA of 3.0. Occasionally, students choose to study abroad for an entire academic
year. Faculty-led and other short-term programs are offered during the summer and January vacations. While most programs are offered in English, foreign language proficiency is required at some partner institutions.

Most study abroad and exchange programs are managed by the Office of International Programs. Exceptions to this are the Architecture and International Management Exchange Programs (IMEP), which are managed by the School of Architecture and Lally School respectively. Also an exception is the International Scholars Program (ISP), a 10-week intensive graduate-level international educational experience, which is open to students from all Rensselaer schools and disciplines. The ISP is overseen by the Rensselaer Hartford Campus.

For more information, please contact the appropriate office from the list below.

Office of International Programs, Academy Hall, 4th Floor, Suite 4226
Karen Dvorak, Program Manager, (518) 276-3411, dvorak2@rpi.edu
Jamie Obst, Senior Program Administrator, (518) 276-6663, violaj2@rpi.edu
http://undergrad.rpi.edu/, click on Office of Intl. Programs tab

Architecture International Programs
Carly Bracket, Administrative Specialist, (518) 276-6466, perruc@rpi.edu

International Management Exchange Program (IMEP)
Beth Macey, IMEP Coordinator (518) 276-2388, maceyb2@rpi.edu
International Scholars Program (for graduate and co-terminal students only)
John Maleyeff, Associate Dean for Academic Affairs (Hartford campus), (860) 548-7870, maleyj@rpi.edu.

PreHealth Programs

Rensselaer successfully prepares students to enter medical and other health professional schools. These students major in such fields such as biology, chemistry, biomedical engineering and other engineering programs, mathematics, physics, or psychology. Students from any major may apply to any health professional schools as long as they meet basic prerequisites. With their adviser, these students develop a plan of study that allows them to fulfill professional school prerequisites while earning their B.S. degree. For further information, students should contact the Advising & Learning Assistance Center (ALAC) located in 4226 Academy Hall, (518) 276-6269 to meet with members of the PreHealth Professions Committee.

Pre-Law Programs

The baccalaureate program in a number of fields will prepare Rensselaer students to enter law school. Rensselaer graduates who obtain law degrees are equipped to enter general practice or to serve in important legal positions in business, industry, or government. In cooperation with Albany Law School and Columbia University Law School, Rensselaer has also developed accelerated programs that permit students to earn law degrees within six years. After a three-year accelerated undergraduate program, the student enters law school. Upon completion of the fourth year, the student receives the B.S. degree. The J.D. is awarded at the end of the sixth year. See the Science and Technology Studies program within the School of Humanities, Arts, and Social Sciences section and the Lally School of Management and Technology section of this catalog for further information.

Public Service Internship Program

The Public Service Internship (PSI) is an upper level course that matches students' skills with community needs. Interning throughout Troy and the Capital region, students work for 80 hours at non-profit organizations and government agencies. The aim of the course is to help students learn how to participate as active citizens in their own communities. By putting technical skills to work in the real world, students gain tangible hands-on experience. Community organizations, in turn, get motivated and highly skilled workers to accomplish goals that might not otherwise be met. Together, both groups benefit through sustainable change. For more information please see http://www.sts.rpi.edu/index.php?pageid=308&siteid=20&cn=STSS-4800.

First-Year Courses

Rensselaer offers special courses or course sections in first-year subjects designed to accommodate the diverse backgrounds and preparations of entering first-year students. These include special course sections for advance placement students and for students who require extra help.

Reserve Officer Training Corps

Reserve Officer Training Corps (ROTC) programs are available on an elective basis for students desiring commissions as officers in the armed forces. ROTC programs are undertaken concurrently with baccalaureate degree studies.
Graduate Programs

Office of Graduate Education

Vice Provost and Dean: Stanley M. Dunn

The Office of Graduate Education at Rensselaer provides current graduate students with the administrative, academic, and curricular information they need to progress through their courses and programs. This includes assisting in changes to student degree status and advising on thesis, registration, and graduation issues, and providing approvals and processing for withdrawals, academic dismissals, and leaves of absence. The office closely monitors the effectiveness of graduate education policies and recommends and institutes adjustments to improve program quality. Online information and forms can be located at Office of Graduate Education homepage at http://gradoffice.rpi.edu/setup.do.

All doctoral programs and many master’s programs involve students in research activities that generally are supported by government, industry, or foundations. Faculty members serve as senior investigators for a wide range of challenging research projects and are assisted by postdoctoral investigators and graduate students. Research opportunities for graduate students are also an important part of many Rensselaer research centers. These centers include the Center for Automation Technologies (CATS), the Center for Biotechnology and Interdisciplinary Studies, the Center for Future Energy Systems, the Center for Integrated Electronics, the Computational Center for Nanotechnology Innovations (CCNI), the Network Science and Technology Center (NEST), the Rensselaer Nanotechnology Center, and the Scientific Computation Research Center. Additional information about these centers can be found in the Research Resources and Centers and several other sections of this catalog.

In addition to graduate students working full-time at the Troy campus, working professionals seek degrees on a part-time basis through the Rensselaer Hartford Campus and distributed sites.

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Education for Working Professionals

Acting Dean, Rensselaer Hartford Campus: David L. Rainey

Education for Working Professionals (EWP) is one of Rensselaer’s four core enterprises and encompasses a range of programs designed specifically for current and future workforce leaders with a range of high-end, customized degree, certificate, and professional development programs. Program content flows from the heart of Rensselaer’s research strengths and unique academic programs. Rensselaer supports this vision by forging strategic partnerships with businesses, governments, universities, and innovative professionals who impact society and technology around the nation and the world.

The mission of EWP is to educate business and technical leaders with the knowledge, analytical skills, creativity, and inspiration to think strategically, lead change, and create breakthrough solutions that meet the technological and business challenges of the global environment now and in the future. With dramatic increases in the rate of change, working professionals expect and demand an academic environment that fits the evolving needs of their fast-paced world, and Rensselaer responds to this need through the EWP enterprise.

Rensselaer Hartford Campus

Rensselaer Hartford campus provides a challenging educational environment and a dynamic learning experience for students who need to balance their professional, academic, and personal lives. Part-time students attend classes at Rensselaer’s Hartford campus and Groton, Connecticut site.

Rensselaer Hartford campus offers graduate programs in Management, Computer and Systems Engineering, Computer Science, Electrical Engineering, Engineering Science, Information Technology, and Mechanical Engineering. Specialized programs include Dual Master’s Degrees, the MBA, the Executive MBA, and the International Scholars Program as well as several graduate certificates in Computer and Information Sciences and Engineering. Courses are delivered by faculty with significant industry experience, solid academic credentials and scholarship, and exceptional teaching skills whose expertise is grounded in sound research and best practices from a global perspective. Each course is designed to meet the needs of working professionals seeking to advance their careers and enhance their organizations’ successes. Rensselaer graduates are entrepreneurial and personify the Institute’s slogan, “Why not change the world?”

Regional Site in Groton, Connecticut

Rensselaer operates a regional site at the Mystic Executive Park in Groton, Connecticut. Students participate in cohort-based learning programs to complete their degrees.
Division of the Chief Information Officer

Vice President for Information Services Technology and Chief Information Officer: John E. Kolb

The Division of the Chief Information Officer (DotCIO) provides information strategies, services, and technology and collaborates with Rensselaer’s diverse campus constituents to find solutions for changing educational research, communication, and business needs. DotCIO responds to the rapid evolution of distributed computing and the need for combining computing and communications services and supports Rensselaer’s nationally recognized interactive learning initiatives.

Campus computing facilities offer students a variety of software including programming language compilers, desktop publishing packages, spreadsheets, and computer-aided design packages, as well as electronic mail and conferencing.

Of the Division of the Chief Information Officer’s seven departments, students interact most closely with Academic and Research Computing and Libraries. Therefore, these two departments are described below.

Academic and Research Computing
Acting Director: Mark Miller
Web site: http://www.rpi.edu/computing

Academic and Research Computing (ARC) provides educational computing services and assistance in support of Rensselaer’s learning and research activities. Computing is integrated into the curriculum and is an essential component of course work and communication.

ARC consists of five groups: Consulting and Research Computing, Help Desk Services, Educational Technology Services, the Campus Computer Store, and Rensselaer Computer Repair. Some of the department’s responsibilities include: administering the Mobile Computing Program, software licensing services, and the numerically intensive computing service providing consulting for researchers; maintaining the registrar-scheduled computer classrooms; and deploying software for all public computing sites. Professional staff members assist students, faculty members, and other computer users by providing specialized consulting, Rensselaer-specific documentation, and training through online short courses. At the Help Desk in the Voorhees Computing Center (VCC), consulting help is available from any DotCIO department.

All undergraduates are required to have a laptop computer. Through the Mobile Computing Program (http://www.rpi.edu/laptops), Rensselaer offers students a powerful laptop loaded with software at an excellent price, along with on-campus support for both hardware and software. There are network ports in public buildings across campus and in every residence hall room. The wireless network includes large portions of core campus buildings and residence halls and is continually expanding.

Each student receives a Rensselaer Computing System (RCS) account that allows access to the campus network, the Internet, RPInfo (Rensselaer’s Web site), electronic mail, the Learning Management Systems (RPILMS), and library services.

Campus computing facilities offer students several platforms including PCs running Windows and Linux connected to the network in public labs and classrooms. Some of the larger public computing areas are located in the Voorhees Computing Center (VCC, open 24 hours a day), Troy Building, Folsom Library, and Russell Sage Laboratory. There are also many laptop classrooms across campus that have a network port and power at each seat.

From a single workstation, personal computer, or laptop, a student can connect to Division of the Chief Information Officer host computers on campus as well as to off-campus host computers, data services, and networks. A variety of software is available including numeric and symbolic computation programs (Maple and MATLAB), programming language compilers (C, C++, and Fortran), desktop publishing packages and spreadsheet software (Microsoft), computer-aided design packages (NX is now the more popular CAD package), graphics packages, and electronic mail programs. Specialized software for course work is also installed where utilized.

For high performance computing (long-running, numerically intensive jobs), a Batch Cluster and several UNIX workstations are available. In addition, a cluster of high-performance Linux workstations can run programs that employ parallel processing.

Rensselaer Libraries
Director: Bob Mayo

The Rensselaer Libraries, comprised of the Folsom Library and the Architecture Library (located in the Greene Building), provide the university community with information resources and services in support of teaching and research missions. Researchers can access over 385,000 print book titles, electronic and print journals, electronic books, and view several extensive image databases. Collaboration with the Cole Library (Rensselaer at Hartford) further enhances library support on both campuses.
When researchers need material not held by the Libraries, they can initiate online interlibrary loan requests or use the Connect NY service to borrow books directly, and receive rapid delivery, from a statewide consortia holding over 5,000,000 titles. They may also borrow books in person from more than 50 regional libraries.

Reference & Instructional Services’ librarians are available to assist students and researchers personally and also provide specialized classes and workshops on such topics as “Research in a Digital Library,” “Biotechnology Resources,” and “Patent Searching.”

RensSearch, the Rensselaer Libraries’ information gateway at http://library.rpi.edu, provides a variety of services including an online catalog, access to electronic resources, guides to services, and the latest library news. The Libraries’ Archives Web pages provide a digitized history of the Institute.

Notwithstanding the emphasis on digital resources, the Rensselaer Libraries continue to be an important “place” on campus for intellectual and social nourishment.

Patrons may socialize in Library Café, peruse the latest best-selling fiction and non-fiction books in the Class of ’96 Reading Room, browse, or just relax in the Architecture Library’s bright and airy reading room. Small group meeting rooms can be reserved for collaborative work and group study. Seminar and conference rooms are available to Student Union recognized groups. The Friends of the Folsom Library sponsor monthly “Lunch & Learn” topics in a casual setting. Folsom’s 4th floor provides breathtaking views of New York’s Capital District and the Hudson Valley. A unique stainless steel water sculpture, designed by Charles Moore, rises from Folsom Library’s third floor up through the fourth floor, creating a soothing ambience for study.

**Advising and Learning Assistance Center**

**Director:** Michael Hanna

The Advising and Learning Assistance Center, located in 4226 Academy Hall, provides support and training for students to become independent learners. The Center trains faculty, staff, undergraduate, and graduate students as advisers, peer mentors, learning assistants, teaching learning assistants, and tutors. Advising events, academic workshops, tutoring sessions, and office hours are offered to all registered students and are coordinated by the staff.

Members of the professional staff are available to consult with students individually or in groups where they discuss such topics as academic performance, exam anxieties, stress management, time management, note taking, and general improvement of learning skills. The staff also works with students previously diagnosed with learning disabilities to improve their coping skills. Additional responsibilities include PreHealth advising, Professional Health Committee, advising Undeclared/General Studies students, and coordinating English as a Second Language programs.

Through its PreHealth Committee, students are guided through the development of their application portfolio, for medical, dental, and other graduate health professional schools. The Committee advises students and provides professional letters of recommendation as well as specific advice.

The Center also provides information, makes referrals, interprets, administers, and makes exceptions to Institute registration policies and procedures; serves as a support for students experiencing academic difficulty; and processes all academic issues regarding academic awards, dismissals, and probation. Additionally, the Center facilitates a First Year Seminar, training sessions for all new advisers and updates experienced advisers on changes to institute policies and procedures.

The Center takes part in a strong collaboration effort with other support services on campus—the Office of the First-Year Experience, the Dean of Students Office, the Counseling Center, the Center for Career & Professional Development, and the Office of Graduate Education—to help assure that positive, helpful, and exciting connections are made early and throughout the student’s experience at Rensselaer.

**Institute Diversity**

The Office of Institute Diversity serves as a campus-wide advocate, liaison, consultant, and clearinghouse to enhance campus synergy among faculty, students, and staff. Part of its mission is to provide leadership and direction in creating a “seamless” diversity perspective that capitalizes on the creativity and richness of Rensselaer constituents. It is proactive in its efforts to align campus diversity initiatives with the vision and mission of the university, thereby fostering the growth of a community that embraces intellectual, geographic, ethnic, and gender diversity. Institute Diversity is located at 1516 Peoples Avenue.
Center for Initiatives in Pre-College Education

The Center for Initiatives in Pre-College Education (CIPCE) seeks to leverage Rensselaer’s strengths in interactive pedagogies and technologies by developing technology and scientifically based activities which are implemented in after-school workshops and summer experiences for pre-college teachers and students. With one of Rensselaer’s stated objectives being to “seek a diverse body of students, especially groups underrepresented in science and technology”, CIPCE’s programs all have as their ultimate aim to fill the pre-college pipeline, while at the same time developing deep and lasting partnership with school districts. CIPCE believes that Rensselaer must include as part of its mission to prepare more young men and women for challenging careers as part of the future STEM workforce. However, it is not enough to wait for students to apply for admission before inviting them to campus. Rensselaer must reach into K-12 schools to identify, motivate, and educate those with a talent and drive to excel and lead, while paying special attention to the one-half to two-thirds of the population represented by women and minorities. Members of the Rensselaer community must mentor and encourage young people to engage in the study of mathematics and the sciences. Additionally, with the recognition that Rensselaer undergraduates are often our best recruiters, CIPCE’s programs use undergraduate students as facilitators. Its activities include:

- Professional development activities for teachers including on-site classroom support; after-school workshops; and summer institutes.
- The use of online and other distance learning technologies to facilitate its professional development activities.
- The development of instructional materials for classroom use.
- The development and implementation of after school LEGO, VEX, and other robotics and interactive technology experiences for K-12 students.
- The development and implementation of summer Robotics Engineering Academies for K-12 students.
- Cognitive research focused on how technology affects student learning.

CIPCE is in the process of developing articulation agreements with several universities that have Schools or Departments of Teacher Education. With these agreements, Rensselaer students desiring New York State secondary school teacher certification will be able to seamlessly receive this through these universities.
Research Resources and Centers

Research plays an integral role in Rensselaer’s vision of the technological university. The discovery and application of new scientific concepts and technologies, especially in emerging interdisciplinary fields, are core goals for faculty, staff, and students. Rensselaer’s research programs reach across the campus, linking departments, schools, interdisciplinary centers, and unique platforms such as the Curtis R. Priem Experimental Media and Performing Arts Center, the Computational Center for Nanotechnology Innovations, and the Center for Biotechnology and Interdisciplinary Studies. This fertile research environment creates opportunities for the integration of research and education, the development of entrepreneurship, and experiences with collaborators from a broad range of academic, private, national, and international institutions.

The Office of the Vice President for Research works closely with faculty to foster high-impact research to address today’s and tomorrow’s challenges in science, engineering, technology, and society. The Office oversees a “research ecosystem” that supports faculty and student innovation, facilitates interdisciplinary synergistic work in Rensselaer centers, and coordinates major research themes and programs.

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Center for Automation Technologies and Systems (CATS)

Director: John T. Wen, Professor of ECSE and MANE
Associate Director: Craig Dory

CAT Home Page: www.cats.rpi.edu

The Center for Automation Technologies and Systems (CATS) at Rensselaer Polytechnic Institute serves as a focal point for a broad range of industrially-relevant research and development in both practical and theoretical aspects of automation. Automation — processes and devices that improve efficiency, increase productivity, or enhance functionality — is a key enabling technology, and a critical component of sustainable global competitiveness for a wide range of industries, from biomedical and renewable energy to manufacturing. Nearly 40 faculty members in multiple departments at Rensselaer participate in the research and educational programs of the Center. With annual funding from the State of New York as a NYSTAR-designated Center for Advanced Technology, the CATS pursues a mission of research excellence and service to industry, and focuses on bridging the “laboratory-to-market” chasm in a broad range of high-impact applications. The CATS works with industrial partners to pursue an integrated systems approach to solving real-world problems, advancing model-based methods and applying them to design, optimization, control, and monitoring. Current focus areas include fuel cell manufacturing, advanced modeling and simulation for design automation, adaptive optics systems, microsystem assembly, active flow control, thermal management, and power grid monitoring and control.


Staff: J. Gullotta, H. Merrill, K. Myer, R. Puffer, S. Rock, G. Saunders, J. Young

Center for Biotechnology and Interdisciplinary Studies

Director: Deepak Vashishth, Ph.D.
Director of Operations: Glenn M. Monastersky, Ph.D.

Web site: www.biotech.rpi.edu

The Center for Biotechnology and Interdisciplinary Studies (CBIS) is a 218,000-square-foot facility on the Rensselaer campus. With its high-tech laboratories, it provides a platform for collaboration among many diverse academic and research disciplines to enhance discovery and encourage innovation. Research and office space is available for approximately 500 faculty, staff, and students, and the Bruggeman Conference Center and Auditorium host world-class programs and symposia.
The CBIS facilitates groundbreaking discoveries by Rensselaer faculty at the intersection of the basic life sciences, physical and computational sciences, and engineering sciences, which leads to new biotechnology breakthroughs. By maximizing core strengths and collaborations, CBIS ensures the impact of Rensselaer’s financial, organizational, and intellectual investment to society.

Center faculty and researchers are engaged in interdisciplinary research, focused on the application of engineering and the physical and information sciences to the life sciences. Residents include members of several academic departments including Biology, Biomedical Engineering, Chemical and Biological Engineering, Chemistry and Chemical Biology, and Physics.

The Center is home to nine state-of-the-art Research Core facilities, which permit investigators to address fundamental research questions from the atomic and molecular level through cellular and advanced tissue systems, and finally in live animal platforms. The Research Cores include Proteomics, Microbiology and Fermentation, Analytical Biochemistry and Nanotechnology, BioResearch (Animal Research), Cell and Molecular Biology, Microscopy and Cellular Imaging, BioImaging, Nuclear Magnetic Resonance (NMR), and Stem Cell Research.

Rensselaer has supported the creation of four research Constellation areas in CBIS that build on existing Rensselaer research strengths: Biocatalysis and Metabolic Engineering; Tissue Engineering and Regenerative Medicine; Integrated Systems Biology; and Biocomputation and Bioinformatics. Each Constellation contains a mix of senior and junior faculty, and students and postdoctoral scientists from multiple backgrounds and departments.

Biotechnology is an inherently multidisciplinary pursuit. Students interested in studying Biotechnology at Rensselaer may apply for degrees through several existing departments and programs and create a truly interdisciplinary program with consultation and approval from faculty advisers who represent at least 12 different university departments.

**Center for Future Energy Systems**

**Acting Director:** Jian Sun, Professor, ECSE  
**Associate Director:** Martin Byrne, MBA ’82  
**Home Page:** www.rpi.edu/cfes/

The Center for Future Energy Systems (CFES) is one of 15 Centers for Advanced Technology (CAT) across New York State funded by the New York State Office of Science, Technology and Innovation (NYSTAR). The Center’s mission is to connect novel energy materials, devices, systems research, know-how, and technology in academia with the needs of industry to solve problems and spur economic development.

Energy is one of the most pressing issues facing society. Achieving energy security, combating global warming, and developing a new green energy economy, will require harvesting more energy from renewable sources such as solar and wind, as well as using energy more efficiently across different sectors of the industry and in all aspects of daily life. In collaboration with Cornell University, CFES addresses these challenges through cutting-edge research and industry collaboration in a wide range of areas including photovoltaic materials and cells, advanced wind turbine design and control, solid-state lighting and smart lighting sources, intelligent and energy-efficient building systems, fuel cells, advanced materials for energy storage and thermoelectric energy conversion, distributed generation, control and grid integration of wind and solar power, operation and control of future energy systems, power conversion for transportation systems, as well as power system economics.


**Staff:** L. Valenti, K. Georgeadis, T. Simmons
The Center for Integrated Electronics (CIE) was created to carry out fundamental research that is industry-oriented in electronics design and manufacturing including Semiconductor Interconnect technology. The center's mission is to build integrated top-down and bottom-up nanostructures, devices, and systems for information, biological, and broadband communication applications. Major activities at the CIE include pioneering research into gigascale interconnects, 3-D interconnect structures, materials properties and process modeling, wideband gap semiconductors and devices, terahertz devices and imaging systems, power electronic devices and systems, and biochips.

The Center’s activities range from basic and applied research and education to commercialization through partnerships with industry. CIE faculty, students, and research post-doctoral fellows, and technical staff conduct research activities incorporating projects for specific companies, as well as longer-range programmatic efforts in fundamental areas of materials processes, design, fabrication, and characterization related to integrated electronics, electronics manufacturing, and micro-electro-mechanical systems (MEMs).

State-of-the-art facilities enhance research opportunities and include a Class 100 nanofabrication clean room with processing capabilities both for Si and base devices/circuits, and microsystems, extensive computer resources from such companies as Apple, AT&T, DIGITAL, Hewlett Packard, IBM, and Sun, and numerous state-of-the-art processing design, testing, and characterization facilities in individual laboratories. Located on the Rensselaer campus, the CIE has immediate access to expertise in a broad range of disciplines. Participants include internationally recognized faculty from Rensselaer’s Schools of Engineering and Science.

Center for Power Electronics Systems The Center for Power Electronics Systems (CPES), sponsored by the National Science Foundation and established in 1998, is a national Engineering Research Center (ERC), which envisions enhancing the competitiveness and growth of the power electronics industry by developing an integrated system approach with Integrated Power Electronics Modules (IPEMs). The goal of CPES is to improve the quality, reliability, and cost effectiveness of power electronics systems by tenfold at the end of the expected 10-year life span. Virginia Institute of Technology administers this Center; and the five-university consortium consists of Rensselaer, Virginia Tech, University of Wisconsin-Madison, North Carolina A & T, and University of Puerto Rico at Mayaguez.

Focus Center—New York, Rensselaer: Interconnects for Hyperintegration This program investigates radical alternatives and new concepts leading to new solutions that will enable the U.S. semiconductor industry to transcend known limits on interconnections that would otherwise decelerate or halt the historical rate of progress toward gigascale integration (GSI). This program is part of the nationally distributed Interconnect Focus Center (IFC) administered from Georgia Institute of Technology. The university consortium includes Rensselaer, SLTNY-Albany, Georgia Tech, MIT, and Stanford. Rensselaer’s efforts focus on nanowire and molecular technologies, multiple layers of active devices (“3-D Chips”), optical interconnects, and fundamental materials and process characterization and modeling.

Center for Broadband Data Transport and Technology IBM Corporation endows this interdisciplinary Rensselaer center, which involves faculty from the Schools of Engineering and Science, SUNY Albany, Cornell University, City College of New York, and affiliated IBM researchers. The center’s primary mission is to conduct research in optical and electrical data transport, switching, and processing to enable future generations of information technology systems. The center is also involved in educating a new generation of students and postdocs for broadband data transport science and technology. The center operates the Internet Accessible Remote Laboratory (visit http://ninct.ecse.rpi.edu/shur/broadband).

Connection One This is a Rensselaer NSF Industry/University Cooperative Research Center involved in basic and applied interdisciplinary research in secure optical and electrical data transport switching, processing, materials, devices, systems, and information technology, enabling the massive scaling required by these systems. The research at RPI also addresses terahertz device design and characterization for VLSI testing and for wireless interconnects. This research is based on using plasma waves in semiconductors to carry information rather than relying on the electron drift, since the velocity of plasma waves is 10 to 20 times higher than the maximum electron drift velocity (visit http://www.connectionone.org/).

Computational Center for Nanotechnology Innovations (CCNI)

**Director:** Christopher D. Carothers, Ph.D.

**Associate Director, Research Computing Operations:** Jacqueline A. Stampalia

**Associate Director of Research:** Mark S. Shephard

**Web site:** [http://www.rpi.edu/research/ccni](http://www.rpi.edu/research/ccni)

The Computational Center for Nanotechnology Innovations (CCNI) is a partnership between Rensselaer Polytechnic Institute, IBM, and New York State that operates one of the world’s most powerful university-based supercomputers as a resource supporting computationally intensive research and development by the Center’s academic, industry, and government partners. The CCNI, based on the Rensselaer campus and at its Rensselaer Technology Park, in Troy, N.Y., provides services to more than 150 projects and over 800 users representing a broad range of university, industry, and government groups and organizations focused on the development and application of new generations of simulation technologies on world-class supercomputers.

The goals of the CCNI include:

- providing an enabling platform for world-class computational and data-intensive nanotechnology research and development.
- supporting collaborative partnerships between academic and industrial researchers pursuing the development and application of new integrated predictive modeling methods and design tools for nanoscale materials, devices, and systems.
- developing and growing a strategic portfolio of research projects, cyberinfrastructure acquisitions, and industry engagements design to grow CCNI’s capabilities and continually position it as a partner of choice for industrial and research organizations employing high-performance computational and data-intensive techniques.
- fostering economic growth in Tech Valley in New York State and beyond.

The CCNI operates heterogeneous supercomputing systems including a massively-parallel Blue Gene supercomputer, Power-based Linux clusters, and Intel processor-based clusters. This diverse set of systems enables large-scale leading-edge computational research in both the scientific and technical arenas. This hardware and software configuration provides nearly half a petaflop of aggregate computational power with associated high-speed networking and storage.


**Staff:** D. LaBrie-Belser, M. Henesey, E. Karaismail, N. Kharche, C.W. Smith

**Postdoctoral Associates:** M.O. Bloomfield, L.E. Fovargue, R.A. Molecke, S. Seol

**Technical Staff:** J.S. Fisher, R.L. Todd, D.M. Weeks, T.B. Wickberg
Network Science and Technology Center (NEST)

**Director:** Boleslaw K. Szymanski  
**Web site:** [http://scnarc.rpi.edu/](http://scnarc.rpi.edu/)

The Network Science and Technology (NEST) Center is focused on the fundamental research and engineering of natural and technological networks, ranging from social and cognitive networks to computer networks. The fundamental understanding of network structures and dynamic processes arising in them combined with the novel designs of protocols for communication and algorithms for applications will enable experts in the fields ranging from sociology, to biology, medicine, physics, computer science and engineering to apply the results of the Center's research in their specific disciplines.

NEST research is focused on studying fundamental properties of networks, the processes underlying their evolution and the paradigms for network engineering to enhance their desirable properties such as efficiency, reliability, and robustness. Research on natural networks focuses on cognitive models of net-centric interactions, models and algorithms of community creation, evolution, impact of mobility on network formation, dependencies between social, information and communication networks and spread of opinions and ideologies among network nodes. Research on technological networks, such as computer, transportation and energy distribution networks, focuses on their optimal design from the point of view of flow maximization, fault tolerance to failure, graceful degradation in case of partial damage, etc.

In communication networks, NEST develops and studies network protocols and algorithms, especially for wireless and sensor networks and studies system issues in interoperability of communication networks with computer systems. NEST actively transitions the developed protocols and algorithms to industrial practice and commercialization.

NEST partners with universities, national laboratories and industry in large scientific programs targeting interdisciplinary research. NEST is the primary member of the Social Cognitive Network Academic Research Center (SCNARC), a part of Network Science Collaborative Technology Alliance (NS-CTA), as well as member of the International Technology Alliance, both funded by collaborative agreements with ARL. Other supporteres include NSF, DARPA, DTRA, IARPA, ARO, ONR, MIT Lincoln Laboratory, and BrandXadds.

**Affiliated Faculty:** S. Adali, M. Goldberg, J. Hendler, G. Korniss, K. Kar, C. Lim, M. Magdon-Ismail, F. Spier, B.K. Szymanski, W. Wallace, B. Yener.

**Postdoctoral Associates:** N. Derzsy, D. Hunt, S. Sreenivasan, W. Zhang

Rensselaer Nanotechnology Center

**Director:** Richard W. Siegel  
**Associate Director:** Dennis Hull  
**Home Page:** [http://www.nano.rpi.edu](http://www.nano.rpi.edu)

The Rensselaer Nanotechnology Center (RNC) was founded in March 2001 to conduct fundamental research on nanomaterials and nanotechnology. From September 2001 to September 2012, the RNC has hosted the NSF’s Nanoscale Science and Engineering Center for Directed Assembly of Nanostuctures, which comprised three coordinated interdisciplinary and inter-institutional thrusts: Nanoparticle Gels and Polymer Nanocomposites; Nanostructured Biomolecule Composite Architectures; and Serving Society through Education and Outreach. As a result the RNC has developed significant skills in assembling functional multiscale nanostructures with junctions and interfaces between structurally, dimensionally, and compositionally different nanoscale building blocks.

The Center focuses on creating novel materials and devices that could enable more effective drug delivery in the human body, result in stronger and more durable plastics, enable high capacity energy and information storage devices, produce flame-retardant plastics for planes and automobiles, and address many other important applications to societal needs.


**Administrative Staff:** E. Schultz, B. Jordan
The Scientific Computation Research Center (SCOREC) is focused on the development of reliable simulation technologies for engineers, scientists, medical professionals, and other practitioners. These advancements enable experts in their fields to appraise and evaluate the behavior of physical, chemical, and biological systems of interest.

SCOREC research is focused on the development of the technologies necessary to enable simulation-based engineering. Simulation-based engineering will introduce a new paradigm in which all interacting scales important to the behavior of materials, devices, and systems are accurately modeled and accounted for in the design of optimized products and processes. SCOREC research includes the development of adaptive methods for reliable simulations, methods to do all computation on massively parallel computers, multiscale computational methods and interoperable technologies that will speed simulation system development. Application areas for simulation technologies being developed include fluid mechanics, solid mechanics, electromagnetics, nanomaterials, and nanoelectronics. As part of this research SCOREC partners with universities, national laboratories and industry on the construction of simulation systems for specific applications in multiple areas. SCOREC actively transitions the simulation technologies developed to industrial practice and commercialization by software companies.


**Senior Research Associate:** M. Bloomfield

**Research Associate:** S. Seol

**Postdoctoral Research Associates:** L. Fovarque, R. Molecke

**Computational Scientist:** C. Smith

**Technical and Administrative Staff:** M. Verville, T. Wickberg
Student Life

Rensselaer helps educate “leaders of tomorrow” by providing a robust set of student life programs and services designed to:

• facilitate academic success
• offer education and practice in leadership and followership
• encourage fitness for a lifetime of growth
• connect students to careers and the world of work
• build maturity, an appreciation of cultural diversity and expression, and a set of personal and professional goals and values.

Dean of Students Office

Dean of Students: Mark Smith

The mission of the Dean of Students Office (DOSO) is to support and assist students in the achievement of personal and academic success with an emphasis on student development, advocacy, rights and responsibilities, safety, and liability. The services and initiatives of this office include counseling, advising, and referral information; policy development and implementation.

Office of Minority Student Affairs

The Office of Minority Student Affairs (OMSA) provides support services — academic, personal, financial, and career — to underrepresented groups in the sciences, technology, and engineering professions. Underrepresented groups, as defined by Rensselaer, include African American, Latino, Native American, and Higher Education Opportunity Program students. Support services focus on facilitating with recruitment, enrollment, retention, graduation, graduate school, and entry into professional careers. The initiatives of this office include programs and services for pre-college, undergraduate, and graduate students.

International Services for Students and Scholars

International Services for Students and Scholars (ISSS) provides educational programs and consulting, arrival information, orientation programs, counseling and advising, and immigration information for Rensselaer’s international community. ISSS also serves as liaison to government agencies, sponsors, and other campus offices. All Rensselaer students and exchange visitors who are not United States citizens or permanent residents must register with ISSS.

Disability Services for Students

Disability Services for Students (DSS) provides support services and referral information to current or potential Rensselaer students with disabilities. This service assists students in achieving access to the academic, social, and cultural programs offered on campus. Services are available to students whose disabilities may be physical/orthopedic, psychiatric, sensory (hearing, vision), or learning-related (including dyslexia, attention deficit, traumatic brain injury).

Student Conduct

Regulations governing student conduct and a statement of student rights and responsibilities are contained in The Rensselaer Handbook of Student Rights and Responsibilities. These policies are intended to help maintain an atmosphere conducive to learning and personal growth and to make the process of education positive and successful for all members of the community. Each student is expected to obtain a copy of the current handbook and to know its contents. For more information, visit www.rpi.edu/dept/doso/2010-2012RPIStuden
tHandbook.pdf.

Student Experience Office

Assistant Vice President: Lisa Trahan

The Student Experience office provides students with resources and programming designed to assist them during their college years. Focus areas include academic and personal success, orientation and transition, as well as experiential opportunities. Staff members are highly involved in academic intervention including the electronic warning system which is designed to encourage students who may be experiencing academic difficulties to utilize academic support services. Class Deans are responsible for the specific and individualized support of a cohort of students. Additionally, the Student Experience office manages the administrative operations of excused absences, leaves, withdrawals, and re-admissions as well as coordination of the Information and Personal Assistance Center (IPAC).

Office of the First-Year Experience

The Office hosts a (FYE) comprehensive orientation program offerings include Student Orientation (SO) and Navigating Rensselaer & Beyond (NRB), a highly programmed robust immersion designed for students to experience first-hand what Rensselaer and the surrounding community have to offer. Both programs are designed to facilitate a smooth transition to life at Rensselaer, while building relationships between new and upper-class students, faculty and staff, and the surrounding community. Programs continue throughout students’ first year to address academic and transitional needs. FYE’s in-depth communication tools provide students
with important dates to remember and information about upcoming programs of interest, student leadership opportunities, and important academic deadlines. FYE also provides support to students and their families on a walk-in, email, and phone basis.

**Parent and Family Programs** Parents and families play an integral role in the lives of Rensselaer students. The Student Experience office coordinates parents and family programming, including the Parents of Rensselaer association, the Parents Council and a rich Rensselaer tradition, Family Weekend. Parents and families of all Rensselaer students are encouraged to take part in the programs and services offered. In addition, parents and family members are invited to register for email newsletters, participate in discount programs, and contact staff at any time if a question or concern arises.

**Orientation Fee** All entering first-year and transfer students will be charged for the opportunity to attend programs held during the summer and/or before fall or spring semester for overall orientation, academic advisement, and course registration. Fees are $175 for first-year, freshman, fall-admitted students, and $100 for spring-admitted first-year, freshman students, and all transfer students. This fee is non-refundable except where withdrawal is made prior to the fall Final Registration date for fall-admitted students or prior to spring Final Registration date for spring-admitted students.

**Center for Career and Professional Development**

**Associate Director:** Dawn Cairns-Weaver

**Center for Career and Professional Development Home Page:** [www.rpi.edu/dept/cdc](http://www.rpi.edu/dept/cdc)

The Center for Career and Professional Development (CCPD) helps students develop key professional development competencies throughout their undergraduate experience at Rensselaer. The CCPD offers comprehensive career services, including on-campus recruiting and job postings via JobLink, their online job-posting and recruiting system; a spring career fair; full-time, co-op, and summer internship opportunities; career days and employer information sessions; career counseling and assessments by appointment; career and professional development workshops and special programs; daily walk-in hours; assistance with applying to graduate or professional school; and a nationally award winning Sophomore Career Experience. In 2011-2012, over 3,000 students utilized the CCPD for various career and professional development services.

Within six months of graduation, approximately 75% of the graduates reported future plans to the CCPD that included full-time employment, graduate/professional school, or the military. Top employers of the Class of 2012 graduates included: United Technologies Corporation, GE, GlobalFoundries, Cisco Systems, FactSet Research Systems, General Dynamics, Oracle, Lockheed Martin, RBC Bearings The Boeing Company, and Booz Allen Hamilton.

**Cooperative Education Program** Rensselaer’s optional co-op program, which is open to both undergraduate and graduate students, provides an excellent vehicle for students to gain critically needed work experience while still in college. More than 300 students actively participated in the co-op program for 2011-2012, working for leading employers in the U.S. and abroad. Top co-op employers for 2011-2012 included: General Electric, United Technologies Corporation, Hasbro, IBM, Energizer, Cisco, NASA, Stryker Orthopaedics, Johnson & Johnson, Apple, Bristol-Myers Squibb, Vicor, Philips, Deutsche Bank, Intel, Honda, and PepsiCo, in addition to many other companies and organizations. The vast majority of students find their co-op positions through the Center for Career and Professional Development. Undergraduate students are required to work a summer and a semester, and usually work January through August or June through December. Graduate students may work during one of the same time periods or during summer only.

**Athletics**

**Director:** Jim Knowlton

**Rensselaer Department of Athletics Mission Statement:**

The Rensselaer Athletics Department provides broad-based opportunities to enhance the overall student-athlete experience through high-level intercollegiate and recreational competition that emphasizes superior sportsmanship and the pursuit of excellence while winning championships. Creating an atmosphere that encourages personal growth while balancing academic and athletic excellence is of highest importance. Essential to the team is the development of core values in a diverse and equitable environment while promoting positive, life-long contributions to the Rensselaer community and beyond.

**Intercollegiate Sports** Rensselaer fields intercollegiate teams in 23 sports:

- **Baseball** Karl Steffen, head coach
- **Men’s Basketball** Mike Griffin, head coach
- **Women’s Basketball** John Greene, head coach
• Men’s and Women’s Cross-Country John Lynch, head coach
• Field Hockey Bridget LaNoir, head coach
• Football Ralph Isernia, head coach
• Men’s Golf Miles Nolan, head coach
• Men’s Ice Hockey Seth Appert, head coach
• Women’s Ice Hockey John Burke, head coach
• Men’s Lacrosse Jim Townsend, head coach
• Women’s Lacrosse Leslie DeLano, head coach
• Men’s Soccer Adam Clinton, head coach
• Softball Amber Maisonet, head coach
• Men’s and Women’s Swimming Shannon O’Brien, head coach
• Men’s Tennis Jon Satkowski, head coach
• Women’s Tennis Erica Hollot, head coach
• Men’s Indoor and Outdoor Track Colin Tory, head coach
• Women’s Indoor and Outdoor Track Colin Tory, head coach
• Women’s Soccer Cord Farmer, head coach

The men’s and women’s hockey teams compete at the Division I level and in ECAC Hockey. The remaining teams play in Division III. In three sports, Rensselaer also fields junior varsity teams. Rensselaer is a member of the NCAA, the ECAC, and the Liberty League.

The department trains and employs student trainers, lifeguards, and equipment room attendants. Several varsity teams sponsor student managers that assist in all matters of team operations.

Athletic Clubs Among the more than 160 clubs sponsored by the Rensselaer Union include Abada Capoeira, Aikido Karate, Archery, Badminton, Ballroom Dance, Cheerleading, Chung Do Kwan, Crew, Cricket, Cycling, Equestrian, Fencing, Ishrinyu Karate, Judo, Juggling and Unicycling, Kendo Outing, Racquetball, Rifle Marksmanship Rugby, Sailing, Scuba, Ski Club and Team, Squash, Table Tennis, Tae Kwon Do, Tennis, Ultimate Frisbee, Volleyball, Water Polo, and Wrestling.

Intramural and Recreational Program An extensive intramural athletic program offers competition in 24 sports: baseball, basketball, billiards, golf, gym hockey, ice hockey, indoor soccer, soccer, softball, swimming, tennis, flag football, track, badminton, aerobics, wallyball, wiffleball, dodge ball, and volleyball. Two intramural leagues are subdivided into as many divisions as necessary to accommodate all who are interested and to provide a level of competition commensurate with abilities. Recreational opportunities of all descriptions, either planned or unstructured, are available to all students.

Facilities The East Campus Athletic Village opened on October 3, 2009. One of the most extensive athletic construction projects in the institute’s history, the complex features a multipurpose lighted stadium with field turf and seating for 5,200 along with a 1,200 seat basketball arena. The facility features a 5,000 square foot strength and conditioning center connecting to a professional-caliber sports medicine suite, and within the arena are offices for athletics administrators and coaches, numerous meeting spaces, a new Athletics Hall of Fame, a pro shop, and a cafe.

The Houston Field House is the current home of Rensselaer’s Division I Men’s and Women’s hockey teams. Seating more than 4,800 fans, the Field House features six locker rooms, numerous offices, and several meeting spaces. Since opening in 1949, the building has undergone a number of renovations. A recent update took place during the 2008-2009 season when new locker rooms with spacious lounges and study areas were constructed. Additionally, a new equipment room, athletic training suite and video room were also completed. The second phase of that project featured a new look to the front facade of the arena and coaches offices and was completed during the 2010-2011 season.

The Alumni Sports & Recreation Center (AS&RC) houses the Robison Gymnasium, which has an indoor track. Also included are basketball, volleyball, and tennis courts on a resilient surface as well as locker facilities. Home to the Rensselaer men’s and women’s swimming and diving teams, the Robison Pool features eight lanes for competitive swimming. Additionally, the complex has multiple three-meter and one-meter diving boards. The Mueller Center, which adjoins the AS&RC, opened in 2000 and features cardiovascular and weight lifting equipment as well as space for aerobic fitness activities.
The '87 Gymnasium contains two general purpose gymnasiums, an indoor track, and seven four-wall combination handball and squash courts.

The home field for the Rensselaer softball team, Doris Robison Field, features team dugouts, a press box, and multiple areas for fan seating. Previously known as the 17th Street Field, Robison Field is home to the Rensselaer baseball team. Located on the corner of 17th Street and Eagle Street, off main campus and just north of Samaritan Hospital, it is one of the top fields in the state of New York.

The Ned Harkness Field and Track is a synthetic turf field and track which opened in 1994. Dedicated to the memory of former RPI men's hockey and lacrosse coach, Ned Harkness, the complex is home to the Rensselaer field hockey and men's and women's track and field teams.

Renwyck Field is home to the Rensselaer men's and women's soccer and women's lacrosse programs. The field was redone and laid with a new synthetic surface in the spring of 2009 as part of the first phase of the East Campus Athletic Village.

Home to the men's and women's tennis programs, Sharps Courts features six courts for varsity, club, and recreational use.

The Rensselaer Union

**Director:** Joe Cassidy

Every enrolled activity fee-paying student is a member of the Rensselaer Union, a self-supporting and a self-governing body that controls, finances, and organizes student activities.

The Union recognizes over 200 service, media, religious, performing and visual arts, multicultural, athletic, and extracurricular clubs and organizations. The Union serves as a partner in intramurals and intercollegiate athletics, providing operating budgets for all varsity programs. In addition, the Union manages and develops programs for the Mueller Center. Students are also responsible for the business operations of the Union, including the University Bookstore, a convenience food store, Post Office substation, a full-service credit union, and a number of other retail food operations. The Union, which founded the Archer Center for Student Leadership Development, continues to fund those programs that support leadership development for students outside the classroom.

Student leaders at Rensselaer are elected each spring during GM WEEK, which is the all-campus student election. The offices of Grand Marshal, established in 1866, and President of the Union, established in 1891, are the two most responsible positions. An Executive Board of students makes major budget decisions for the Union. The Student Senate is the chief legislative body for student government and draws representation from the entire student body.

The Archer Center for Student Leadership Development

**Director:** Linda McCloskey

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Religious Affairs

**Coordinator:** Edward Kacerguis

Rensselaer has a combination of resident and part-time chaplains who represent major faiths and work with the appropriate student organizations: the Rensselaer Christian Association, B.A.S.I.C., the Rensselaer Newman Student Fellowship, Hillel, and the Islamic Student Organization. All chaplains are available for personal counseling regardless of the beliefs of the individual.
The Rensselaer Newman Foundation and the Catholic Chaplaincy offer all the services of the usual parish and operate the Chapel and Cultural Center (C+CC). The Protestant Chaplain (who works with the Troy Area United Ministries), the local rabbis, and an imam on campus seek to involve students in the life of the local churches, synagogues, and mosques.

The Catholic Chaplains conduct mass daily and four times on weekends when classes are in session, and the Protestant Chaplain holds services on nights chosen by the students. The Rensselaer Christian Association gathers each Friday for song, prayer, and sharing, and in small groups daily. The Rensselaer Newman Student Fellowship organizes varied activities and speakers. Hillel is a focal point for the Jewish student community, gathering for their activities throughout the year. The Islamic students meet throughout the day for prayer as well as on each Friday for Sabbath. A number of churches, synagogues, and mosques in the area welcome students to their communities.

**Residence Life**

**Dean:** Todd H. Schill

Residence Life is composed of the Residential Commons, the Greek Commons, and the Off Campus Commons. Our focus is to provide support and services for all Rensselaer Students.

The Residential Commons focus is to provide clean, comfortable, and well-maintained residence halls and apartments on campus where residents can thrive academically and socially. Each community on campus has a special identity, fostered by live-in professional staff and student staff through programming and in-hall leadership opportunities. The Resident Student Association is a platform to gain more leadership regarding the development of Residential Commons initiatives.

The Greek Commons focus is to provide counseling, advising, and program development for individual social fraternities and sororities, as well as advising the Interfraternity and Panhellenic Councils. In addition, the Greek Commons office coordinates educational programming, reviews and approves applications for recognition, is involved in policy development and implementation, and is committed to positive alumni and community relations.

Off-Campus Commons focus is to provide support for students living in accommodations off campus. Currently in development, the services offered will specifically address the unique needs of these students. Off-campus students play a vital role as both students and ambassadors to the greater Troy Community. The Off-Campus office will assist students with resources regarding the many aspects of renting an apartment, being a good tenant, citizen, and neighbor, and being an engaged and active member of the RPI community.

With all of the Commons involved, Residence Life strives to build a community that values the potential of each individual and encourages students to broaden their perspectives, enhance personal growth, and prepare for life beyond Rensselaer. With CLASS (Clustered Learning, Advocacy, and Support for Students), Rensselaer aims to transform the student experience by elevating the quality of support for students throughout the undergraduate years.

**Rensselaer Dining Services**

**Resident District Manager:** Timothy MacTurk

Rensselaer Dining Services, managed by Sodexo Campus Services, offers an innovative dining program designed to meet the diverse dining needs of the Rensselaer community. With four “all you care to eat” facilities, eight retail outlets and two convenience stores, the dining team caters to the need for convenience and flexibility, providing a variety of menu choices, hours of operation and meal plans. The program is designed to deliver fresh, healthy, high quality food.

Students with special dietary needs for religious, health, or personal reasons should make arrangements to meet with dining services so that the needs can be met. Dining Services also offers “Simply to Go” meals within Commons and Russell Sage Dining Hall to support students that do not have enough time to eat a meal within the facility.

For more information, refer to our Web site at [http://rpihospitalityservices.com/](http://rpihospitalityservices.com/).

**Student Health Center**

**Director:** Leslie Lawrence, M.D.

The Student Health Center is a comprehensive, nationally accredited, physician-directed program providing outpatient health care, mental health counseling, and health promotion services. Health care services include primary and urgent care, referrals to specialists, as well as gynecological and allergy clinics. Counseling services include individual counseling sessions and group workshops for personal and academic adjustment problems. Confidentiality is strictly maintained except when a student’s behavior presents a clear and present danger to the student or to others.
The Student Health Center is fully certified by the Accreditation Association for Ambulatory Health Care (AAAHC). The AAAHC is an independent national organization that evaluates the quality of care at ambulatory centers such as outpatient surgery centers, clinics, and college health centers. Rensselaer’s commitment to seek and maintain AAAHC certification provides assurance of the quality of patient care and the appropriate organizational framework for providing care.

Located on the Troy campus, the Gallagher Student Health Center is open Monday through Friday from 8:30 a.m. to 5 p.m. and from 10 a.m. to 1:30 p.m. on weekends during the academic semesters. Summer session and vacation hours are Monday through Friday from 8 a.m. to 4:30 p.m. A 160-bed community hospital with a 24-hour emergency department is located two blocks from the campus.

All matriculated students pay a Health Center Fee that provides access to the Student Health Center during each regular semester (see Tuition and Fees section). This is a mandatory fee that cannot be waived. Coverage for summer sessions is included in the spring semester fee.

Rensselaer students are required to have adequate health insurance. The Rensselaer Student Health Insurance Plan provides a low-cost plan that includes nationwide year-round coverage at a very reasonable cost (see Tuition and Fees section). This insurance plan, together with the services of the Student Health Center, provides seamless coverage for students while at school. The plan also meets J-1 visa requirements. Dependent coverage is available at reasonable cost. A student, who has equivalent health insurance that provides non-urgent coverage in Troy, may request a waiver of the insurance fee.

All students, including part-time students, must submit a medical history and immunization information to the Student Health Center. Students must show adequate evidence of meeting Rensselaer and New York pre-matriculation immunization and tuberculosis screening requirements.

Office of the Registrar

Registrar: Sharon L. Kunkel

The office provides a wide range of services to faculty, students, alumni, and staff. In addition to maintaining the official academic record for all current and former students, the office coordinates registration; schedules classrooms and final exams; provides transcripts, verifies enrollment and degrees; certifies Veteran’s benefits; oversees the degree clearance process and issues diplomas; compiles and distributes the official enrollment and degree statistics. The office is committed to providing quality service, maintaining the integrity of academic records, and protecting students’ right to privacy.
Admissions

Undergraduate Admissions

Director, Undergraduate Admissions: Karen S. Long

Office of Admissions
Rensselaer Polytechnic Institute
110 8th Street
Troy, N.Y. 12180-3590
Phone: (518) 276-6216
E-mail: admissions@rpi.edu
World Wide Web: http://admissions.rpi.edu

Admissions information is subject to change from year to year. For the most up-to-date information on requirements, application process, deadlines, testing, and other relevant topics, please refer to the admissions pages on the Web at http://admissions.rpi.edu.

Rensselaer accepts the Common Application, the Universal College Application, or the Candidate’s Choice Application and gives equal consideration to all. If you apply via the Universal College Application, Rensselaer also requires you to submit the appropriate Supplemental Form.

Rensselaer admits qualified students without regard to gender, sexual orientation, gender expression or identity, age, race, color, religion, national or ethnic origin, marital status, or disability.

Freshman Admission

Admission to Rensselaer is competitive. The Committee on Admissions, in evaluating the qualifications of each applicant, pays particular attention to (1) academic performance throughout secondary school; (2) results of the College Entrance Examination Board (SAT) or results of the ACT Assessment (ACT); (3) the recommendation from the applicant’s school; and (4) character and extracurricular achievements.

Students interested in Rensselaer have the option of applying to one of the five schools or as undeclared candidates. Architecture and Electronic Arts applicants are required to submit a creative portfolio. Games and Simulation Arts and Sciences and Electronic Media Arts and Communication applicants are strongly encouraged to submit a creative portfolio.

Applications for freshman admission should be addressed to Rensselaer Admissions and filed by January 15 of the year in which the applicant expects to begin his or her college program. The nonrefundable application processing fee for all applications submitted is $70.

Accelerated Programs Applicants to the physician-scientist and law programs must apply by November 1. Special requirements apply to this process. Please contact the Office of Admissions for further detail, or access Rensselaer’s undergraduate Web site under the appropriate heading.

Early Decision Rensselaer offers a binding early decision opportunity to students who have decided definitely that Rensselaer is their first choice. An Early Decision application must be received by November 1 (Early Decision 1) or December 15 (Early Decision 2) of the candidate’s senior year in secondary school. Early Decision is not available to students applying to the accelerated programs.

Early Admission Rensselaer considers candidates who have completed all admission requirements and who wish to enter the university after the junior year of high school. Early Admission is not possible for the accelerated programs in medicine, law, or for the School of Architecture.

January Admission Rensselaer does enroll students beginning in January. A full range of freshman courses is available during the spring semester, and the midyear entrant may pursue a degree through the traditional eight-semester timetable or accelerate through summer work. January admission is not possible for the accelerated programs in medicine, law, the School of Architecture, or for the program in Games and Simulation Arts and Sciences (GSAS).
Applying to Rensselaer

Academic Preparation

All applications are reviewed individually by the Admissions Committee. It is important to note that some differences in preparation and academic background may be considered. The applicants who are best suited for Rensselaer will have completed four years of English, four years of mathematics through pre-calculus, three years of science including chemistry and physics, and two years of social studies and/or history. Additionally, the admissions committee pays particular attention to candidates who demonstrate qualities and talents that will contribute to the richness of the Rensselaer community.

Note to international applicants: Official transcripts must be translated into English. The international financial statement must be completed and mailed with the application.

Standardized Test Requirements

- SAT or ACT with writing
- SAT Subject Tests in Math (Level 1 or 2) and Science (biology, chemistry, or physics) for accelerated program applicants only (or ACT in lieu of SAT and SAT Subject Tests).
- Test of English as a Foreign Language (TOEFL) (international applicants only). Applicants must have a minimum score of 570 on the paper-based test (PBT), a minimum score of 230 on the computer-based test (CBT), or a minimum of 88 on the Internet-based test (iBT).

Portfolio Requirements

- Architecture and Electronic Arts candidates are required to submit a creative portfolio online at https://rpi.slideroom.com/.
- Games and Simulation Arts and Sciences and Electronic Media Arts and Communication candidates may submit a creative portfolio online at https://rpi.slideroom.com/ or on CD-Rom.

Entrance Tests

Candidates for freshman entrance are expected to take the College Entrance Examination Board’s SAT or the ACT with writing. Students applying for January 2015 should contact the Admissions Office.

These examinations may be taken at the student’s convenience, but not later than the December test date for ACT or the January test date for College Board sponsored tests in the senior year. Early Decision applicants must complete the tests by the November test date. The Admissions Committee cannot assure full consideration if tests are taken later than these dates. The student is responsible for having all test results sent directly to Rensselaer by the testing service.

Note: Please include Rensselaer’s institutional code of 2757 for the SAT and TOEFL exams, and include the college code of 2866 for the ACT Assessment. This will ensure that your scores arrive at Rensselaer’s Admissions Office.

Accelerated Program Requirements

The SAT and SAT Subject Tests or the ACT with writing will be accepted in fulfillment of test requirements for students applying for the seven-year accelerated physician-scientist and six-year law programs. These students must complete the tests by the December test date. The SAT Subject Tests are required in Mathematics (Level 1C or 2C) and Science (biology, chemistry, or physics).

Application Fee and Admission Deposit

A non-refundable fee of $70 is required with every application to a baccalaureate program at Rensselaer. A candidate who accepts Rensselaer’s offer of admission reserves his or her place in the class by making a nonrefundable $500 deposit by May 1. These funds are credited toward the student’s first semester charges. If the student does not enroll, the deposit is forfeited.

Undergraduate Transfer Admission/Special Programs

Transfer students are an important part of the university community. Each year, Rensselaer enrolls more than 200 transfer students from accredited two-and four-year colleges in the United States and many other countries. Rensselaer accepts transfer students for all programs except the accelerated programs in medicine and law.

To be considered for transfer admission, a student should have earned at least 12 credit hours in the appropriate course work at another accredited college or university. Admissions requirements vary across programs.

Transfer applicants should submit an application by June 1 for fall entrance, November 1 for spring entrance, and by March 1 for entrance to the School of Architecture. In addition to the application form, students should submit a non-refundable $70 application fee, official transcripts from all previously attended colleges, and a faculty letter of recommendation from the major department. Applicants to the School of Architecture, Electronic Arts, and Games and Simulation Arts and Sciences programs must also submit a creative portfolio with their applications. Students with less than four semesters of full-time college work should also submit a complete high school record. A high school record consists of an official transcript, results of standardized tests, and a recommendation from a high school official.
Transfer admissions decisions are made on a rolling basis. Files are reviewed when they become complete and notification is sent to the student. Once a student has been admitted, the faculty will review all previous course work to determine transfer of credit. Each student will be mailed an evaluation of all previous course work. Students must send a syllabus or catalog description for all previous course work.

In order to earn a Rensselaer undergraduate degree, a student must be registered full-time for a minimum of four semesters and must complete at least 64 credits at Rensselaer, all of which will be applied to the baccalaureate degree. Two semesters of part-time study at Rensselaer will be considered equivalent to one semester of full-time study. If a transfer student elects to study abroad in a program not affiliated with the Institute, no more than 16 credits may be transferred from that program. These credits will not be considered in the 64 credits which must be completed at Rensselaer. Students who participate in study-abroad programs that are affiliated with the Institute can count those transfer credits toward the 64 credits taken at Rensselaer.

The Institute requires a degree candidate to earn the last 30 credits in courses completed on this campus or through a program formally recognized by the Institute. Transfer courses are limited to two courses or eight credits counting towards the student's last 30 credits and require the approval of the director of the Advising and Learning Assistance Center.

Rensselaer offers transfer students a wide range of aid options and a staff of financial aid professionals who will work with them to devise the best solutions. Students interested in federal and/or Rensselaer need-based financial aid are required to complete the College Scholarship Services (CSS) Profile application and the Free Application for Federal Student Aid (FAFSA).

For further information on our financial aid programs, please contact the Office of Financial Aid at (518) 276-6813, or e-mail them at finaid@rpi.edu.

Two-Year College Affiliated Program Students graduating with an A.S. degree from a two-year or community college affiliated with Rensselaer may transfer at the end of two years with full junior status if accepted for admission to Rensselaer.

(The schools listed below have agreements for programs in the School of Engineering. Some schools also have agreements for programs in Science (SCI), Management (MGT), and Humanities, Arts, and Social Sciences (HASS).)

Alfred State College, N.Y.  
Anne Arundel Community College, Md. (SCI)  
Berkshire Community College, Mass. (MGT)  
Broome Community College, N.Y.  
California Community College System, all 107 campuses (SCI, MGT)  
Canton College of Technology, N.Y.  
Cayuga County Community College, N.Y.  
College of Technology at Delhi, N.Y.  
Corning Community College, N.Y. (SCI, MGT, HASS)  
County College of Morris, N.J. (SCI)  
Dutchess Community College, N.Y.  
Erie Community College, N.Y. (MGT)  
Fulton-Montgomery Community College, N.Y.  
Greenfield Community College, Mass.  
Holyoke Community College, Mass. (MGT)  
Hudson Valley Community College, N.Y. (SCI, MGT, HASS)  
Jamestown Community College, N.Y.  
Jefferson Community College, N.Y.  
Miami-Dade Community College, Fla.  
Mohawk Valley Community College, N.Y. (SCI, MGT, HASS)

Monroe Community College, N.Y.  
Montgomery Community College, Md. (SCI)  
Morrisville State College, N.Y.  
Nassau Community College, N.Y.  
Niagara Community College, N.Y.  
North Shore Community College, Conn.  
Onondaga Community College, N.Y.  
Orange County Community College, N.Y.  
Rockland Community College, N.Y.  
St. Louis Community College, Mo.  
Springfield Tech Community College, Mass.  
Suffolk County Community College, N.Y.  
SUNY Adirondack, N.Y.  
Tompkins-Cortland Community College, N.Y.  
Ulster Community College, N.Y.  
Westchester Community College, N.Y.  
Program in Science only:

Schenectady County Community College, N.Y.

Four-Year Affiliated College Engineering Program The Affiliated College Program combines the resources of Rensselaer and a select group of affiliated liberal arts colleges and universities. This program is designed especially for students who decide during their college careers to enter the field of engineering. Students transfer to Rensselaer after completing three years of liberal arts study, including extensive and advanced course work in mathematics and science. After two or three years of concentrated study in engineering and applied science at Rensselaer, these students receive degrees from both the liberal arts college and Rensselaer.

Interested students apply for the program during the fall of their junior year on the recommendation of the liberal arts college’s pre-engineering committee. Applicants may submit either the Common Application or the Universal College Application for transfer. An official college transcript is required in addition to a letter of recommendation from the liberal arts college’s pre-engineering committee. Most students accepted for the Affiliated College Program have achieved at least a B average with grades of A or B in calculus, calculus-based physics, and chemistry courses.
A 3-2 program is offered in which a student completes three years (through the junior year) at the liberal arts college, then transfers to Rensselaer’s School of Engineering. Two years of carefully planned study complete the requirements for the bachelor’s program of the liberal arts college and the B.S. degree with a major in engineering at Rensselaer.

Institutions participating in this program are:

- Amherst College, Mass.
- Atlanta University Center, Ga.: Clark Atlanta University, Morehouse College, Spelman College
- Bates College, Maine
- Beloit College, Wis.
- Benedict College, S.C.
- The Claremont Colleges, Calif.: Claremont-McKenna College, Pitzer College, Scripps College
- Colgate University, N.Y.
- College of William & Mary, Va.
- The College of Saint Rose, N.Y.
- Colorado College, Colo.
- Denison University, Ohio
- Dickinson College, Penn.
- Earlham College, Ind.
- Fairfield University, Conn.
- Franklin & Marshall College, Penn.
- Gettysburg College, Penn.
- Grinnell College, Iowa
- Hamilton College, N.Y.
- Hobart and William Smith Colleges, N.Y.
- Hope College, Mich.
- Ithaca College, N.Y.
- Kenyon College, Ohio
- Knox College, Ill.
- Lawrence University, Wis.
- Lincoln University, Penn.
- Middlebury College, Vt.
- Ohio Wesleyan University, Ohio
- Pace University, N.Y., all campuses
- Reed College, Ore.
- Ripon College, Wis.
- Roberts Wesleyan College, N.Y.
- Russell Sage College, N.Y.
- St. John Fisher College, N.Y.
- St. Lawrence University, N.Y.
- Siena College, N.Y.
- State University of New York College at Fredonia, N.Y.
- State University of New York College at Oneonta, N.Y.
- The University at Albany, N.Y.
- University of the South, Tenn.
- Washington & Lee University, Va.

**Part-Time Matriculated Undergraduates**

Rensselaer Polytechnic Institute accepts a limited number of part-time matriculated undergraduate students. Students seeking admission must meet the same academic standards (SAT scores and previous scholastic records) as full-time entering transfer students and freshmen. Prospective part-time students from outside the Institute and currently enrolled non-matriculated students should apply to the Office of Admissions.

Part-time undergraduates will be assigned an academic adviser in the department of their major and must select courses from the regular day or evening course offerings at the Institute. Part-time students must pay a continuing registration fee and are subject to changing requirements given in the Rensselaer Catalog.

**Part-Time Non-degree Students**

Rensselaer welcomes students who wish to take one or more courses on a non-matriculated basis for personal enrichment or professional development. Such students should contact the Office of Admissions in order to complete the necessary application procedure at least one week prior to the last day of registration before each semester. An official transcript of former academic work is required. The admission decision is based on the student’s demonstrated academic ability, the appropriateness of the course(s) requested, and the availability of space in the course(s). Non-matriculated students receive transcripts and full academic credit for courses successfully completed. However, only 12 hours of such credit may be applied toward a Rensselaer degree should the student later apply and be accepted for degree-seeking status. Rensselaer also accepts a limited number of qualified secondary school students who wish to enroll in appropriate courses in conjunction with their secondary school programs. All course work receives full credit, which may be applied toward degrees at Rensselaer or other universities. For application information please visit [http://admissions.rpi.edu](http://admissions.rpi.edu).
International Students

More than 1,000 international students representing 62 nations are enrolled at Rensselaer. Through the Offices of Admissions and International Services for Students and Scholars, Rensselaer provides special services to ensure that international students make a seamless entrance into Rensselaer’s academic community and are geared to success in their endeavors. Freshman and transfer international applicants should begin planning at least a year in advance of application deadlines.

Freshman International Applicants Submit a completed application with official copies of all academic transcripts for secondary school, with English translations; official results of SAT exam; and results of the TOEFL. For students who will study on an F-1 or J-1 visa, evidence of financial support to cover educational and living expenses is also required. Please also refer to the Freshman Admission section on general admission, standardized test, and portfolio requirements.

Transfer International Applicants Submit a completed application with official copies of all academic transcripts with English translations; results of the TOEFL; and a letter of recommendation from a college official. Students with less than four semesters of post-secondary study must also submit official transcripts of secondary school studies and SAT results. For students who will study on an F-1 or J-1 visa, evidence of financial support to cover educational and living expenses is also required. Architecture, Electronic Arts, and Games and Simulation Arts and Sciences applicants are required to submit a portfolio.

English Language Requirement There are several options for international students to demonstrate their English language proficiency. These options include achieving minimum scores on one of the following testing options: 580 (SAT Critical Reading); 88 (TOEFL iBT); 230 (TOEFL CBT); 570 (TOEFL PBT); or 7.0 (IELTS).

Financial Aid With the exception of Canadian citizens, Rensselaer does not offer need-based financial assistance to international students.

Graduate Admissions

Director, Graduate Admissions: Christina Murray

Contacting Rensselaer Admissions
Information and application forms are available by contacting:

Rensselaer Admissions
Graduate Programs
Rensselaer Polytechnic Institute
110 8th Street
Troy, New York 12180-3590
Phone: (518) 276-6216
E-mail: gradadmissions@rpi.edu
http://admissions.rpi.edu/graduate

Admission to all graduate courses and degree programs at Rensselaer is based on the electronic submission of a formal and competitive application. The applicant’s prior academic records as well as references and test scores, where required, are examined for evidence of ability to meet Rensselaer’s graduate standards and degree requirements as outlined under individual program and course description sections of this catalog.

For admission to graduate studies, a student must have a U.S. bachelor’s degree or the equivalent of a U.S. bachelor’s degree prior to enrollment. Degree-seeking applicants may sometimes be admitted with conditions on continued enrollment. In these cases, continued enrollment is dependent upon the satisfactory fulfillment of the conditions. Rensselaer admits qualified students without regard to gender, sexual orientation, age, race, color, religion, national or ethnic origin, marital status, or disability.

Graduate Student Classification

Full-Time Degree-Seeking Status The applicant who intends to complete a graduate degree on a full-time basis is considered for regular, degree-seeking status. Only full-time degree-seeking graduate students are eligible for financial support from Rensselaer in the form of research or teaching assistantship or institutionally supported fellowship.

Part-Time Degree-Seeking Status Students wishing to pursue degrees on a part-time basis may do so in most departments. Admission procedures are the same as for full-time, degree-seeking applicants. This pathway is mainly for students who wish to pursue their advanced education concurrent with full-time employment or other pursuits.
Non-matriculated Status The applicant who wishes to undertake graduate course work to improve his or her knowledge in a specific area, but not follow a degree program, is considered for non-matriculated status. A minimum B average must be maintained to continue enrollment. The Rensselaer Admissions Office coordinates advisement and approvals for registration. However, should the student later apply for and be accepted into degree-seeking status, the number of credit hours taken as a non-matriculated student that can be credited toward a degree varies by department and program, usually from a low of six to a university-wide maximum of 12 credit hours. Time limit to completion of degree begins with the first course taken as a non-matriculated student and applied to the degree program.

Admission Procedures

For application forms and program information, visit http://admissions.rpi.edu/graduate/admission or contact the Rensselaer Admissions Office. Prospective applicants should indicate their preferred academic area and whether they are interested in full-time, part-time, or non-matriculated status when they inquire about admission. Applicants must submit a completed official application form and a nonrefundable $75 application fee. An applicant holding a bachelor’s degree and wishing to register for university courses as a part-time or non-matriculated student also must apply according to these procedures.

The Graduate Record Examination (GRE) is required by most departments and is strongly recommended for applicants whose prior academic records are not clearly competitive. Submission of GRE results is especially important for applicants requesting financial aid. Complete information on individual departments requiring the GRE is available with the admission application. Department-specific requirements are available in the admissions application and on-line at admissions.rpi.edu/graduate/admission.

The Graduate Management Admission Test (GMAT) is preferred of all applicants to the Lally School of Management & Technology. The Lally School also accepts the Graduate Record Examination (GRE).

Applicants whose native language is not English must submit official score reports from the Test of English as a Foreign Language (TOEFL), International English Language Testing System (IELTS), or Pearson’s Test of English (PTE). A minimum score of 230 CBT/88 iBT/570 PBT is required for the TOEFL. An IELTS score of 6.5 or higher or a PTE score of 60 or higher may be substituted for the requirement. Some departments require a higher TOEFL/IELTS/PTE score and evidence of speaking proficiency. Please see the department-specific requirements at http://admissions.rpi.edu/graduate/admission.

Reapplication for Graduate Admission

Reapplication for graduate admission is available to those applicants who applied to Rensselaer for graduate study within the past two years and can provide significant new information such as new coursework in a relevant area, improved test scores, or relevant research or publication. A student whose previous application to Rensselaer occurred more than two years ago must complete a new graduate application and submit all new documentation. Students returning from official or unofficial absence must submit a new application if the absence exceeded one year.

Dual Degrees

Many programs now offer dual degree options, especially the combination of technological master’s and the MBA degree. Please see department-specific information for dual degree opportunities. Prospective students must complete two applications for admission and each must be for a different term. The Statement of Background and Goals must clearly outline the interest in, preparation for, and intersection of the degree programs to which the student is applying. Letters of recommendation must also support the dual degree intent of the student. Two application fees are required as are two sets of supporting materials. Doctoral students who have completed the candidacy requirement for their doctoral degree and who wish to pursue a master’s degree outside of their department must have the approval of the Graduate Program Director and the Office of Graduate Education.
Co-terminal Degree Program

The co-terminal degree program allows Rensselaer undergraduates to study for a master’s degree while completing their bachelor’s degree(s) in the same or a different department. Undergraduate students wishing to pursue the co-terminal degree must complete the application process by the end of the 1st semester of the senior year. At the time of application, they must have completed 90 credits of coursework, with an overall GPA of 3.0 or above, towards their undergraduate degree (101 credits for B.Arch. students). This includes any credits received through Advanced Placement, courses in progress, or transfer from another institution. The co-terminal application is available at http://admissions.rpi.edu/graduate/admission. Specific admissions requirements (e.g. minimum GPA, test scores, recommendations, etc.) vary by department. Basic requirements include:

• Students must complete the application process with all required materials submitted to the Office of Graduate Education by the end of the 1st semester of the senior year.

• Written approval of the undergraduate academic adviser, who must verify the student’s current total accumulated credits and cumulative GPA.

• Written approval of graduate program director (GPD) or graduate admission director of the program which the student is applying.

• Approval of Dean of the Office of Graduate Education; the Office of Graduate Education will forward approved applications to Graduate Admissions for processing.
Financial Aid

Undergraduate Financial Aid

Director: Larry Chambers

Education for leadership in the technological professions requires substantial resources. As a private university, Rensselaer helps with the costs of education, laboratories and facilities, student services, and administrative support through a combination of tuition, fund raising, and endowment earnings.

While a quality education adds value well in excess of its cost, many students and families are unable to meet the cost with their own resources. Rensselaer participates in federal, state, and its own institutional aid programs. These encompass scholarships, grants, work, and loans. Rensselaer aid programs consist of merit-based, merit within need, and need-based aid programs. It is committed to partnering with students to assist in making a quality education financially possible for undergraduates and their families. All prospective freshmen and transfer students are automatically considered for Rensselaer merit-based financial aid programs.

International Students

International students cannot receive institutional aid, unless a Rensselaer Medal Award recipient or receiving a Division I Athletic Scholarship. An exception to this policy is Canadian citizens who apply for admission on or after the Fall 2012 semester shall be considered for institutional aid. For federal or state assistance, international students must be U.S. citizens or permanent residents; possess a valid alien registration receipt card; have an arrival-departure record (I-94) from the Department of Homeland Security showing a status of refugee, asylum granted, parole (I-94 confirms paroled for a minimum of one year and status has not expired), or Cuban-Haitian entrant; possess a valid temporary resident card (I-688); or have a conditional permanent resident card (I-151C).

Current and prospective students are invited to contact the Office of Financial Aid, at (518) 276-6813, or via email at finaid@rpi.edu. Additional information may be found at www.rpi.edu.

Applying for Financial Aid

Prospective first-year freshman and undergraduate transfer students apply for need-based financial aid by submitting the Free Application for Federal Student Aid (FAFSA) as well as the College Scholarship Service (CSS) Profile. These forms entitle the applicant to consideration for all financial aid administered by Rensselaer. Additional applications may be required for state financial aid programs. Returning students requesting need-based aid, must submit the FAFSA, however the CSS profile is not required. Returning students seeking summer session financial aid are required to submit the Rensselaer Summer Financial Aid Application.

CSS Profile: https://profileonline.collegeboard.com (School Code 2757)
FAFSA: www.fafsa.gov (School Code 002803)

New York State Tuition Assistance Program: www.hesc.org (School Code 0635)

PRIORITY FILING DEADLINE DATES:

<table>
<thead>
<tr>
<th>CSS Profile</th>
<th>Early Decision I/Early Decision II Applicants</th>
<th>Regular Admission Applicants</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAFSA</td>
<td>November 1 of year prior to which aid is sought</td>
<td>February 1 of year seeking aid</td>
</tr>
<tr>
<td></td>
<td>February 1 of year seeking aid</td>
<td>February 1 of year seeking aid</td>
</tr>
</tbody>
</table>

The priority deadline date for returning students is April 1 of the year the applicant is seeking aid.

Applicants who file after any of these filing deadline dates will be reviewed, but cannot be guaranteed full consideration of all aid programs.

FAFSA applications are available in mid-November but cannot be completed prior to January 1st. CSS Profile is available in mid-September. The Profile application may only be filed electronically. The FAFSA may be filed in paper or electronically. Applicants are strongly encouraged to file electronically.

It is the student’s responsibility to complete all forms or applications for aid which he or she is determined to be eligible unless declining the aid source being offered. A student selected for verification by the Department of Education and/or Rensselaer is required to submit additional information which may include federal tax transcripts and other supporting documentation.
Eligibility for Rensselaer need-based financial aid is determined by taking the Cost of Attendance minus the Expected Family Contribution (EFC) as determined by the Institute. An EFC is determined by evaluating family income and assets. Families are expected to utilize a combination of income, assets, and borrowing ability to fund educational costs. When determining the EFC for Rensselaer awards, we look to all information as reported on the CSS Profile and/or FAFSA applications. We do not consider parents attending college nor siblings attending graduate study. For Canadian citizens, only the CSS Profile application is required to determine eligibility for Rensselaer need-based financial aid.

Students enrolled in the co-terminal program are considered undergraduate students for financial aid purposes and are instructed to file the FAFSA as a student who has not yet completed a Bachelor’s degree.

STUDENT SELF HELP – All undergraduate Rensselaer students are expected to contribute a minimum of $1750 from summer earnings when determining need-based Institute funding regardless of the federally calculated EFC.

An award of Federal Work Study employment is not a guarantee of a job. Federal Work Study offers represent the maximum a student may earn once s/he is assigned a work study position. There are a limited number of off-campus community service positions. Students may not work more than 20 hours per week while classes are in session.

Loan programs such as the Federal Direct and Perkins loan programs are liabilities that must be repaid, with interest. Repayment schedules may begin immediately or be have grace periods of six or nine months, depending on the loan program.

Cost of Attendance The total estimated expenditure for a Rensselaer undergraduate for the nine-month 2013-2014 academic year for a undergraduate student living on-campus is as follows:

<table>
<thead>
<tr>
<th>Resident Students</th>
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</thead>
<tbody>
<tr>
<td>Tuition</td>
</tr>
<tr>
<td>Fees</td>
</tr>
<tr>
<td>Room and board</td>
</tr>
<tr>
<td>Books and supplies</td>
</tr>
<tr>
<td>Personal expenses</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

In addition to the above expenses, new undergraduate students are required to have a laptop computer which may be purchased through the Institute Computer Center at an approximate expense of $1,600. New Architecture majors are required to pay approximately $1,295 for the purchase of special software through the Institute, which includes a one-time technology fee.

Updated cost information is available online at www.rpi.edu/cost.

Aid Award In making aid awards, Rensselaer’s typical approach is to award scholarship funds first and because these funds are necessarily limited, then add self-help awards (loans and work-study jobs) to help meet need. Most awards are a combination of scholarship(s), grant(s) loan(s), and/or job.

Adjustments Rensselaer evaluates parent and student IRS tax data and verifies the enrollment status of other family members in college. Awards may be adjusted when there are differences between FAFSA/Profile estimates and actual figures. If you receive aid from sources other than what is provided on your award notification, you must inform the Office of Financial Aid of these awards.

Generally, outside aid will be treated as follows:

- first, it will be used toward any unmet need in your package. Unmet need is the difference between your Estimated Family Cost to Attend Rensselaer and your Federal EFC.
- if the outside aid exceeds your unmet need, the outside aid will replace need-based federal sources (i.e. Federal Work Study, Perkins Loan, SEOG, and/or subsidized Direct Loan programs).
- finally, if there is still outside aid left, the remaining outside aid will replace existing Rensselaer need-based aid rounded up to the nearest $50 increment.
Annual Renewals

A student receiving Rensselaer merit-based awards will automatically have those awards renewed as long as he or she has not been academically dismissed and meets all other eligibility requirements. Need-based awards are renewed subject to the student continuing to demonstrate financial need as determined by the Office of Financial Aid. Students must complete the FAFSA by the priority filing deadline date to be considered for renewal of need-based awards. Rensselaer awards typically require full-time attendance, but may be prorated if a student is attending on a part-time status. Students are encouraged to meet with an Assistant Director prior to deciding to attend part-time to understand any impacts on financial aid eligibility. In addition, Rensselaer awards are not available during summer session(s), Federal and state aid programs may be utilized during the summer session(s) which may reduce annual/aggregate eligibility.

Some students may receive scholarships that are provided by the generosity of Rensselaer donors, alumni, corporations, or other friends of the Institute. Recipient selection and renewal are subject to the conditions set forth by the donor.

Generally speaking, funds from Rensselaer may only be received for a maximum of eight semesters; ten semesters for Architecture majors. Students in approved co-terminal programs may receive up to an additional two semesters of assistance. The Office of Financial Aid routinely monitors students approaching the minimum amount of credits required for graduation. Upon request, a student must provide to the Office of Financial Aid an approved academic plan from his/her academic adviser stipulating coursework required for graduation. In such instances, federal and institutional aid is only provided for coursework to meet graduation requirements.

A student who has utilized eight semesters of eligibility (10 if in Architecture or co-terminal) seeking institutional aid must appeal in writing with an academic plan from his/her adviser outlining the coursework needed for graduation.

Federal and state aid recipients are subject to the terms and conditions of those programs. Satisfactory Academic Progress (SAP), full time attendance, and aggregate limits are evaluated for renewability. Details on SAP guidelines are available at http://admissions.rpi.edu/aid/info.html. For Federal aid programs students must complete the FAFSA application annually.

Waiver of NYS Tuition Assistance Program Satisfactory Academic Progress Standards

The standards for program pursuit and satisfactory academic progress may be waived, provided a student can show fully documented medical or unusual personal circumstances. Request for a waiver of the NYS TAP standards are made to the Registrar's Office.

Additionally, under New York State education law, the president of the New York State Higher Education Services Corporation (NYSHESC) can waive the academic progress requirement of a minimum C (2.00) cumulative GPA for a student who has received two years of state-funded aid.

The student may appeal in writing; the circumstances must be specific to the issue of the student’s inability to achieve the C (2.00) cumulative GPA as of the end of a particular semester or term. The state’s language provides for a waiver of the 2.00 requirement for undue hardship based on the death of a relative of the student, personal injury or illness of the student, or other extenuating circumstances.

Use of the one-time president’s waiver does not preclude the possibility of waiver of the C (2.00) cumulative GPA requirement alone in a subsequent semester. Conversely, waiver of the C (2.00) cumulative GPA requirement alone in a term does not affect a student’s subsequent eligibility for the one-time waiver of the NYSHESC standards. Waivers of standards are granted for one semester only.

Financial Aid Awards

Rensselaer Aid Programs

To provide access to a quality education for high-quality students, Rensselaer offers substantial financial aid from its own funds. Scholarships and grants are awarded after full consideration of any of the following factors: relative financial need, academic achievement and promise, qualities of character as suggested by recommendations submitted on behalf of the student, evidence of willingness to help oneself by working, and participation in community and school activities. Students do not apply separately for these awards. If a student earns multiple Rensselaer merit scholarships prior to admission, Rensselaer will award the highest merit award for which the student is qualified, but does not combine multiple Rensselaer awards. The total Rensselaer provided scholarships or grants may not exceed tuition. Recipients of the Rensselaer Tuition Remission benefit are not eligible to receive other Rensselaer scholarships or grants. The total of all sources of grants/scholarships may not be greater than the published cost of attendance used for financial aid purposes. All Rensselaer scholarships and grants are awarded based upon full-time attendance. Less than full-time attendance may result in a reduction or elimination of awards; federal and state aid programs may also be adjusted if a student is attending less than full-time. A student is expected to meet with a staff member in the Office of Financial Aid prior to attending less than full-time to understand the implications on financial aid sources s/he is receiving.
Rensselaer Leadership Award/Rensselaer Merit Award These merit-based awards are given in recognition of an outstanding record of academic and personal achievements, a strong commitment to excellence, and illustration of intellectual curiosity. Recipients receive one of these awards for a maximum of eight semesters of full-time undergraduate study. School of Architecture or co-terminal program students may receive awards for up to 10 semesters. There is no minimum grade point average required for renewal each year.

Rensselaer Medal Award First presented in 1916, the Medal is a merit-based scholarship awarded to promising secondary school juniors who have distinguished themselves in mathematics and science. Responsibility for selecting the Medalist belongs to the faculty and staff within the participating secondary school. Recipients receive this award for a maximum of eight semesters of full-time undergraduate study. School of Architecture or co-terminal program students may receive the award for up to ten semesters. There is no minimum grade point average required for renewal each year.

2024 Bicentennial Award This award assists recipients to attain the benefit of a Rensselaer education and is supported by donations from Rensselaer alumni and friends since the inception of the Institute in 1824. All (or a portion of this award) may be replaced with other Rensselaer merit award(s) that best match a student's overall attributes and/or academic record; however the total value will be equal to the original 2024 Bicentennial Award.

Rensselaer Grant (formerly Rensselaer Alumni Scholarship) This need-based grant is awarded to students who exhibit strong academic and extracurricular achievement, and display a strong commitment to excellence. Award amounts may change if the student's demonstrated need decreases significantly. Increases in the award are subject to the availability of funds. Recipients may receive this award for a maximum of eight semesters of full-time undergraduate study. School of Architecture or co-terminal program students may receive the grant for up to 10 semesters. There is no minimum grade point average required for renewal each year.

Rensselaer Access Grant This limited need-based grant is awarded to students who demonstrate extreme financial hardship as determined by the Rensselaer Office of Financial Aid. There is no minimum grade point average required for renewal each year. Recipients may receive this award for a maximum of eight semesters of full-time undergraduate study. School of Architecture or co-terminal program students may receive the grant for up to 10 semesters.

Rensselaer Recognition Award This limited fund is provided to select students based upon a holistic view of the students' academic record, extracurricular activities, and potential for success at the Institute. It is not based on financial need. There is no minimum grade point average required for renewal each year. Recipients receive this award for a maximum of eight semesters of full-time undergraduate study. School of Architecture or co-terminal program students may receive the award for up to 10 semesters.

Rensselaer Merit Scholarship The Institute is a sponsor in the National Merit Scholarship Corporation (NMSC) program, which provides up to $2,000 to students who list Rensselaer as their first-choice institution in accordance with NMSC guidelines. This award is renewable on an annual basis for up to eight semesters. Co-terminal and Architecture students may not receive more than eight semesters of eligibility.

Rensselaer National Merit Recognition Award This award is provided to students who list Rensselaer as their first-choice institution but do not meet NMSC criteria for the maximum award. Recipients are eligible to receive up to $1,000. The combination of the Rensselaer Merit Scholarship and the Rensselaer National Merit Recognition Award cannot exceed $2,000.

Room & Board Scholarship The Room & Board Scholarship was awarded to outstanding students regardless of financial need. The scholarship provides funding to be used toward Rensselaer room costs. The award will automatically be renewed as long as the student continues to live in Rensselaer campus housing or in Greek housing that bills through the Bursar's Office and the organization has signed a Greek Commons Agreement with the Dean of Students Office. Recipients who are denied housing through the lottery process will receive one half of the scholarship for the fall term only. Students in study abroad programs or in Co-op programs are not eligible for the award for the semester(s) they do not meet eligibility requirements. This award has been discontinued and is not awarded to new students, but is renewed for those who have received this scholarship previously and who meet the renewal criteria.

ROTC Room & Board Scholarship The ROTC Room & Board Scholarship is awarded to all ROTC scholarship recipients attending on a full-time basis. The ROTC Room and Board Scholarship is equal to the average room and board allowance provided to non-ROTC students residing on-campus as determined by the Office of Financial Aid. If an ROTC student is receiving a Rensselaer merit based award, the student will receive the merit award s/he would otherwise receive or the ROTC Room and Board Scholarship, whichever is greater except as follows:

The sum of all other grants and scholarships (including ROTC Scholarships) cannot exceed the cost of attendance determined by the Office of Financial Aid. In such cases the ROTC Room and Board Scholarship and/or other Rensselaer grants and scholarships are adjusted.

RPI Athletic Grant-in-Aid The Grant-in-Aid is awarded to Division I athletes who have been recruited and selected by the ice hockey coaches. Rensselaer is Division I for men's and women's ice hockey. (Please note that Division III athletes are prohibited from receiving any financial aid that is based upon athletic participations/performance per NCAA regulation.)
Transfer Student Awards

With the exception of the Phi Theta Kappa Award, the awards listed below provide a minimum of $10,000 per academic year.

Affiliated Two-Year Community Colleges

The Award for Excellence Provided to the top student transferring into a non-engineering program from two-year affiliated colleges and universities.

The Joseph H. Smith Jr. ’45 Award This award was created for the most outstanding student in the engineering science program at the Institute’s affiliated community colleges. The award is presented to the qualifying student with the highest cumulative average.

Four-Year Affiliated Colleges and Universities

The Award for Excellence Provided to the top student transferring to a Rensselaer engineering program from each of the Institute’s four-year affiliated colleges and universities.

Two- and Four-Year Affiliated Colleges

The Garnet D. Baltimore Rensselaer Award and Scholarship for Minority Students This annual scholarship is awarded to the qualifying African American, Hispanic, or Native American student with the highest combined average in mathematics and science at each of the Institute’s two- and four-year affiliated colleges.

Phi Theta Kappa Society Scholarship Phi Theta Kappa recognizes intellectual achievement in American two-year colleges. All Theta Kappa Society transfer students who are accepted and subsequently enroll at Rensselaer Polytechnic Institute will receive the $5,000 annual scholarship.

Corporation, Endowed, Foundation, Industrial, and Endowed Scholarships

A great many scholarships are given to Rensselaer by corporations and foundations and through the generosity of alumni and friends. Some of these scholarships are available to first-year students and continue for four years; others are available only in the upper-class years. Currently over 400 of these scholarships exist for undergraduate students. Most are awarded on the basis of financial need, academic excellence, major, community service, leadership, or other criteria established by the donor. No special application is required. Award amounts vary, ranging from $500 to full tuition.

Federal Grants, Loans, and Work-Study Assistance

Full details on all federal financial aid programs may be found at www.federalstudentaid.ed.gov. Recipients of federal aid programs must be United States citizens or eligible non-citizens and meet other requirements. The federal government offers a number of grant, loan, and work-study programs. Additionally, students enrolled in a study abroad program approved for credit by Rensselaer may be considered as enrolled at Rensselaer for purposes of determining federal student financial aid eligibility. The programs listed below are most popular with Rensselaer students and require the completion of the FAFSA (Free Application for Federal Student Aid) for determination of eligibility:

Federal Pell Grant The maximum award for the 2013-2014 academic year is $5,645. Eligibility is determined by data provided on the FAFSA; however a student whose parent or guardian died as a result of service in Iraq or Afghanistan after 9/11/2001 is provided the maximum award. Students must be enrolled for a minimum of three credits to be eligible. Effective 7/1/2012 and thereafter, all Pell grant recipients are limited to receive no more than 12 semesters of Pell Grant awards.

Federal Supplemental Education Opportunity Grant (SEOG) These additional grants are made to Pell Grant recipients who demonstrate exceptional financial need. Maximum award is $4,000.

Federal Perkins Loan A need-based loan program for students with exceptional financial need, with a fixed interest rate of 5%. Payment of both principal and interest are deferred while the student is in attendance at least half time. The annual maximum a student may borrow is $5,500. The aggregate limit for undergraduate study is $27,000. Repayment begins nine months after a student is no longer in attendance on a half-time basis. Students offered this program are required to complete a Master Promissory Note (MPN) and complete an entrance interview explaining the rights and responsibilities in the program.

Federal Direct Loan (Subsidized) A need-based student loan with a fixed interest rate (6.84% as of 7/1/12) with a maximum cumulative total of $23,000. Both principal and interest are deferred while the student is enrolled at least half time. The federal government may deduct a default fee up to 1% of the amount borrowed. Please note that interest rates and fees are subject to change July 1 of each year.
**Federal Direct Loan (Unsubsidized)** Students who do not qualify for all or part of the subsidized Stafford Loan program may qualify for an unsubsidized Direct Loan, that is, a loan for which the student must either start paying interest while still in school or allow the interest to accrue. Students may borrow up to the limits of the subsidized program less any subsidized loan they may already have. The interest rate on this loan will be fixed at 6.8%. The federal government may deduct a default fee up to 1.05% of the amount borrowed. Please note that interest rates and fees are subject to change July 1 of each year. Effective July 1, 2013 new borrowers under the program may receive subsidized loan, in the aggregate, to 150 percent of the published length of the student’s current educational program. Once the student has reached that limit, s/he may borrow only unsubsidized loans, and interest begins to accrue on the student’s outstanding subsidized loan.

**Annual Federal Direct Loan eligibility:**
Freshman: $5,500 with no more than $3,500 from the subsidized program
Sophomore: $6,500 with no more than $4,500 from the subsidized program.
Junior and beyond: $7,500 with no more than $5,500 from the subsidized program

Participation in the Federal Direct Loan program requires a student to confirm his/her acceptance via Rensselaer’s Student Information System (SIS), complete a Master Promissory Note, and successfully complete an Entrance Interview and Exit Interview explaining the rights and responsibilities in the program.

Various deferments allowing postponement of repayment are available depending on when the student received the first loan. Periods of deferment are limited to those who are (1) in school at least half-time; (2) on graduate fellowships or rehabilitation training; (3) unemployed; (4) serving on active duty during a war, being on active duty as a member of the national guard, or (5) in economic hardship. Students should contact the Direct Loan Servicing Center ([https://studentloans.gov/myDirectLoan/index.action](https://studentloans.gov/myDirectLoan/index.action)) for specific information.

**Federal Work-Study Program** This is a need-based program for students with a substantial financial need. Recipients earn $8.50-$10.00 per hour with an academic year maximum earnings of up to $2,000 per year. In addition there ar limited number of community service positions available. Students selected to participate in this program must provide proof of employment eligibility to work in the United States. An acceptance of an offer of work study is not a guarantee of employment nor may a recipient utilize anticipated work study earnings to pay bills owed to the Institute.

**Federal Direct PLUS (Parent Loan for Undergraduate Students)** Borrower must be the parent or stepparent of a financially dependent undergraduate. Student eligibility is similar to federal Direct Loan program. Student must complete the FAFSA (Free Application for Federal Student Aid).

The borrower utilizes the Department of Education (DOE) Direct Loan Web site ([www.studentloans.gov](http://www.studentloans.gov)) to initiate the required credit check and complete a Master Promissory Note (MPN).

Parent borrower must complete a separate form for the Rensselaer Office of Financial Aid called a PLUS Loan Request Form (PLRF). The Office of Financial Aid transmits appropriate information to the federal Department of Education (DOE).

The maximum amount of Direct PLUS loan is the total cost of attendance, minus other financial aid. The interest rate is fixed at 7.9 percent. An origination fee of 4% is deducted from the gross amount borrowed. Repayment begins 60 days after the final disbursement for the loan period and a borrower has 10 to 25 years to repay. In addition, the borrower may defer payments while the student is enrolled at least half time.

**Application** Based on the FAFSA, the Office of Financial Aid reviews eligibility for these programs and makes awards within program guidelines and formulas (as always, subject to available funds). Detailed information on eligibility, award schedules, distributions of funds, cancellation, and specific rights and responsibilities of recipients is available from the Office of Financial Aid.

**Satisfactory Academic Progress (SAP)** To remain eligible for these Title IV federal student assistance programs, students must complete a specified percentage of attempted credit hours and maintain a required cumulative grade point average (GPA) as well as a minimum semester grade point average each semester. Students who fail to maintain the minimum credit hours or achieve the required grade point...
averages may be placed on federal financial aid warning for one semester, allowing for the potential to continue receiving federal aid. Federal financial aid warning status may only be granted once. Thereafter, a student who is not making SAP are pla will no longer be eligible to receive federal aid until s/he regains SAP or is granted federal financial aid probation. Students denied federal financial aid for failure to make satisfactory academic progress may appeal through the Office of Financial Aid. For complete details, visit the Office of Financial Aid website (http://admissions.rpi.edu/aid/current_students.html)

**Federal Policy on Drug Conviction & Aid Eligibility**

A student who has been convicted of any offense under any Federal or State law involving the possession or sale of a controlled substance shall not be eligible to receive any federal Title IV grant, loan, or work assistance during the period beginning on the date of such conviction and ending after the interval specified in the following table:

<table>
<thead>
<tr>
<th>Offense</th>
<th>Possession of illegal drugs</th>
<th>Sale of illegal drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Offense</td>
<td>1 year from date of conviction</td>
<td>2 years from date of conviction</td>
</tr>
<tr>
<td>2nd Offense</td>
<td>2 years from date of conviction</td>
<td>Indefinite Period</td>
</tr>
<tr>
<td>3rd Offense</td>
<td>Indefinite period</td>
<td></td>
</tr>
</tbody>
</table>

A student whose eligibility has been suspended may resume eligibility before the end of the ineligibility period if the student satisfactorily completes a drug rehabilitation program, defined by the Secretary, that includes two unannounced drug tests; or the conviction is reversed.

**Code of Conduct**

**Policy Statement**

Rensselaer Polytechnic Institute, as a participant in federal loan programs, is required to have a code of conduct applicable to the institution's officers, employees, and agents. The code of conduct requirements are set forth in the Higher Education Opportunity Act (HEOA) signed into law on August 14, 2008. The Code of Conduct Related to Student Loan Activities is a requirement specific to certain transactions and activities related to financial aid matters. In addition, the law includes requirements related to publication of the code and annual disclosures.

**Reason for Policy**

The HEOA program participation agreement, which must be executed by all institutions participating in Title IV financial aid programs including student loan programs, requires a code of conduct with which the institution's officers, employees, and agents shall comply. Such code must prohibit a conflict of interest with the responsibilities of an officer, employee, or agent of an institution with respect to such loans, and include the provisions set forth in the HEOA related to conflicts. The law further specifies that the code shall be displayed prominently on the institution's Web site and that all institutional officers, employees and agents with responsibilities related to such loans be annually informed of the provisions of the code of conduct. Rensselaer Polytechnic Institute also adheres to the Student Lending, Accountability, Transparency and Enforcement (SLATE) Act.

**Code of Conduct**

Rensselaer Polytechnic Institute adopts the following provisions from the HEOA, Section 493 as its Code of Conduct Related to Student Loan Activities and will annually inform all institutional officers, employees, and agents with responsibilities for student loan activities and decisions of the provisions of this code. Where New York State law under the SLATE Act is stricter than federal law inserts are in bold.

(1) **BAN ON REVENUE-SHARING ARRANGEMENTS**

(A) Prohibition—The institution shall not enter into any revenue-sharing arrangement with any lender.

(B) Definition—For purposes of this paragraph, the term ‘revenue-sharing arrangement’ means an arrangement between an institution and a lender under which—

(i) a lender provides or issues a loan that is made, insured, or guaranteed under this title to students attending the institution or to the families of such students; and

(ii) the institution recommends the lender or the loan products of the lender and in exchange, the lender pays a fee or provides other material benefits, including revenue or profit sharing, to the institution, an officer or employee of the institution, or an agent.

(2) **GIFT BAN**

(A) Prohibition—No officer or employee of the institution who is employed in the Office of Financial Aid, or an individual who has been assigned by the Rensselaer Polytechnic Institute President with supervisory authority over the Director of Financial Aid, or who otherwise has responsibilities with respect to education loans, or agent who has responsibilities with respect to education loans, shall solicit or accept any gift from a lender, guarantor, or servicer of education loans.
(B) DEFINITION OF GIFT

(i) In General—In this paragraph, the term ‘gift’ means any gratuity, favor, discount, entertainment, hospitality, loan, stock, or other item having a monetary value of more than a de minimus amount ($25 per year). The term includes a gift of services, transportation, lodging, or meals, whether provided in kind, by purchase of a ticket, computer hardware, printing costs or services for which the recipient pays below-market value, payment in advance, or reimbursement after the expense has been incurred.

(ii) Exceptions—The term ‘gift’ shall not include any of the following:

(I) Standard material, activities, or programs on issues related to a loan, default aversion, default prevention, or financial literacy, such as a brochure, a workshop, or training.

(II) Food, refreshments, training, or informational material furnished to an officer or employee of an institution, or to an agent, as an integral part of a training session that is designed to improve the service of a lender, guarantor, or servicer of education loans to the institution, if such training contributes to the professional development of the officer, employee, or agent. Reimbursement of expenses to a covered institutional employee for serving on the board of bona-fide professional association recognized by the Commissioner of NYS Education Dept., related to student financial aid.

(III) Favorable terms, conditions, and borrower benefits on an education loan provided to a student employed by the institution if such terms, conditions, or benefits are comparable to those provided to all students of the institution.

(IV) Entrance and exit counseling services provided to borrowers to meet the institution’s responsibilities for entrance and exit counseling as required by subsections (b) and (l) of section 485, as long as—

(aa) the institution’s staff are in control of the counseling, (whether in person or via electronic capabilities); and

(bb) such counseling does not promote the products or services of any specific lender.

(V) Philanthropic contributions to an institution from a lender, servicer, or guarantor of education loans that are unrelated to education loans or any contribution from any lender, guarantor, or servicer that is not made in exchange for any advantage related to education loans.

(VI State education grants, scholarships, or financial aid funds administered by or on behalf of a State.

(iii) Rule for Gifts for Family Members—For purposes of this paragraph, a gift to a family member of an officer or employee of an institution, to a family member of an agent, or to any other individual based on that individual’s relationship with the officer, employee, or agent, shall be considered a gift to the officer, employee, or agent if —

(I) the gift is given with the knowledge and acquiescence of the officer, employee, or agent; and

(II) the officer, employee, or agent has reason to believe the gift was given because of the official position of the officer, employee, or agent.

(3) CONTRACTING ARRANGEMENTS PROHIBITED

(A) Prohibition—An officer or employee who is employed in the Office of Financial Aid or who otherwise has responsibilities with respect to education loans, or an agent who has responsibilities with respect to education loans, shall not accept from any lender or affiliate of any lender any fee, payment, or other financial benefit (including the opportunity to purchase stock) as compensation for any type of consulting arrangement or other contract to provide services to a lender or on behalf of a lender relating to education loans.

(B) Exceptions—Nothing in this subsection shall be construed as prohibiting—

(i) an officer or employee of an institution who is not employed in the institution’s Office of Financial Aid and who does not otherwise have responsibilities with respect to education loans, from performing paid or unpaid service on a board of directors of a lender, guarantor, or servicer of education loans;

(ii) an officer or employee of the institution who is not employed in the Office of Financial Aid but who has responsibility with respect to education loans as a result of a position held at the institution, or an agent who has responsibility with respect to education loans, from performing paid or unpaid service on a board of directors of a lender, guarantor, or servicer of education loans, if the institution has a written conflict of interest policy that clearly sets forth that officers, employees, or agents must excuse themselves from participating in any decision of the board regarding education loans at the institution; or

(iii) an officer, employee, or contractor of a lender, guarantor, or servicer of education loans from serving on a board of directors, or serving as a trustee, of an institution, if the institution has an interest policy that the board member or trustee must excuse themselves from any education loans at the institution.
Sanctions
Violations of Institute policies, including the failure to avoid a prohibited activity or disclose a conflict of interest in a timely manner, will be dealt with in accordance with applicable Institute policies and procedures, which may include disciplinary actions up to and including termination from the institution.

ROTC Financial Aid Programs
Financial assistance is available for both scholarship and non-scholarship Reserve Officers Training Corps (ROTC) students.

ROTC scholarship recipients receive awards for periods varying from two to four years. These provide tuition ranging from approximately $18,000 to full tuition, a variable allowance for books, some fees, plus a monthly stipend. Students entering Rensselaer with ROTC scholarships receive an additional scholarship covering the average cost of on-campus room and board. This scholarship will be paid each year the student remains eligible for ROTC scholarship benefits regardless if the recipient resides on or off-campus. Please refer to the ROTC Room and Board Scholarship for details.

Non-scholarship students receive a monthly stipend during their junior and senior years.

Deadlines for scholarship applications vary among the Army, Navy, and Air Force. Details are available from service representatives:

- Aerospace Studies (Air Force), (518) 276-6236
- Military Science (Army), (518) 276-6254
- Naval Science (Navy/Marines), (518) 276-8001

Veterans Assistance (VA) Programs
The Institute has provided a specific Web site with detailed information for veterans: http://www.rpi.edu/veterans/index.html.

Students receiving VA benefits may also qualify for additional federal grants, loans, and work-study programs. VA recipients not qualifying for the Yellow Ribbon program will be considered for Rensselaer merit-based scholarships and grants.

In addition to participation in various GI educational programs, the Institute is partners with the VA in the Post-9/11 GI Bill Yellow Ribbon Program, which provides qualified veteran’s with a scholarship of up to $15,000 per year (matched by the VA). Participation is limited to 60 students per year on a first-come, first-served basis.

A Yellow Ribbon recipient is not eligible to receive other Rensselaer merit or grant aid programs.

New York State Grant Programs
New York offers a number of financial aid programs to residents. The Tuition Assistance Program (TAP) is described below. In addition, the state offers other special programs including the following for which details and application information are available on the Web at www.hesc.org or at New York State Higher Education Services Corporation, 99 Washington Avenue, Albany, NY 12255.

Tuition Assistance Program (TAP)
The Tuition Assistance Program (TAP) provides grant assistance to help eligible New York residents attending in-state postsecondary institutions pay for tuition. TAP grants are based on the applicant’s and his or her family’s New York State net taxable income. Applicants may apply directly to HESC or file the Free Application for Federal Student Aid (FAFSA), authorizing the release of information to HESC.

The amount of the TAP award is scaled according to type of school, level of study, tuition charge, and net taxable income. Seven award schedules are currently in effect. Award schedules may be changed by subsequent legislative action. All income data reported are subject to verification by the New York State Department of Taxation and Finance and NYSHEC.

Undergraduate award amounts currently range from $500 to $5,000, depending on family New York State net taxable income and when the student receives his/her first TAP payment.

Recipients must be in good academic standing in accordance with commissioner’s regulations and must not be in default of a federal loan or a loan guaranteed by NYSHEC.

- New York State Leaders of Tomorrow Scholarship
  Recipients are selected by their high school. To be considered, the student must have a high school average of at least 3.0, demonstrate leadership skills, participate in leadership activities, and attend a NYS accredited college, university, community college, or trade school. The award is $1,000 per year.

- Regents Awards for Children of Deceased or Disabled Veterans
  The student must be a New York State resident at the start of the term for which payment is made. The student’s parent or stepparent must have served in the U.S. armed forces during specified periods of war or national emergency and, as a result of service, have died or
have suffered 40 percent or more disability or be classified as missing in action. Alternatively, the parent (the veteran) must have been a prisoner of war during the specified period of service. The veteran must currently be a New York State resident or have been a resident at the time of death, if the death occurred during or as a result of service. The award is $450 per year.

- **Regents Awards for Children of Deceased Police Officers or Firefighters**
  This award provides financial assistance to children and spouses of deceased police officers, firefighters, volunteer firefighters, peace officers, and emergency medical service workers who served in New York State and died as a result of injuries sustained in the line of duty.

  The amount of the award is equal to the actual tuition and room and board costs, plus an allowance for books, supplies, and transportation, or the same costs at a SUNY institution, whichever is less.

- **Vietnam Veterans Tuition Awards**
  Under this program, Vietnam, Persian Gulf, Afghanistan, or other eligible combat veterans matriculated at an undergraduate or graduate degree-granting institution or in an approved vocational training program in New York State are eligible for awards for full or part-time study. For full-time study, a recipient shall receive an award of up to the full cost of undergraduate tuition for New York state residents at the State University of New York, or actual tuition charged, whichever is less.

- **State Aid to Native Americans**
  The applicant must be on an official tribal roll of a New York State tribe or the child of an enrolled member of a New York State tribe, as well as a resident of New York State. The award is $2,000 per year for a maximum of four years of full-time study (five years, where a fifth year is required for completion of degree requirements) and a minimum of 12 credits per semester. Students registered for fewer than 12 credits per semester will be funded at prorated amounts.

  Application forms may be obtained from the Native American Education Unit, New York State Education Department, Education Building, Room 478EBA, Albany, NY 12234. Call 518-474-0537 for deadline dates and additional application information.

  Source: Native American Education Unit, New York State Education Department, Albany, NY 1223.

- **Scholarship for Academic Excellence**
  Scholarships for Academic Excellence are awarded to outstanding graduates from registered New York State high schools. Awards are based on student grades in certain Regents’ exams.

  Awards are $1,500 to the top graduating senior of each high school in the state. Awards of $500 are made to other academically gifted students. The scholarship is renewable for up to four years, or five years in certain programs, and must be used within seven years of being awarded.

- **Part Time TAP**
  This program helps eligible New York State residents attending in-state postsecondary institutions on a part-time basis to pay for tuition. The student must have earned at least 12 credits in each of two consecutive semesters, for a total of 24 credits earned. Award amounts vary depending on the number of credit hours the student is taking. Note that this program is not the same as the Aid for Part-Time Study (APTS) program (in which Rensselaer does not currently participate).

- **New York World Trade Center Memorial Scholarship**
  World Trade Center Memorial Scholarships provide funds to help meet the cost of attending college. The award covers up to four years of full-time undergraduate study (or five years in an approved five-year bachelor’s degree program).

  Children, spouses, and financial dependents of deceased or severely and permanently disabled victims of the September 11, 2001, terrorist attacks on the United States, or the subsequent rescue and recovery operations, are eligible to apply. Recipients need not be New York State residents or U.S. citizens to receive the scholarships.

- **Memorial Scholarships for Children and Spouses of Deceased Police Officers and Firefighters**
  This award provides financial assistance to children and spouses of deceased police officers, firefighters, volunteer firefighters, peace officers, and emergency medical service workers who served in New York State and died as a result of injuries sustained in the line of duty.

  The amount of the award is equal to the actual tuition and room and board costs, plus an allowance for books, supplies, and transportation, or the same costs at a SUNY institution, whichever is less.

- **Persian Gulf Veteran’s Tuition Award**
  The award is $1,000 per semester for full-time study or $500 per semester for part-time study. The recipient must currently be a New York State resident and have served in the U.S. armed forces in the hostilities that occurred in the Persian Gulf from August 2, 1990, to the end of such hostilities.

  The student must submit a Persian Gulf Veterans Tuition Award supplement form to NYSHESC.
Recruitment Incentive and Retention Program (RIRP)
RIRP is a New York State program designed to recruit and retain quality personnel for the state military forces (army and air guard and naval militia). This program will pay the cost of tuition up to a maximum of $4,350 per calendar year for qualified applicants. Full details on the program may be found at the New York State Division of Military and Naval Affairs (DMNA) Web Site: http://dmna.state.ny.us/index.php.

Segal AmeriCorps Educational Award
AmeriCorps provides opportunities for adults of all ages and backgrounds to serve through a network of partnerships with local and national nonprofit groups. In return for their service, members of AmeriCorps programs earn money for school in the form of an education award that can be applied to outstanding student loans or future higher educational and vocational training pursuits. Full-time AmeriCorps members perform 1,700 hours of service. Part-time AmeriCorps members perform 900 hours of service. Awards of up to $4,725 are given for full-time service, and up to $2,363 for part-time service.

For additional information, see the AmeriCorps Web site. New York residents can contact the New York State Office for National and Community Service, 52 Washington St., Rensselaer, NY 12144. AmeriCorps Web site is www.americorps.gov/

Vocational Rehabilitation Grants
Persons with disabilities can obtain a list of locations where grant application information is available by contacting the Office of Vocational and Educational Services for Individuals with Disabilities (VESID), New York State Education Department, 80 Wolfe Rd, Suite 200, Second Floor, Albany, NY. Phone: 800-272-5448.

Other Non-New York State Grant Programs
Both Vermont and Rhode Island offer grant programs that provide partial support for study at Rensselaer. Vermont Incentive Grant applications are made to the Vermont Student Assistance Corporation, 10 East Allen St., PO. Box 2000, Winooski, VT 05404 or via the Web at www.vsac.org.

Rhode Island State Scholarship applications are made to the Office of Scholarships, Rhode Island Department of Education, 560 Jefferson Blvd., Suite 100, Warwick, RI 02886 or via the Web at www.riheaa.org.

Rensselaer encourages all non-NY residents to check with their state agencies to see if their educational grant or loan programs may be used while in attendance at the Institute.

Other Opportunities for Undergraduates
In addition to the above, there are other possibilities for undergraduate students or, in some cases, their families.

Part-time Employment
There are many opportunities for part-time work during the college year, both on the campus and in surrounding communities. Information on part-time employment is available from the Career Development Center, (518) 276-6234.

Alternative Loans
These non-federal loans are secured through private lending institutions. Typically in such programs, the student is considered the primary borrower, with a credit worthy co-signer. Please be aware that most lenders will not lend to a student who has not attained his/her 18th birthday at the time of application, regardless if a co-signer is used. Interest rates are variable, typically ranging from 2.25% - 13.79% depending on the borrower(s) credit rating. In addition, the lender will look to other factors such as income and current outstanding debt. Repayment begins after disbursement, and the borrower may have up to 20 years to repay. Payment may be postponed while the student is in school at least half time. The borrower chooses the lender, submitting the application through that lender. The lender will communicate with Rensselaer and the Office of Financial Aid in turn will notify the lender of the amount a student is eligible to borrow. Rensselaer does have some preferred lenders, selected because of their popularity with Rensselaer students, commitment to customer service, competitive interest rates, and interactive Web sites. Please visit www.elmselect.com for additional information.

Financial Aid Refund and Repayment
Students attending Rensselaer Polytechnic Institute who are receiving federal Title IV financial aid (e.g., federal Direct, Direct PLUS, or Perkins loans; federal Pell, and FSEOG grant funds) are required to return the portion of unearned aid if they withdraw, do not register, or otherwise fail to complete the period of enrollment for which the Title IV aid was provided. The return of funds does not apply to any student whose date of withdrawal is beyond the 60 percent enrollment period for which the student has been charged. The last date of attendance is determined by the date the student began the Institute’s withdrawal process, the student’s last date of recorded attendance (or other acceptable academic activity), or the midpoint of the semester for a student who leaves without notifying the Institute.

To determine the percentage of aid earned, divide the number of calendar days completed by the total number of calendar days in the enrollment period (excluding scheduled breaks of five days or more AND days that the student is on approved leave of absence).
Federal financial aid is returned to the program from which it was disbursed based on the percentage of unearned aid. To determine the percentage of unearned aid, subtract the percentage of aid earned from 100. The percentage of unearned aid is then multiplied by the amount of aid disbursed toward allowable institutional charges (e.g., tuition, room, and board).

Generally speaking, fees are non-refundable (i.e. student activity, registration, late payment, laboratory, matriculation, transcript, technology, and other special fees). A refund schedule of tuition and room and board charges based on a 15-week semester is provided below.

<table>
<thead>
<tr>
<th>Date of Withdrawal</th>
<th>Refund</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to commencement of term</td>
<td>100%</td>
</tr>
<tr>
<td>Prior to second week of term</td>
<td>90%</td>
</tr>
<tr>
<td>Prior to third week of term</td>
<td>80%</td>
</tr>
<tr>
<td>Prior to fourth week of term</td>
<td>70%</td>
</tr>
<tr>
<td>Prior to sixth week of term</td>
<td>60%</td>
</tr>
<tr>
<td>Prior to seventh week of term</td>
<td>50%</td>
</tr>
<tr>
<td>Prior to ninth week of term</td>
<td>40%</td>
</tr>
<tr>
<td>Thereafter</td>
<td>0%</td>
</tr>
</tbody>
</table>

Please note that the above refund policy also applies to students who are not federal aid recipients. It also applies to the return of institutional aid. In the case of any student for whom it is determined that a return must be made to programs based on prorated charges, those funds will be returned in the following order: unsubsidized federal Direct loan, subsidized federal Direct loan, federal Perkins loan, federal Direct PLUS, federal Pell grant, FSEOG funds, and other Title IV aid programs. Finally, if no institutional, state, or private financial aid refund is required, a refund will be made to the student.

More detailed information, including examples of refund and repayment calculations, is available in the Admission, Bursar, and Financial Aid offices.

Any federal aid recipient who is taking a leave of absence or withdrawing within the ninth week should be aware that a return of federal aid may be required even though full tuition and room and board charges will be incurred.

Official withdrawals and leaves are coordinated through the Office of Student Experience.

Special Considerations

Students who take a leave of absence, or withdraw, and are also Title IV aid recipients should be aware of the following: The grace period for federal loans (Perkins, Direct PLUS, and Direct Loan) begins from the student’s last date of attendance as determined by the Office of Student Experience. A student who is on an approved leave of absence will be considered as in school for purposes of repayment of federal loans. Should the student not return from an approved leave of absence, the last date of attendance will be considered the date the approved leave of absence began.

When a student withdraws from the Institute, the last date of attendance will be determined as outlined under Academic Information and Regulations section of the Catalog.

Federal regulations do not allow for the period of study to be interrupted for more than 180 days, excluding standard periods of non-enrollment.

Before being granted approval for withdrawal, or leave of absence, all students who are federal loan recipients are required to be counseled by the Office of Financial Aid to discuss the consequences of their changed status on loan programs.

Funding Graduate Study

Only full-time, degree-seeking graduate students are eligible for financial support from Rensselaer in the form of research assistantship, teaching assistantship, or fellowship. The Office of Graduate Education awards Rensselaer Graduate Fellowships and the schools and departments award fellowships and research and teaching assistantships. In the awarding of student support, the Office of Graduate Education and the departments consider such factors as the candidate’s academic record and background, and Rensselaer Graduate Fellowships are awarded for the full academic year, and are typically allocated in March or April for the following academic year. These fellowships consist of a calendar year stipend of at least $18,500. Assistantships consist of full academic year tuition and a stipend of at least $18,500 for the current academic year and, if the student is requested to register and work full time during the summer, at least $24,667 for the current calendar year. The Office of Financial Aid makes student loan determinations during July.

Academic departments review the progress of continuing graduate students each term. Continuation of or changes in aid are determined by this review and depend on satisfactory academic and research or teaching performance, as well as the continued availability of funds.
College Cost – Graduate - The total estimated expenditure for a Rensselaer graduate students for the nine-month 2013-2014 academic year is as follows:

GRADUATE STUDENTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition</td>
<td>$45,100.00</td>
</tr>
<tr>
<td>Fees and insurance</td>
<td>$1,972.50</td>
</tr>
<tr>
<td>Estimated living expenses</td>
<td>$12,265.00</td>
</tr>
<tr>
<td>Books and supplies</td>
<td>$2,656.00</td>
</tr>
<tr>
<td><strong>Total Estimated Cost of Attendance</strong></td>
<td><strong>$61,993.50</strong></td>
</tr>
</tbody>
</table>

Financial Assistance from Rensselaer

Several types of assistance to help defray the cost of graduate study are available from Rensselaer funds.

Graduate Assistantships Each department selects a number of graduate students each academic year to work as graduate teaching and/or research assistants. The graduate teaching assistant assumes classroom, laboratory, and/or grading responsibilities for his or her department. The graduate research assistant conducts directed research with individual faculty members.

A full-time assistant receives an academic year stipend and tuition scholarship, and is responsible for 20 hours of work each week. The remuneration and workload are determined by the department and approved by the Office of Graduate Education.

Opportunities exist for additional work and study during the summer in many programs. Students receiving assistantships are expected to devote their full-time efforts to the assistantships and their scholarly activities.

Rensselaer Graduate Fellowships The Institute awards full-stipend, tuition, and fees fellowships for select incoming students. Nominees are put forward by the departments based on the strength of the application information. No separate forms are necessary.

Corporate, Foundation, and Private Fellowships Many corporations, foundations, and individuals offer fellowships for graduate study at Rensselaer. The benefits for grants vary; most include tuition allowances. Any student awarded a fellowship through the Institute will receive a stipend equal to or greater than the Institute approved rate. A list of these fellowships is provided at the end of the graduate financial aid section of this catalog.

Federal Financial Assistance

The federal government offers the Federal Direct loan program to graduate students. Students must complete a FAFSA application and a Rensselaer Graduate Financial Aid application to be considered for Federal Financial Aid. Graduate students are awarded up to Cost of Attendance or up to the annual Direct Loan limits, whichever comes first. Direct Loan Eligibility is affected by changes in credit hours taken and in the amount of outside and department aid received.

Federal Direct Loan (Subsidized)

Note that this program is no longer available to graduate students for any loan period beginning on or after 7/1/2012.

Federal Direct Loan (Unsubsidized)

Students who do not qualify for all or part of the subsidized Stafford Loan program may qualify for an unsubsidized Direct Loan, that is, a loan for which the student must either start paying interest while still in school or allow the interest to accrue. Maximum eligibility is $20,500. The interest rate on this loan will be fixed at 6.8%. The federal government may deduct a default fee up to 1.05% of the amount borrowed. Please note that interest rates and fees are subject to change July 1 of each year.

Graduate PLUS Loan Program

Available to graduate and professional students. Borrowers can supplement the Federal Stafford loans currently available to them by borrowing a Graduate PLUS loan up to the full cost of their education, including books, living expenses, and more. PLUS loans have a fixed 7.95% interest rate and a 4.204% processing fee upon disbursement. Repayment begins 60 days from disbursement, unless deferment has been requested to the federal processor. The PLUS loan requires an initial credit application in addition to a Master Promissory Note. Students are advised to exhaust other Direct Loan eligibility prior to applying for a Graduate PLUS loan.

Disbursement of Federal Direct Loans

Federal Direct and Graduate PLUS Loans are disbursed to the school in equal installments unless scheduled for a single term. Initial disbursements are made during the first week of each eligible term. Loans established after initial disbursement will be disbursed on a rolling basis.
Repayment of Federal Direct Loans
Students are required to complete student loan exit counseling for Federal loans upon exiting school. Instructions will be sent to students on how to complete the counseling upon leaving school.

Depending on loan type, students may receive a six month grace period prior to the required repayment period with the Direct Loan programs. Students may need to verify their grace period with the federal Direct Loan Service Center (https://studentloans.gov/myDirectLoan/index.action). The standard repayment term for the Direct Loans is 10 years. Other repayment options may be available to students including extended, graduated, income-based and income sensitive repayment.

Other Opportunities for Graduate Students
Veterans’ Benefits Veterans and children of veterans may qualify for educational benefits. The veterans’ coordinator in the Registrar’s Office handles these benefits and should be contacted as soon as the student arrives on campus. The veterans’ coordinator will provide forms and information for initiating benefit procedures.

The Registrar’s Office is responsible for certifying all veterans who receive benefits. A veteran who changes his or her credit-hour load or who withdraws from the Institute must notify the veterans’ coordinator immediately.

International Students Rensselaer encourages applications from highly qualified international students. Over 500 international graduate students are currently enrolled at Rensselaer.

Financial aid is available to well-qualified first year students in the form of fellowships and assistantships. Competition for awards is very high. Generally, awards are committed well before the start of the academic year; awards are usually mailed during March and April for the following fall term.

The estimated cost of living expenses and books and supplies for the 2013-2014 academic year is $14,910. If the student intends to stay in the United States for the summer vacation period and enroll in classes at Rensselaer during that time, he or she must have adequate additional funds. Students also must pay for round-trip transportation to Rensselaer. A nonrefundable fee of $35 is required for an orientation program held prior to registration. Immigration restrictions generally preclude spouse employment.

Financing for International Students:
International students may be eligible for private (alternative) student loans up to their Cost of Attendance. Most private loan suppliers will require a U.S. creditworthy co-signer to accompany the applicant. Students may contact the Office of Financial Aid for more information on private loans for International students.

List of Graduate Fellowships
The following fellowships are administered by departments, and in some cases the Office of Graduate Education, and are awarded after a review of the admissions application. No separate application is necessary.

AT&T Graduate Scholarship Programs for doctoral study in science and engineering.

Air Products and Chemicals Grant-in-Aid for graduate study in chemical engineering.

Philip L. Alger Fellowship for graduate study in engineering ethics.

American Nuclear Insurers Fellowship for graduate study in nuclear engineering.

American Nuclear Society Scholarships for graduate and undergraduate studies in nuclear engineering.

BASF Corporation Grant-in-Aid for graduate study in chemical engineering.

Michael W. Bellanti Fellowship for graduate study in nuclear engineering.

Irene and Robert P. Bozzone ’55 Fellows in Management and Technology for graduate students enrolled in the management and technology MBA program.

Robert S. Brown ’52 Fellows Program for travel fellowships for architecture students.

Karin and Ellis Chingos ’37 Fellowship

Bill Clemow ’71 Memorial Fellowship for graduate study in electrical, computer, and systems engineering.

Dr. Andrew N. Dascheff ’89 Memorial Fellowship for graduate study in chemistry.

Civil Engineering Fellowship Sponsored by Alumni in Construction
Department of Energy (DOE) Fellowships for graduate studies in nuclear engineering.

DeWitt-Wallace Foundation Fellowship for graduate study primarily in humanities and social sciences.

Joaquin B. Diaz Memorial Fellowship for graduate study in mathematical sciences.

Dow Chemical Grant-in-aid for graduate study in chemical engineering.

DuPont Grant-in-aid for graduate study in chemical engineering.

DuPont Grant-in-aid for graduate study in mechanical engineering.

Eastman Kodak Fellowship for graduate study in electrical, computer, and systems engineering.

Eastman Kodak Grant-in-aid for graduate study in chemical engineering.

Electric Power Engineering Fellowship for graduate study in electric power engineering.

Exxon Education Foundation Stewardship for graduate study in civil engineering.

Exxon Grant-in-aid for graduate study in chemical engineering.

Exxon Grant-in-aid for graduate study in electrical, computer, and systems engineering.

Nancy Fitzroy Scholarship for graduate study for women in engineering.

FMC Corporation Grant-in-aid for graduate study in chemical engineering.

W. Cary Franklin ’77 Fellowship for graduate study in mechanical engineering or an allied field.

General Electric Foundation Fellowship for graduate study in electrical, computer, and systems engineering and in materials engineering.

Goldbaum Family Fellowship for graduate studies in nuclear engineering.

W. R. Grace Fellowship for graduate study in chemical engineering.

E.T.B. Gross Endowment Fund for graduate study in electric power engineering.

GTE Foundation Fellowship for graduate study in electrical, computer, and systems engineering, and computer science.

David Hansen Fellowship for graduate study in chemical and environmental engineering.

Robert G. Hawkins Fellowship for underrepresented students in graduate management studies.

Herman Family Fellowship for women in entrepreneurship.

Fannie and John Hertz Scholarship for graduate study in engineering or science.

Charles S. Humphrey Fellowship for graduate study for a Canadian citizen in science or engineering.

IBM Fellowships for graduate study in computer science.

IBM Fellowships for graduate study in integrated circuits.

IBM Fellowships for graduate study in materials engineering.

IBM Fellowships for graduate study in mathematics.

IBM Mass Spectrometer’s Ion Physics Lab Fellowship for graduate study in nuclear engineering.

Intermagnetics General Corporation Fellowship for graduate study in condensed matter physics.

Interscience Incorporated Fellowship for graduate study in condensed matter physics.

Howard P. Isermann ’42 Fellowships for graduate study in chemical engineering.

Professor Howard Kaufman ’62 Memorial Fellowship for graduate students in electrical, computer, and systems engineering, with preference given to students working in the area of control systems.

Stanley L. Landgraf ’46 Memorial Fellowship for graduate students with preference given to former recipients of the Barbara and Stanley Landgraf ’46 Scholarship.
Carlton E. Lemke Fellowship in Decision Sciences and Engineering Systems.

Carlton E. Lemke Fellowship in Mathematics for graduate students in the Department of Mathematical Sciences.

George Mahe ’42 Fellowship in memory of John L. Sharp ’42.

Harry F. Meiners ’52 Fellowship for graduate study in physics.

Merck Fellowships for graduate study in chemical engineering.

Mobil Chemical Grant-in-aid for graduate study in chemical engineering.

National Academy for Nuclear Training (NANT) Fellowships for graduate study in nuclear engineering.

Dr. Ernest F. Nippes ’38 Graduate Research Enhancement Award for graduate students in materials engineering.

North American Philips Fellowship for graduate study in condensed matter physics.

North American Philips Graduate Fellowship for graduate study in electrical, computer, and systems engineering.

Parthesius Fellowship for graduate study.

Albert S. Paulson Fellowship in Quantitative Financial Management for outstanding graduate students enrolled in the Lally School of Management and Technology.

Perkin Elmer Fellowship for graduate work in electrical, computer, and systems engineering.

Michael Aloysius Philbin Memorial Fellowship for graduate study in civil engineering.

Procter & Gamble Grant-in-aid for graduate study in chemical engineering.

Reinert-Rader Fellowship in Financial Technology for graduate students in the Lally School of Management and Technology.

Richards Scholarship for graduate study in civil engineering.

Robert S. Roller Fellowship in Lighting for graduate students exploring fundamental issues in lighting technologies at the Lighting Research Center.

Veera and Arjun Saxena Fellowship in Microelectronics for outstanding Ph.D. students working in the area of microelectronics.

Schenectady Chemicals Industrial Fellowship for graduate study in chemical engineering.

Shavell-Weinman Graduate Research Enhancement Award for graduate study in economics or humanities related to understanding economic behavior.

Slezak Memorial Fellowship for graduate study in chemistry.

Chauncey and Doris Starr Graduate Fellowship for worthy and needy students with first preference to those pursuing doctoral study in the interdisciplinary area of energy and the environment.

Joseph R. Takats ’41 Fellowship for graduate study for Western New York residents in mechanical, civil, nuclear, or biomedical engineering.

Union Carbide Grant-in-aid for graduate study in chemical engineering.

Voorhees Fellowships for graduate study in management.

Joanne Wagner Memorial Fellowship for graduate study for women in communications and rhetoric.

Yamada Corporation Fellowship for graduate study for Japanese citizens.

Weissman Family Fellowship for outstanding graduate students enrolled in the School of Science or the School of Engineering.

William Weightman Walker Fellowship for a graduate student in chemistry and chemical biology, biochemistry-biophysics, or chemical and biological engineering.

Stephen B. Zimmerman ’66 Memorial Fellowship for study in industrial and management engineering.
Tuition and Fees

Each month, students will receive a courtesy e-mail sent to their Rensselaer e-mail address indicating the eBill logon link and the availability of that month’s bill. Other individuals designated by the student will also receive a similar email indicating the link and the availability of the bill. Bills covering the charges of any term are emailed before the start of the term and are payable no later than the date specified, approximately one month before classes start. A student’s registration is not complete until he or she has paid or arranged for payment of all charges. Academic credit, degrees, grade reports, diplomas, and transcripts are not granted to students who have not fulfilled all financial obligations to the Institute. If special arrangements for payment are necessary, they should be made through the Bursar’s Office.

It is the students’ and parents’ joint responsibility to ensure that timely and accurate applications are made for financial aid, scholarships, and loans. In the event Rensselaer Polytechnic Institute grants credit for these or any other payment source, and payment is not received from that source, the Institute will expect payment from the student and/or parent. Should a student or parent fail to pay any amounts due Rensselaer Polytechnic Institute in accordance with the terms of this catalog, the Institute may at its option increase the amounts due by any attorneys’ fees, collection agency fees, or any other costs or charges incurred in the collection of any amount not paid when due.

No fees or payments will be refunded other than tuition and room and board charges as outlined below. Rensselaer subscribes to the Policy Guidelines for Refund of Student Charges as issued by the Office on Self-Regulation Initiatives Program of the American Council on Education.

Questions regarding assessment of fees, purpose, and payment should be directed to the Bursar’s Office.

Monthly Installment Plan As an alternative to paying relatively large amounts twice a year, Rensselaer offers a monthly payment plan. The plan permits academic year charges for tuition, fees, residence, and board to be paid in 10, nine, or eight equal installments. There is a $60.00 per year service charge for use of the Monthly Installment Plan.

Applications to participate in the plan and additional information regarding the plan are normally mailed to prospective and returning students in mid-April. Applications may also be obtained at the Bursar and the Financial Aid Offices. There is no interest charge associated with the plan.

Late Payment and Unpaid Balances Any balances not paid or covered by financial aid by the due date noted on any bill will be subject to a late payment fee of $250. In addition to the $250 fee, students with unpaid balances after the first day of classes will be unable to receive grades or transcripts, register for future terms, or receive diplomas. If any amounts are still outstanding at the end of the term, Rensselaer will require a one-semester leave of absence. Readmission after this leave is contingent upon full payment of money owed plus full payment for the next term.

Tuition

Undergraduate Tuition The tuition for a normal undergraduate program (12 to 21 credit hours a semester) is $45,100.00 per academic year. This includes use of apparatus, athletic fields, and gymnasium, but charges for breakage in laboratory classes are additional.

Summer 2013 session tuition for matriculated Renssalaer undergraduates is $880.00 per credit hour.

Undergraduate students who are allowed to take more than 21 credit hours in any term, exclusive of ROTC, will be charged an additional $1,879.00 for each credit hour in excess of 21. Overload charges will be based on the student’s registration at the end of the eighth week of classes. No appeals due to late drops will be accepted.

Undergraduate students who are allowed to take fewer than 12 credits are charged $1,879.00 per credit hour unless they are certified as full-time for TAP purposes. Charges for students who drop to fewer than 12 credit hours after the fifth week of classes will not be adjusted below the full-time charge.

Graduate Tuition Full-time graduate tuition is $45,100.00 per academic year. Payment of this tuition allows a student to register for 12 to 15 credit hours in each of the fall and spring semesters. A student paying tuition and taking between 12 and 15 credits in the fall and spring is considered a full-time student throughout that calendar year. Students must register for at least 12 credits per semester to maintain full-time status. The only exception to this requirement is for those students serving as teaching assistants. These students may register for a minimum of nine credits to maintain their full-time status. Students enrolling for more than 15 credits during the fall or spring terms will be charged the academic year tuition rate plus a per-credit-hour rate of $1,879.00 for each credit hour exceeding 15 credits or for each credit taken in the summer sessions.

Graduate Summer Part-time graduate tuition is paid on a per-credit-hour basis of $1,879.00 per credit hour.
**Summer Administrative Registration** Summer Administrative Registration (SAR) is a no charge registration requirement for graduate students who will be receiving a stipend over the summer or graduating in the summer semester. Students taking credit-bearing course or research credits should not register for SAR. Eligibility for SAR requires that the student has been registered in both the previous fall and spring semesters.

**Cooperative Education** Students engaged in cooperative education (Co-op) are considered full-time students. No tuition is assessed for Co-op students unless the student elects to take classes. Co-op students taking classes are charged the per-credit-hour rate associated with full-time students.

**Tuition Refunds for Official Withdrawals** Except for the application fee and admissions deposit (entering students only), all payments will be refunded if a student officially withdraws before Final Registration. Students who withdraw or who are dismissed from Rensselaer before the completion of a term will be charged tuition according to the portion of the term spent in residence. Before any refunds are made for whatever reason, official written notification of withdrawal and requests for refunds must be submitted to the Student Experience Office or to the Office of Graduate Education as applicable. The refund schedule after Final Registration for fall and spring terms is:

<table>
<thead>
<tr>
<th>Duration</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 week</td>
<td>100%</td>
</tr>
<tr>
<td>Less than 2 weeks</td>
<td>90%</td>
</tr>
<tr>
<td>Less than 3 weeks</td>
<td>80%</td>
</tr>
<tr>
<td>Less than 4 weeks</td>
<td>70%</td>
</tr>
<tr>
<td>Less than 6 weeks</td>
<td>60%</td>
</tr>
<tr>
<td>Less than 7 weeks</td>
<td>50%</td>
</tr>
<tr>
<td>Less than 9 weeks</td>
<td>40%</td>
</tr>
<tr>
<td>More than 9 weeks</td>
<td>40%</td>
</tr>
</tbody>
</table>

Graduate Tuition Refunds for Part-Time Graduate Students fall and spring terms:

<table>
<thead>
<tr>
<th>Duration</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5 weeks</td>
<td>100%</td>
</tr>
<tr>
<td>More than 5 weeks</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Veteran’s Benefits** Any veteran who changes his or her credit-hour load or withdraws from the Institute must notify the veteran's coordinator in the Registrar’s Office immediately.

**Fees**

**Residences** The range of campus housing costs is given below. Detailed information regarding facilities, assignments, specific costs, refund policies, and services is available from the Office of Residence Life.

- **Single Student Housing**: $6,240 to $8,740
- **Family Housing**: Inquire at City Station

Students who accept a campus housing assignment are expected to occupy their rooms for the full academic year. Residence charges are refundable for students who withdraw or are dismissed, according to the same schedule as tuition refunds.

**Contract Dining** The costs for the meal plans are listed below. Dining charges are refundable on a prorated basis for students who withdraw or are academically dismissed. If the student should withdraw prior to late registration, the entire amount of the charges will be refunded.

- **23 On Demand**: $5,430
  
  (23 anytime meals each week plus $150 Flex Dollars per year)

- **19 On Demand**: $5,350
  
  (19 anytime meals each week plus $250 Flex Dollars per year)

- **15 On Demand**: $5,260
  
  (15 anytime meals each week plus $500 Flex Dollars per year)

- **10 On Demand**: $4,570
  
  (10 anytime meals each week plus $900 Flex Dollars per year)

- **Block Plan** $4,140
  
  (250 anytime meals for the year plus $1200 Flex Dollars for the year)

* This plan is available to only students living in an approved Greek Residence Commons and to juniors and seniors living in campus apartments or living off campus.
Activity Fee An activity fee is assessed by the Rensselaer Union and carries with it Union membership privileges. The fee is required of all students except full-time university employees who are registered for graduate study and Professional and Distance Education studies students. The fee is nonrefundable except where withdrawal is made prior to late registration and notification is made in the same manner as required for tuition refunds.

<table>
<thead>
<tr>
<th>Category</th>
<th>Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate</td>
<td>$309.50 per term</td>
</tr>
<tr>
<td>Graduate</td>
<td>$167.00 per term</td>
</tr>
<tr>
<td>Summer students</td>
<td>$132.00 Session I</td>
</tr>
<tr>
<td></td>
<td>$66.00 Session II</td>
</tr>
<tr>
<td></td>
<td>$66.00 Session III</td>
</tr>
</tbody>
</table>

Co-op students pay the fees listed if their assignments are within 25 miles of the Rensselaer campus.

Health Center Fee All matriculated regular undergraduate and graduate students taking courses at Rensselaer are charged a Health Service Fee of $275.00 per six-month period. Students paying the fall semester fee may access the Student Health Center from August 15 to February 15. Students paying the spring semester fee may access health services from February 15 (or, for students admitted or readmitted in the spring term, the first day of spring classes) to August 15. Students admitted or readmitted to summer sessions pay a pro rata fee of $18.33 per week. This is a mandatory fee that registered students may not waive unless they are more than 25 miles from campus while on a co-op assignment. Granting of Health Center Fee waivers is at the discretion of the medical director. This fee provides access to the Student Health Center.

Health Insurance Premium All matriculated regular undergraduate and graduate students are charged $414.00 each semester for the Rensselaer Student Insurance Plan. Like the Health Center Fee, coverage extends for six months (August 15 to February 15, February 15 to August 15).

The insurance plan may be waived if you have equivalent insurance coverage. Waiver of this plan is required each year and must be requested no later than September 15 (February 15 for students admitted or readmitted in the spring term). Waiver applications are online. Approval of waivers is at the discretion of the medical director. Students who waive the health insurance plan still have access to the Student Health Service.

Optional dependent insurance coverage is also available via information posted on the Student Health Center Web site.

Dental Insurance Premium All matriculated regular graduate students are charged $94.00 each semester for the Dental Insurance Plan. Waiver of this fee is allowed by showing proof of comparable dental insurance coverage and by completing a dental fee waiver form available at the Health Center. Deadline for waiver of this fee is September 15 for the fall and February 15 for the spring semester. Dental insurance coverage is optional for undergraduate students. See the Student Health Center Web site for information on enrolling in the undergraduate dental plan.

Orientation Fee All entering first-year and transfer students will be charged for the opportunity to attend programs held during the summer and/or before fall or spring semesters for overall orientation, academic advisement, and course registration. Fees are $175 for first-year, freshman, fall-admitted students, and $100 for spring-admitted first-year, freshman students, and all transfer students. This fee is non-refundable except where withdrawal is made prior to the fall Final Registration date for fall-admitted students or prior to spring Final Registration date for spring-admitted students.

Orientation Fee for International Graduate Students All entering foreign graduate students will be charged $35 for the opportunity to attend a special program held before fall and spring semesters. Attendance is mandatory; students entering for the summer session will participate in the fall program. The fee covers arrival assistance, off-campus housing search service, general orientation, and social activities (services and programs are more limited in the spring semester). This is a nonrefundable fee. Any questions or concerns should be directed to the Office of International Services for Students and Scholars.

Late Registration Fees A $50 fee is levied on students who were enrolled the previous semester and register after the registration period specified in the academic calendar. An additional fee of $25 is charged students in the above category who register after the first day of class as specified in the academic calendar. These fees are imposed to cover the added cost of late registration processing.

Returned Payment Fee A $25 fee is charged for checks or credit card transactions returned by the bank. In addition, if term clearance was granted based on the returned item, the late payment fee will also be charged and the student’s term clearance may be suspended until the returned item is made good.

Validation Examination Fee The fee for an examination to establish credit for work done elsewhere than in an accredited institution is $75 for each examination.
Transcript Fee A transcript fee of $25 is charged all students upon entry to Rensselaer.

Motor Vehicle Fees and Fines Parking at Rensselaer is very limited and student vehicles are restricted by permit to specific areas. An annual vehicle registration fee is charged all students who park a motor vehicle (including motorcycles and mopeds) on Rensselaer property. Parking permits are available from the parking office located in the Visitors Information Center. Parking and driving requirements are available on-line at http://www.rpi.edu/dept/parking. Violations of the requirements involve tickets, fines, fees, booting (wheel lock), and loss of parking privileges. Fees and fines are billed to student accounts. Credit card transactions are not accepted in the parking office. An added fee is charged for bank checks returned by the bank.
Academic Information and Regulations

Each student is expected to be familiar with the academic regulations of the university and the particular requirements for his or her educational program. The student has sole responsibility for complying with regulations and meeting degree requirements as set forth in this catalog and as amended from time to time.

General academic standards and regulations are set forth below, followed by the university requirements for degrees. Students should also consult the current edition of The Rensselaer Handbook of Student Rights and Responsibilities, which explains disciplinary regulations and related matters. This handbook is available from the Office of the Dean of Students.

Exceptions may be granted to the academic regulations when circumstances suggest this to be in the best interest of the student's educational objectives. Such requests are handled individually, and students should first consult with their faculty advisers (graduate students with their graduate program directors) about the correct procedure. The Advising & Learning Assistance Center approves exceptions for undergraduates. In only the most compelling circumstances will exceptions be made to the academic regulations for graduate students. After consulting with their graduate program directors, graduate students can seek exceptions at the Office of Graduate Education.

Registration
Before the end of each semester, all students enroll for courses for the next semester. With the help of a program adviser or by using a Plan of Study, specific required and elective courses are selected, and this information is submitted to the registrar. Registration procedures are in the Class Hour Schedule, which is available on-line at http://sis.rpi.edu or from the Registrar’s Office.

Courses with insufficient registration will be canceled. Students affected will be notified so that they can select another course. The university reserves the right to cancel or not offer any course listed in the Rensselaer Catalog.

School Ombudspersons
Architecture
David Bell, Greene 209
276-6862, fax 276-3034, e-mail: belld@rpi.edu

Engineering
Linda Schadler
Dean's office, JEC 3018
276-6620, fax 276-4860

Humanities, Arts, and Social Sciences
Lee Odell
276-8122, fax 276-4092, email: odellc@rpi.edu

Management and Technology
Margaret McDermott
276-3974, fax 276-8661, e-mail: mcderm3@rpi.edu

Science
Dean's Office — JRSC IC05
276-6305, fax 276-2825

Graduate Education
Dennis Gornic
276-6567, fax 276-2256, email: gornid@rpi.edu

Times for Registration
All full-time continuing students must register during the period specified each semester by the registrar. New, part-time, or readmitted students must register before the first day of classes. An undergraduate may not register for a semester after the tenth class day of the term. Graduate students may not register after the tenth class day of the term. Readmitted students may register when the drop/add period reopens for the term.
Waivers to the above deadlines are not normally given unless circumstances beyond the student’s control prohibit complying with the deadlines. Undergraduates wishing to register after the deadline must have a signed waiver from the director of the Advising and Learning Assistance Center. Graduate students may be granted a waiver from the Office of Graduate Education. Students granted a waiver must pay late fines and file specified forms with the registrar. Students will not be permitted to register after the start of the fifth week of classes except in extraordinary circumstances.

An off-campus student may register for Independent Study by writing to the department chair or adviser prior to the end of the Add Period. The chair or adviser will arrange for the registrar to register the student.

A student’s registration is not complete until he or she has paid or arranged for payment of university fees. If special arrangements for payment are necessary, they should be made through the Bursar’s Office. Every full-time student entering Rensselaer must submit a medical history and record of physical examination on a form provided by Rensselaer. A student’s registration is not complete until this form is submitted.

**Late Registration Fees**

Full-time continuing students who miss registration must pay $50 and register before the first day of classes each term. All students who fail to register before the start of classes will be charged $25 to cover additional processing costs. For full-time continuing students, this charge is added to the $50 fee. Students must pay late registration fees prior to registering.

**Cross-Registration at Area Colleges**

It is possible to register for courses, at no additional tuition charge, at 14 other colleges and universities in the Capital Region. These include:

- Albany College of Pharmacy
- Albany Medical College
- The College of Saint Rose
- Empire State College
- Excelsior College
- Graduate College of Union University
- Hudson Valley Community College
- Maria College
- The Sage Colleges
- Schenectady County Community College
- Siena College
- Skidmore College
- University at Albany
- Union College

Courses taken at one of the colleges are entered on the student’s record in the same manner as courses taken at Rensselaer and thus carry term and cumulative hours and grade points. Students must be full-time and no more than half of a student’s academic credits may be taken off-campus in any semester. Students can not cross register for courses offered at Rensselaer.

Graduate students must have the approval of their Graduate Program Adviser and the Office of Graduate Education prior to enrolling in a course taught at one of the participating colleges that is to be applied to their Rensselaer degree.

Cost for courses taken at one of these colleges is covered by the tuition charge at Rensselaer and subject to the same regulations that apply for courses taken at Rensselaer. Such courses may be taken on the Pass/No Credit option and may be added or dropped in accordance with the policy in effect at Rensselaer. The Pass/No Credit option is not available to graduate students. When the other college is on a calendar year that differs from Rensselaer’s, time adjustments for adding or dropping courses or placing courses on Pass/No Credit will have to be made. The student taking such courses is responsible for learning the last date for such changes. This information may be obtained from the registrar.

The general regulations governing the interchange of students and other forms and information concerning the program are available at the Registrar’s Office.

**Auditing**

Auditing is attending a course without credit. Participation in recitations or discussions (or the requirement of such participation) is at the discretion of the instructor. Auditors must register after classes begin, but before the end of the second week of classes, and may not register for credit in the audited course later in the term. They may, however, register in a later term for this course on a credit-hour basis. A permanent record will be maintained for the audit. The only grade given for the audited course is “AU” (Audit). Full-time matriculating Rensselaer students can audit up to three courses per semester on a nonfee basis with the permission of their adviser and the course instructor. Rensselaer students must be full-time for the summer term in order to be eligible to audit on a nonfee basis. The spouse of a full-time teaching assistant, research assistant, or fellowship recipient may audit one course per semester at no cost. All other persons, if granted auditing privileges, will be charged the regular credit hour fees for the course.
Program Adjustments (Drop/Add)

All Students Specific regulations are given below for undergraduate and graduate students. The following apply to all students.

Dropping or adding courses is done via Rensselaer’s Web registration system. Detailed instructions are available in the Class Hour Schedule. Responsibility for dropping or adding courses prior to the deadline rests entirely with the student. Failure to fulfill the responsibility because of an oversight, ignorance, or possibility of low grades is not sufficient grounds to petition for permission to drop or add a course after the deadline. It is the policy of the Institute that no petitions be accepted for the retroactive dropping or adding of a course except under extenuating circumstances beyond the student's control.

No credit will be given for a course in which the student is not properly registered. Failure to attend a class for which a student is registered or unofficial notification to the instructor does not constitute dropping a course and will result in an Administrative “F” (“FA” grade).

Undergraduate Students The following additional regulations apply to program adjustments:

• Undergraduates may add a course any time during the first 10 class days of a semester.
• A student may change sections of a course any time during the first two weeks of the semester.
• A student may drop a course any time during the first eight weeks of the semester.
• If a full-time undergraduate student is taking less than 12 credit hours, the director of the Advising and Learning Assistance Center must approve.
• During the summer sessions, courses may be added during the first week of each session. Courses may be dropped any time before the end of the third week of classes.

Only the Academic Standing Committee via the director of the Advising and Learning Assistance Center can make exceptions to the drop/add rules. Students wishing exceptions must petition with supporting documents from parties involved, such as instructors, adviser, or medical director.

Students who have approval to drop a course after the eighth week of classes will receive a grade of “W” in the course.

Under no circumstances will a student be permitted to register after the start of the last week of classes for the term.

Full tuition is charged after the fifth week of classes and prorated for courses dropped prior to the fifth week of the semester for students withdrawing from the university.

Graduate Students The following additional regulations apply to program adjustments:

• Tuition charges for part-time students are based on the number of credits a student is enrolled in at the end of the fifth week of the term independent of any further late drops. Any additions made after the fifth week result in additional tuition charges. Tuition for part-time students is charged on a per credit-hour basis.
• When program adjustments are made, the student’s Plan of Study should be updated accordingly.
• During the summer sessions, courses may be added during the first week of each session. Courses may be dropped any time before the end of the third week of classes.
• Graduate students may add a course any time during the first 10 class days of a semester.
• A student may change sections of a course any time during the first two weeks of a semester.
• A student may drop a course during the first eight weeks of the semester.
• A graduate student must take at least 12 credit hours each term to be considered a full-time student unless employed as a teaching assistant, in which case a minimum of nine credits is allowed.
• Graduate students receiving a summer stipend and students intending to graduate in the summer must register for the summer semester.

Only the Office of Graduate Education can make exceptions to the drop/add rules. Students wishing exceptions must petition the Office of Graduate Education. Exceptions may be granted under extenuating circumstances only.

Students who have the approval of the Office of Graduate Education to drop a course after the eighth week of classes will be given a grade of “W” in the course.
Academic Load

Undergraduate The normal academic load for undergraduates is 14 to 18 credit hours. An undergraduate whose program exceeds 21 credit hours must secure the written permission of his or her adviser. An undergraduate whose program is less than 12 credit hours must secure the written permission of his or her adviser and the director of the Advising and Learning Assistance Center.

The minimum requirement for a full-time undergraduate is 12 credit hours. An undergraduate student whose program is reduced to fewer than 12 credit hours in any semester may continue at Rensselaer only on the recommendation of the Committee on Academic Standing. The student must petition the committee for such recommendation.

Graduate The full-time load for a graduate student normally is 12 to 15 credit hours each term. A student who wishes to register for more than 15 credit hours must have the permission of his or her department and the approval of the Office of Graduate Education. A full-time student may register for as many as 12 credit hours during the summer, at the rate of six credit hours for each of two summer terms, with the permission of the adviser and the head of the department. Summer 2014 tuition is charged at $1,805 per credit hour for full-time students.

Graduate Teaching Assistants Graduate teaching assistants are not required to take more than nine credits per semester. However, at their own discretion and with Department Head and Office of Graduate Education approval, graduate assistants may take up to 15 credits per semester for the following reasons:

- Three additional credits assigned to a research project for thesis.
- Three additional course credits added to meet a specific academic objective.

Rensselaer Staff The maximum study load for a full-time member of the Rensselaer staff is eight credit hours per term. This includes all courses taken for credit, whether undergraduate or graduate. Requests from staff members to register for graduate research beyond the maximum study load are decided by the student’s department and the Office of Graduate Education.

Advisers

A faculty adviser is assigned to each student to assist in academic program planning toward a sound plan of study. Accordingly, the adviser’s signature is usually required on Pass/No Credit forms, thesis registration forms, and related forms. Students should contact their advisers on any matters pertaining to their educational programs. The Advising and Learning Assistance Center, the academic department, and the Office of Graduate Education are also available for consultation.

Undergraduate Curricula and Courses of Instruction

To ensure that all Plans of Study are educationally coherent and satisfy degree requirements, a curriculum has been constructed for each field in which the baccalaureate degree is offered. These curricula consist of required courses, recommended courses, course options, and electives. These curricula are outlined in the section of this catalog describing individual schools and departments.

Course Listing

Course descriptions can be seen in the Course Description section. Courses offered for undergraduate academic credit are those at the 1000-4000 levels. Higher-level numbers indicate courses designed primarily for graduate students.

Substitutions for Required Courses

Substitutions for required courses are permitted only with the approval of the heads of the departments concerned and the dean of the school or a designated representative. Where substitutions are granted, written notice must be filed with the registrar.

Undergraduates Taking Graduate Courses

Undergraduates may not ordinarily take graduate courses, unless they have already been accepted for graduate study by the Office of Graduate Education. Exceptions will be considered on an individual basis. An undergraduate wishing to take a graduate course must submit to the Office of Graduate Education a Request to Take a Graduate Course form (available online and at the Office of Graduate Education) that has been signed by his/her adviser and the instructor in charge of the course. Normally the Office of Graduate Education will not approve such a request unless the student meets the requirements for graduate admission. Generally this means that the student should be a senior with a grade point average of at least 3.0. The Office of Graduate Education reserves the right to cancel the registration of an undergraduate in a graduate course if the student has not received approval to take the course. No tuition refund will be given. Courses taken at the 6000 level must be taken on a letter grade basis; they may not be taken under the Pass/No Credit option.

Undergraduate students admitted to a co-terminal B.S./M.S. degree program are excused from submitting the Request to Take a Graduate Course form.
Curriculum Changes
Because life and growth are synonymous with change, the university continuously reevaluates its educational programs and procedures. This means that no curriculum is static, and the listings in this catalog are subject to modification. The entering student, therefore, is advised to keep abreast of his or her curriculum requirements.

An undergraduate student regularly admitted to the university is entitled to transfer from one curriculum to another, subject to the adequacy of related course work and availability of space. In certain curricula, such as the accelerated biomedical program and the management-law program, transfer possibilities are limited.

To make such a change, the student must complete a Change of Curriculum form available from the Registrar’s Office. Those students on academic probation or needing more advice will be referred to the department chair to which the transfer is requested.

Bachelor’s Degree
The bachelor’s degree is awarded to students who have pursued successfully, as evaluated by the faculty, a Plan of Study that encompasses several disciplines. Each Plan of Study has at least two objectives: first, to reach a preprofessional standing or fundamental mastery in a selected discipline; second, to develop some grounding in knowledge found in liberally educated persons, an appreciation of technology and science, and an openness to ongoing learning.

The requirements of each baccalaureate program are outlined as follows:

• The number of courses and credit hours is prescribed by each curriculum. Minimum requirements are 124 credit hours for science and for humanities and social sciences majors, 124 for management, 128 for engineering, and 168 for the professional degree in the School of Architecture.

• Effective Fall 2011, the minimum grade point average (GPA) is 2.00.

• To receive a baccalaureate degree, a student must have been admitted to the curriculum corresponding to the degree, must have satisfied the curriculum requirements, and must be enrolled in that curriculum at the time the degree is granted.

• The course content in physical, life, and engineering sciences must total a minimum of 24 credit hours, including at least eight credit hours of mathematics. For information on additional requirements see the School of Science section of this catalog.

• The course content in humanities and social sciences must total a minimum of 24 credit hours, including at least eight credit hours in the humanities and eight credit hours in the social sciences. For information on additional requirements see the School of Humanities, Arts, and Social Sciences section of this catalog.

• Every student is required to take at least two communication-intensive courses. At least one of these must be in the students’ major and at least one of the courses must be writing-intensive and taught in the School of Humanities, Arts, and Social Sciences. Courses used to fill the communication-intensive requirement may not be taken as Pass/No Credit.

• The minimum course concentration in the area of the selected discipline is prescribed by each curriculum but cannot be less than 30 credit hours.

• At least 24 credit hours are to be elective, of which no less than 12 credit hours are unrestricted electives.

• The student must be registered full-time for a minimum of four semesters. Two semesters of part-time study at Rensselaer will be considered equivalent to one semester of full-time study. In addition, the student must complete a minimum of 64 credit hours at Rensselaer, all of which will be applied to the baccalaureate degree. If a transfer student elects to study abroad or enroll in the co-op program, no more than 12 such credits may apply to the 64 needed for the bachelor’s degree. The student’s Plan of Study at Rensselaer must include at least 16 credits of courses above the 1000 level in the major field, or in an approved concentration.

The Institute requires a degree candidate to earn the last 30 credits in courses completed on this campus or through a program formally recognized by the Institute. Transfer courses are limited to two courses or eight credits counting toward the student’s last 30 credits and require approval of the director of the Advising and Learning Assistance Center.

Baccalaureate candidates must have passed all of the prescribed academic work and have satisfied the fee requirements. Candidates must also be in good academic and disciplinary standing. Undergraduate students on probation at the time of completion of course work may be required to meet certain stipulations for removal from probation. However, such requirements may be waived for those students whose cumulative GPAs satisfy the baccalaureate degree requirements. In general, a term’s work with grades of not less than C will be required in programs arranged by the Committee on Academic Standing. The director of the Advising and Learning Assistance Center will state requirements to the students in writing.
Degree candidates must be registered during the semester in which they intend to graduate and must file a degree application with the registrar by the dates specified in the academic calendar. Students who previously applied for graduation but did not complete all their requirements on time must submit a new application specifying the new date of graduation.

**Double Degrees**

A student may become a candidate for a second baccalaureate degree when he or she has completed: (1) the equivalent of at least two terms (30 credit hours) of additional work beyond the requirements of a single degree, and (2) the courses in the department in which the student is registered and such other courses as are required for the second degree.

**Dual Majors**

Undergraduate students who fulfill all the degree requirements for two curricula and who have met the conditions below will have completed a dual major. They will receive one diploma noting both majors. (1) The student must designate a first-named and second-named major in writing at least one semester prior to graduation, and have the appropriate department(s) approve this designation prior to filing the dual major form with the registrar. (2) Each student will be assigned an adviser in each department who will monitor progress towards degrees in that department. (3) The degree clearance officer in the department will certify that the student has met the degree requirements in that department. (4) The 24-credit-hour mathematics/science requirement and the 24-credit-hour humanities and social sciences requirement will satisfy the Institute requirements for both majors.

**Minors**

Within the distributional requirements described, the student may elect any courses that meet his or her personal or professional needs. Courses can be chosen to form a minor—that is, a set of courses coherent based on subject, methodology, or other factors. Many departments offer one or more such minors; several of the minors are interdisciplinary. A student wishing to complete a minor should consult with the adviser for that minor before completing the second course in it (departmental secretaries have this information). Minors vary in their requirements from 15 to 21 credit hours. Courses for the minor may not be taken on a Pass/No Credit basis. No course which is required for a major can be used for a minor requirement. No course which is required for one minor can be used for another minor requirement.

**Graduate Curricula and Courses of Instruction**

Individual curricula are given under the heading of departments in which they are offered. Course requirements and credit hours usually are tabulated term by term, with specific courses listed by number and title.

**Curriculum Changes**

Because life and growth are synonymous with change, the university continuously reevaluates its educational programs and procedures. This means that no curriculum is static, and the listings in this catalog are subject to modification. The entering student, therefore, is advised to keep abreast of his or her curricular requirements. Announcements of changes, if any, are available from the departmental offices.

A graduate student who wishes to change from one curriculum or department to another must file a Graduate Change of Status form, available at the Registrar’s Office. This change requires approval of the chairpersons involved and of the Office of Graduate Education. When further information is needed before a change can be approved, the student may be requested to follow graduate admission application procedures.

**Courses and Grade Requirements**

Courses offered for graduate credit bear the suffix numbers 4000-9990. However, those designated by 4000-4990 are open for credit to both graduates and advanced undergraduates, and there are limitations on the number of such courses that may be applied to a graduate degree. Undergraduate courses below the 4000 level may not be used for credit toward graduate degrees. Also, graduate students are not permitted to take courses on a Pass/No Credit basis.

The minimum average of all grades used for credit toward an advanced degree must be B. If a student's grades fall below a B average, the Office of Graduate Education may request that the department conduct a formal review to determine whether continuation is warranted. The student's adviser, committee, or department may recommend to the Office of Graduate Education that the student whose performance is unsatisfactory be dropped from the graduate program. A student who has accumulated two failing grades will be dropped from the graduate program.
Satisfactory Performance
Continuation in the graduate program requires satisfactory performance on the part of the student. Satisfactory performance is not limited to the academic record, but includes other appraisals of the student’s record and ability.

Substitutions for Required Courses
Substitutions for required courses are permitted only with the approval of the heads of the departments concerned and the Office of Graduate Education. Where substitutions are granted, written notice must be filed with the registrar.

Plan of Study
The graduate program is flexible and affords each student an opportunity to plan a course of study suited to his or her own objectives. To assure a coherent program in accord with the student’s maturing capacities and aims, each student is to maintain, with the adviser’s assistance, a Plan of Study for the degree for which he or she is studying.

The Plan of Study should be submitted during the student’s second full-time semester. To be considered valid, the Plan of Study requires the approval of the adviser and the designated departmental person. The Plan of Study is to be prepared on the forms provided by the Office of Graduate Education. Upon approval by the adviser and the designated departmental person, the department will transmit the original to the registrar, with copies going to the Office of Graduate Education, the student, and the adviser. The student should also keep a copy for himself or herself.

Each student who has filed a Plan of Study should register in the usual manner and in accordance with the plan. If there are any significant changes, a revised Plan of Study must be submitted promptly following the same procedure outlined above.

Master’s Degree
A student is admitted to study for the master’s degree when the student’s record indicates ability to do advanced work in that field. When a student decides to do graduate work in a field different from the undergraduate degree, however, the department may require him or her to establish additional background by taking certain undergraduate courses.

The Master of Science degree is under the auspices of the Office of Graduate Education. The Professional School in the School of Engineering provides the Master of Engineering degree. The professional Master of Architecture degree is provided by of the School of Architecture and the Master of Business Administration degree is provided by the Lally School of Management and Technology. The School of Humanities, Arts, and Social Sciences provides the Master of Fine Arts.

Office of Graduate Education Requirements
A candidate for a master’s degree must:

- Complete a Plan of Study, approved by the department with satisfactory grades. The master’s requires 30 credit hours beyond the bachelor’s degree. Certain programs have been specifically approved for additional credit hours, (e.g., the MBA requires 45 credit hours and M.F.A. requires 60 credit hours). At least half the total credit hours presented toward the degree must have the suffix numbers 6000-7999, with the further limitation that no more than 15 credits of 4000-4990 courses are to be allowed.

- Satisfy residence requirements.

- Present an independently written (single author) thesis or project, if required.

- Pursue a Plan of Study that will lead to the completion of all requirements, including those of the department, within two and one-half years.

- File a degree application with the Registrar’s Office by the date specified in the academic calendar for the semester in which he or she plans to be graduated. If a degree application was filed for a previous semester but the requirements were not fulfilled, a new degree application must be filed for the semester in which the student actually is graduated.

- Be in good academic and disciplinary standing.

- Satisfy the culminating experience requirement as specified by the department.

Full time graduate tuition will be paid the entire time a student is matriculated and in residence, except for special cohort programs. A student pursuing more than one master’s degree at Rensselaer must meet the above requirements for each degree sought.
Residence and Time Limit

A student working for a master's degree is required to be registered for at least two terms and to complete a minimum of 24 credit hours of resident instruction for each master's degree sought. Department residency must be met in addition to the Office of Graduate Education requirements. Residency requirements for the Troy campus may also be met within programs offered at certain off-campus sites (branch campuses).

For full-time students, all work for a master’s degree, whether done at Rensselaer or elsewhere, must be completed within two and one-half years of registration for the first credits applied toward the master’s degree. Full-time students not fulfilling the master’s degree requirements by the end of two and one-half years will be dismissed unless the Office of Graduate Education has given advanced approval for additional time to complete the degree. Extensions are granted for only the most compelling reasons and are rare. If approved, the student must register full-time for any additional terms and tuition is charged at the normal full-time rate. The student must be in good academic standing and have an acceptable Plan of Study. Satisfactory performance is not limited to academic record, but includes other appraisal of the student’s record and ability.

Students engaged in working professional programs (part-time students), must complete all work for the master’s degrees requiring 30 credits within three calendar years of the original admission date. Those working professionals working on master’s degrees requiring 60 credits must complete the requirements within five years, beginning with the date of the original admission letter. Extensions may only be granted if the student is in good academic standing and has an acceptable Plan of Study. Working professionals must petition and receive approval from the Dean of Graduate Education.

The Office of Graduate Education may initiate an academic review of any student who has accumulated more than 36 credits on a master’s degree program (more than 66 for a 60-credit master’s) without satisfying degree requirements.

A Master’s Plan of Study must contain no more than the minimum number of credits required for the degree, that is, 30 for the M.S., (except the M.S. in Lighting which requires 48), and 45 for the MBA and 60 for the M.F.A. Credits earned in addition to these degree minimums may not be added to the Plan of Study.

Thesis, Projects, and Professional Projects

Certain departments may specify presentation of a thesis or completion of a master’s project as a requirement for a master’s degree. Usually, six, and no more than nine, credit hours are allowed for a master’s thesis or multiple semester master’s project. Professional projects are completed in one semester and are limited to four credit hours for each project.

In a department that ordinarily requires a thesis or project, a student may be permitted to substitute additional courses that constitute a comparable culminating experience on recommendation of the adviser and with the approval of the department head.

When a student’s program includes a thesis, the supervision of the course of study and the research for the thesis are entrusted to a committee whose members are selected in consultation with the director of the graduate program. Each committee consists of at least three members of the faculty associated with the student’s graduate program. One non-program member is permitted, but this selection must be approved by the director of the graduate program. No substitutes are permitted. In either case, the student is encouraged to seek advice during the course of study from the graduate director, committee chair, and professor supervising his or her courses. No graduate student should regard a program of study as the mere accumulation of numerical credits and meeting of formal requirements. Progress toward mastery of a discipline depends largely upon the guidance of the professors in charge of the effort and upon the student’s initiative.

The thesis must be approved by the professor in charge and accepted by the other members of the student’s committee. The thesis or project report must be presented to the candidate’s adviser committee for review by the date specified in the academic calendar for the semester in which the degree is to be awarded. Thesis and dissertation credits must be graded S or U at the end of each semester in which they are registered. Professional projects and certain other multiple semester projects receive a standard letter grade.

Thesis Submission

The candidate must provide the Office of Graduate Education with the Record of Master’s Thesis & Oral Presentation form, with original signatures and supporting documents outlined on the Thesis Checklist, no later than by the date specified in the academic calendar for the semester in which the degree is expected to be awarded. Upon receipt of the required materials, the candidate is then required to upload an electronic copy of the thesis and submit the required fee via the ETD Administrator Web site in order for the official review to begin by The Office of Graduate Education. The Office of Graduate Education must review and approve the thesis before the degree can be awarded.

Publication of Thesis

When the candidate submits his or her thesis through the ETD Administrator Web site, he or she must pay a fee to cover the costs of printing and binding one original copy for preservation at the Rensselaer Libraries. After the thesis is approved by the Office of Graduate Education, it is made available through Rensselaer Digital Collections and ProQuest's Dissertations & Theses database. When the thesis is submitted to ProQuest by the Rensselaer Libraries, a microfilm copy of the dissertation is also deposited with the Library of Congress.
A student who wishes to publish or present publicly any portion of his or her dissertation before it has been accepted in fulfillment of his or her degree requirement must have the permission of the adviser or chair of his or her doctoral committee. Any dissertation material so presented must include the following statement: “This paper is taken in part from a dissertation to be submitted in partial fulfillment for the degree of _______________________ at Rensselaer Polytechnic Institute.”

The right of conventional publication is in no way abridged by the availability of the thesis through Rensselaer Digital Collections, the ProQuest Dissertations & Theses database, or the Library of Congress, and the student is urged to seek additional publication in scholarly journals or elsewhere.

**Doctoral Degree**

Rensselaer awards the doctor’s degree in recognition of high achievement in scholarship and independent investigation. The Doctor of Philosophy degree, under the auspices of the Office of Graduate Education, is awarded when the dissertation is directed toward making an original contribution to fundamental knowledge in a particular field or in an interdisciplinary field. A dissertation that is scholarly, creative, original, and publishable may deal also with the relation of a discipline to educational problems and objectives within the field. The Doctor of Engineering degree, under the auspices of the Professional School of the School of Engineering, is awarded when the student proposes an engineering problem of substance and develops a solution to it in a creative and distinguished manner.

**Office of Graduate Education Requirements**

A candidate for the doctorate degree must:

- Complete a Plan of Study with satisfactory grades containing a minimum of 72 credit hours beyond the bachelor’s degree including any appropriate work completed toward a master’s degree. Some programs require 90 credits; please check individual departmental policies. In satisfying degree requirements at least two-thirds of the total credit hours, excluding thesis, must contain the suffix numbers 6000-7999, with the further limitation that no more than 15 credit hours of 4000-4990 courses are to be allowed for a 72-credit-hour doctorate or no more than 21 credit hours of 4000-4999 courses for a 90-credit doctorate.
- Satisfy residence requirements.
- Form an approved doctoral committee.
- Pass a candidacy examination.
- Present an independently written (single author) dissertation.
- Pass a final examination.
- Pursue a Plan of Study that will lead to the completion of all requirements, including those of his or her department, within seven years or if entering with a master’s, five years.
- File a degree application with the Registrar’s Office by the date specified in the academic calendar for the semester in which he or she plans to be graduated. If a degree application was filed for a previous semester but the requirements were not fulfilled, a new degree application must be filed for the semester in which the student actually is graduated.
- Be in good academic and disciplinary standing.

To be eligible to graduate, degree candidates must maintain registration per the graduate tuition and student support policy.

**Residence and Time Limit**

By New York State Education Department policy, doctoral programs shall require a minimum of three academic years (consecutive fall and spring semesters) of full-time graduate level study, or their equivalent in part-time study. Rensselaer requires that two of the three academic years are spent as a full time student, or part time equivalent, in a Rensselaer doctoral program. A student working for the doctoral degree must earn a minimum of 72 credit hours, and in some programs 90 credit hours, toward their doctoral plan of study. Of these credits, at least 48 credit hours in course and/or thesis work must be taken while in residence at Rensselaer Troy, Rensselaer Hartford, via Rensselaer Distance Programs, or a combination of these.

For full-time students, all work for the doctoral must be completed within seven years of registration for the first credits applied toward the degree, whether enrolled in a 72- or 90-credit program. All doctoral candidates must pass the appropriate examinations as determined by their department within two years of registration for the first credits applied toward the Ph.D. Full-time students entering with a master’s degree in their field of study must finish all degree requirements for the Ph.D. within a continuous five-year time period. Students who have
not met their applicable time limit will be dismissed from the program unless the Office of Graduate Education has given advanced approval for additional time to complete the degree. Extensions are granted for only the most compelling reasons and are extremely rare.

Individuals who leave Rensselaer without obtaining an authorized leave of absence and who have not requested an extension before the seven-year limit will be dismissed from the program. Individuals who do receive authorized leaves because of serious illness, involuntary military service, or maternity leave can, with the submission of the medical or military documentation, request the Office of Graduate Education to exclude up to two years of authorized leave time from the seven-year limit.

**Doctoral Committee**

The program director of the student's department assigns an academic adviser to guide the student until a doctoral committee can be appointed. As soon as the student has chosen a dissertation area, he or she must arrange to conduct the dissertation work with an adviser who is a full-time tenure-track member of the faculty. The dissertation adviser then consults with the chair of the student's department regarding the nomination of a doctoral committee of at least four members. The graduate program director sends the nominations to the Office of Graduate Education for approval.

Each candidate for the doctorate pursues, under faculty direction, an original investigation of a problem or problems in a field of concentration and presents the results of the investigation in a dissertation. The dissertation must be approved by a minimum of three members of a faculty committee of four members. The member of the faculty associated with the program who supervises the student's investigation becomes chair of the committee. The panel also includes two members or associate members of the faculty associated with the program and an "outside" member, who is appointed by the program director in consultation with the student's adviser. Whenever possible, "outside" shall be "outside the university," but in all cases this person must come from outside the program. The outside member is expected to be a recognized authority on the subject of the dissertation. For appointments of committee members who are not members of the faculty, the program director will forward to the Office of Graduate Education a letter appointing the individual to the committee. This letter should explain the basis for the appointment and must include the address of the appointee.

For committees having more than four members, only one non-approval is permitted. Substitutions in committee membership, once it has been determined, are the responsibility of the program director. Replacements will occur only if a member is unable to serve or if a student's dissertation topic changes, requiring a new dissertation director and/or modification in the committee. In cases other than these, approval for changes in committee membership rests with the Dean of the Office of Graduate Education.

The committee will meet to discuss the candidate's dissertation proposal once the candidate has developed some preliminary guidelines with the advice of the dissertation supervisor. Whenever possible, the outside member of the committee will be at this initial meeting. Subsequently, the committee must be kept informed of the student's progress and must agree to follow the candidate's work and assist in its development. The committee also shall agree to give ample and early warning of any reservations concerning the student's progress and must specify in writing the changes required for dissertation acceptance.

**Plan of Doctoral Study**

A prospective candidate for the doctorate ordinarily follows a Plan of Study of a minimum of 72 credit hours, and in certain programs up to 90 credit hours beyond the bachelor's degree, including any appropriate work completed toward a master's degree. Students must list on their Plan of Doctoral Study only the credits that are sufficient to meet the academic requirements for the doctoral degree. Students should list these credits in chronological order of registration, and should stop listing credits once they have listed the minimum number required for the degree, even if they have earned additional credits beyond the minimum.

**Candidacy**

A student may sit for the candidacy examination, given by his or her doctoral committee, when:

- His or her course work nears completion.
- The student has an approved doctoral examining committee.
- He or she has the approval of his or her doctoral committee to take the candidacy exam.
- The candidacy examination must be passed within two years of the date at which the department has formally determined the student is qualified to conduct research (i.e. qualifying or field exams, or the department equivalent).

A student is admitted to candidacy for the doctorate when he or she has passed the candidacy examination and is recommended for such candidacy from his or her doctoral committee and department. The student is admitted to candidacy upon approval by the Office of Graduate Education. All degree requirements, including the dissertation, must be completed within three years of passing the candidacy exam.
Dissertation and Final Examination

The doctoral dissertation demonstrates the candidate's capacity for independent work. It embodies the results of an original investigation in the candidate's principal field of study on a subject approved by the student's doctoral committee. Only work meeting the highest standards of integrity will be accepted for degree requirements at Rensselaer. Academic integrity is a requirement of continued good academic standing and for the awarding of a graduate degree. The field of the dissertation should be chosen as soon as possible after entry upon doctoral study. A Preparation Guide for Dissertation and Theses containing required format specifications is available on the Office of Graduate Education's Web site at http://www.rpi.edu/dept/grad/docs/ThesisManual.pdf. Before preparing the final manuscript, please check the Office of Graduate Education Web site for the most recent formatting and submission guidelines.

The dissertation is presented to the candidate's dissertation adviser by the date specified in the academic calendar for the semester in which the degree is expected to be awarded. Each member of the doctoral committee must be presented with an unbound copy of the dissertation at least one week before the final examination is scheduled.

Dissertation Defense/Final Examination When the dissertation is completed, the candidate must defend it in a public examination conducted by his or her doctoral committee, which passes on its acceptability. The final examination is to be held by the date listed in the academic calendar for the year. The committee transmits a record of its decision on the dissertation examination to the Office of Graduate Education.

Dissertation Submission After passing the final examination and no later than the date specified in the academic calendar for the semester in which the degree is expected to be awarded, the candidate must provide the Office of Graduate Education with the Record of Dissertation Exam form and supporting documents outlined on the Dissertation Checklist. The Record of Dissertation Exam form, approving both content and format, must include original signatures from all doctoral committee members. Upon receipt of the required materials, the candidate is then required to upload an electronic copy of the dissertation and submit the required fee via the ETD Administrator Web site in order for the official review to begin by the Office of Graduate Education. The Office of Graduate Education must review and approve the dissertation before the degree can be awarded.

Publication of Dissertation When the candidate submits his or her dissertation through the ETD Administrator Web site, he or she must pay a fee to cover the costs of printing and binding one original copy for preservation at the Rensselaer Libraries. After the dissertation is approved by the Office of Graduate Education, it is made available through Rensselaer Digital Collections and ProQuest's Dissertations & Theses database. When the dissertation is submitted to ProQuest by the Rensselaer Libraries, a microfilm copy of the dissertation is also deposited with the Library of Congress.

A student who wishes to publish or present publicly any portion of his or her dissertation before it has been accepted in fulfillment of his or her degree requirement must have the permission of the adviser or chair of his or her doctoral committee. Any dissertation material so presented must include the following statement: "This paper is taken in part from a dissertation to be submitted in partial fulfillment for the degree of _____________________ at Rensselaer Polytechnic Institute."

The right of conventional publication is in no way abridged by the availability of the dissertation through Rensselaer Digital Collections, the ProQuest Dissertations & Theses database, or the Library of Congress, and the student is urged to seek additional publication in technical journals or elsewhere.

Academic Credit

Units of Credit

Academic credit is assigned in terms of credit hours. For formal course work, one credit hour represents one lecture or recitation hour or one laboratory period per week for one term. Approximately three hours of endeavor per week, both in and out of class, are associated with each credit hour. Contact hours are the number of class hours per week. When the number of contact hours differs from the credit hours for a course, the course description so indicates.

Students Entering Rensselaer as Freshmen Incoming freshmen may be eligible for advanced placement or advanced standing.

Advanced Placement The student should request the Educational Testing Service (ETS) to send Advanced Placement (AP) scores to the Registrar's Office at Rensselaer. The scores are evaluated and notice of the decision is sent to the student. Credit is granted, but there is no grade assigned and the credit is not included in calculating the grade point average (GPA).

Students who have completed the General Certificate of Education (GCE) Advanced Level Examinations may receive credit for relevant courses. Students must have an official copy of the Advanced level examination results sent to the Registrar. The scores are evaluated and the student will be notified of the credit decisions. No grade is assigned and the credit in not included in calculating the grade point average.
**Advanced Standing** Credit may be granted for college-level work taken while in high school. Transfer credit will not be given for any college courses taken while in high school if these courses are used in obtaining the high school diploma. One exception is the matriculated student who attends college full time and transfers back credits to complete the high school diploma. This rule does not exclude the possibility of placement in a higher level of a subject area without being given academic credit for the placement. "Placement" in this case does not refer to the Educational Testing Service Advanced Placement Tests, which are accepted at the Institute depending on the level of score.

After admission, the student should have an official copy of a transcript from the college sent to the Registrar’s Office at Rensselaer along with a copy of the course description for each course. The appropriate academic department evaluates the material. If acceptable, it is posted on the student’s record and a copy of that record is sent to the student. No grade is given and it is not included in calculating the GPA.

Rensselaer Polytechnic Institute does not accept the College Level Entrance Program (CLEP) for credit.

**Undergraduate Students Entering Rensselaer from Another College** Students entering Rensselaer from another college must apply to the Office of Transfer Admissions. The Office of Transfer Admissions notifies the student of the results of preliminary evaluation and requests the student to send a final transcript at the end of the current semester to the Office of Transfer Admissions. After the final course evaluation is made, the credit hours will be posted on the student’s permanent record. No grade is given for accepted courses, nor are these courses included in calculating the GPA.

**Undergraduate Transfer Credit**

Subject to specific approval, academic credit for courses taken at another college or university may be transferred to Rensselaer. For information on additional requirements for transferring Humanities and Social Sciences credits or Science credits, refer to the individual school’s section of this catalog. Rensselaer students taking courses at other institutions should follow the following procedures.

The Transfer Credit Approval form, which can be obtained in the Registrar’s Office, should be used for approval of all transfer credit granted. Equivalent "A," “B,” or "C" grade work is required for transfer credit. The minimum equivalent grade accepted for transfer credit is “C-.”

Students desiring to take course work at other institutions should obtain approval prior to enrollment at that institution. Transfer credit cannot be guaranteed unless prior approval is obtained, since unapproved courses may not be equivalent to Rensselaer courses. In addition, many institutions require proof of prior approval before allowing a visiting student to register.

Students entering as first-time freshmen can transfer a maximum of 32 credits (including Advanced Placement credit or other equivalent credit). Students entering as transfer students must complete 4 full-time semesters at Rensselaer and a minimum of 64 credits at Rensselaer, all of which will be applied to the baccalaureate degree. Students who participate in study-abroad programs not affiliated with the Institute may transfer in a maximum of 16 transfer credits from that program. Those credits will count toward the maximum 32 transfer credits allowed. Students who participate in study-abroad programs that are affiliated with the Institute can transfer in additional credits. Those credits will not count toward the maximum 32 transfer credits allowed.

Students desiring transfer credit must have the registrar of the other institution forward an official transcript to the Registrar’s Office. A student who repeats at another college a course failed at Rensselaer may be required by the department at Rensselaer to pass an examination.

The Institute requires a degree candidate’s last 30 credits in courses to be completed on this campus or through a program formally recognized by the Institute. Transfer courses are limited to two courses or eight credits counting toward the student’s last 30 credits and require approval of the director of the Advising and Learning Assistance Center.

A student transferring back to Rensselaer who now holds an associate’s degree and who formerly was a Rensselaer matriculating student may begin a new cumulative GPA subject to the approval of the director of the Advising and Learning Assistance Center. His or her former Rensselaer courses will still appear on the permanent record but will not be calculated in the new GPA.

**Graduate Credit by Transfer and Examination**

Credit for graduate work completed at other accredited institutions may be offered in partial fulfillment of the requirements for a degree at Rensselaer when the work is appropriate to the student’s program. As a rule, this work will have been earned prior to enrolling at Rensselaer, but no more than five years prior to matriculation. Students already enrolled at Rensselaer who wish to take courses elsewhere must obtain the prior approval of his or her adviser and the Dean of Graduate Education.

Because the residence requirement for the master’s is 24 credit hours, not more than six credit hours may be transferred toward the 30-credit master’s degree, and not more than six credit hours used for a master’s degree in one area can be applied to a second master’s degree of 30 credits. In no case can the result of transfer or waived credits reduce this general degree requirement below 24 earned credit hours in a master’s program at Rensselaer.
Because the residence requirement for the Ph.D. degree is 48 credit hours, no more than 24 credit hours may be transferred toward the doctorate.

Application for the transfer of credit must be made to the student’s department. The department is responsible for evaluating course work taken elsewhere and reporting allowable transfer credit to the registrar on the transfer credit approval form. Courses taken elsewhere and approved for transfer to Rensselaer must be taken at the graduate level and have a grade of “B-” or better to be approved. They are not considered in computing the B average requirement.

A student who obtains the approval of his or her adviser and the Dean of Graduate Education to work elsewhere while already enrolled at Rensselaer must apply for transfer of credits as soon as the credit has been earned. Transfer of Credit forms may be obtained from the Registrar’s Office.

A graduate student who has taken courses at Rensselaer as a special nondegree student may transfer to a degree program a maximum of 12 credits earned in that status. If a student has taken a graduate credit course while an undergraduate, received a grade of B or B- or better, and did not use the credit to fulfill the requirements for the bachelor’s degree, he or she may request, through the faculty adviser, that the Office of Graduate Education count the credit toward the requirements for an advanced degree.

Class Attendance and Examinations

Attendance Requirements

The academic department concerned generally determines requirements for class attendance. Each instructor must make these requirements clear at the beginning of the course, and the student must abide by them. If the instructor does not inform the class of the attendance policy, the class should ask for a statement of the policy.

The instructor maintains the academic standards held by Rensselaer. The instructor who defers a class or changes his or her class schedule for any reason is still responsible for arranging for the work that is missed. The entire class must agree with any change in a class meeting schedule or final exam schedule.

When an instructor finds a student’s attendance unsatisfactory, the student may be referred to the class dean or dean of students for counseling.

A student who is a member of an authorized team or organization for which events are scheduled should meet with the professor in advance to request an excuse from class attendance during the time actually spent away from the campus or during the hours of the events on campus. The student still has to complete the work that is missed. A student admitted to hospital will, upon request, receive a written excuse from the medical director.

Because Rensselaer is a nondenominational university that welcomes all faiths, the decision regarding absence from classes and laboratories on religious holidays is left to the individual. In the case of conflicts between the university calendar and an individual’s beliefs, students, faculty, and administrative staff will make arrangements to assure that religious participation is not restricted.

Final Examinations

The examinations given at the end of each semester take place at the times announced on the examination schedule, published prior to the examination period. No student is allowed more than one final examination in a course. (See Senior ‘F’ Examination Rule.)

Every student has to take all of his or her examinations at the scheduled time unless excused because of illness or other sufficient reason by the dean of students/Student Experience Office or, in the case of graduate students, by the Office of Graduate Education. Students with exam conflicts (i.e., examinations scheduled at the same time) should contact their course instructors to schedule a make-up exam. Examinations for lower level courses generally take precedence over the upper level courses. Students with more than two exams on one day can request a make up examination. Details on the procedures will be announced with the final examination schedule. The reason for an expected absence should be presented in advance of the examination. The dean of students/Student Experience Office or the dean of the Office of Graduate Education will accept no excuse on the grounds of illness unless the medical director approves it.

The student who has been excused by the dean of students/Student Experience Office or dean of the Office of Graduate Education from a final examination is reported “NE” (Not Examined) and will be examined later at a time set by the instructor. Only the dean of students/ Student Experience Office and the Office of Graduate Education may excuse a student from a final examination. Unless so excused, a student who is absent from final examinations is given zero credit for the exam and may at the discretion of the instructor be given an “F” for the course.
Senior “F” Examination Rule

Senior students who have no outstanding failures on record that would prevent graduation and who fail only one course taken during the first semester of their senior year and who are candidates for a degree at the end of the second semester, may be eligible to take a re-examination in the course that was failed. These students must not have outstanding “I” or “NE” grades, either in prior semesters or in the current semester that would prohibit them from graduating. A senior who fails a course in the second semester may take a re-examination providing the course failed is the only course preventing his or her graduation.

Students must apply to the registrar to qualify for a Senior “F” Exam. The registrar will certify the eligibility of the student for a re-examination and authorize the instructor to examine eligible students.

For students who seek to qualify for their bachelor’s degree in the spring semester, the following applies: A student failing a course in the fall semester of the senior year will be examined after the middle and before the end of the spring term. If it is possible to repeat the failed course in the spring semester, the student has that option. A re-examination in a failed spring semester course may not be taken until the first summer session at the earliest. The time of the re-examination will be at the discretion of the department involved.

Students should know that it may not be possible to give re-examination in courses that require certain physical facilities until those facilities are again available.

For students who seek to qualify for their bachelor’s degree in August or December, similar rules apply. The student should consult the registrar for details.

Under no circumstances will an examination be taken later than one year after the end of the term in which the failure occurred. The results of the re-examination when passed or failed will not alter the term or cumulative grade point average previously earned nor remove the “F” grade from the record. When passed, a statement is posted on the transcript stating the failed course was passed by re-examination.

Study-Review Period

No classes or exams will be held during the study-review period at the end of the semester. This day or these days will be the study period for final examinations.

Grading System

Letter Grades

The letter grades and their meanings are:

- **A** = Excellent, **A-** = Excellent
- **B+** = Good, **B** = Good, **B-** = Good
- **C+** = Average, **C** = Average, **C-** = Average
- **D+** = Passed, **D** = Passed (not available to graduate students)
- **F** = Failed, **FA** = Failed (due to administrative reasons)
- **I** = Incomplete course work
- **IP** = In Progress (multiple-term course)
- **NE** = Not Examined
- **NC** = Failed a Pass/No Credit course (undergraduates only)
- **P** = Passed a Pass/No Credit course (undergraduates only)
- **S** = Satisfactory in a Satisfactory/Unsatisfactory graded course
- **U** = Unsatisfactory in a Satisfactory/Unsatisfactory graded course
- **W** = Withdrawn
- **WI** = Failed (course that was previously graded “I” and the student did not meet the deadline for completing course work)
- **Z** = Grade Unknown-see instructor
- **AU** = Audit
**“D” Grade** The letter grades “D” or “D+” does not apply to graduate students. Thus, when a graduate student takes a course that is also open to undergraduates and performs at a level equivalent to a “D” or “D+” grade, this grade cannot be recorded. Such grades are automatically converted to “F.”

**“FA” Grade** This letter grade is assigned by the registrar to students who withdraw from a course but do not submit a Drop/Add form or an official notice of withdrawal from the university.

**“I” Grade** The grade “I” (incomplete course work) is given, when, due to illness or other extenuating circumstances such as a personal emergency beyond the student’s control, a student has been unable to complete the required course work. The “I” grade is given only after the contract form, Authorization for Grade of Incomplete, has been completed and signed by both the instructor and the student and received by the registrar. The “I” grade is given only in instances of incomplete course work, such as laboratory exercises, course projects, term papers, etc. Under no circumstances may the “I” be given for the following situations:

- Absence from a final examination.
- Student on class list who has never attended class.
- Student who wishes to do additional post-semester work in order to improve a grade.
- Student who wishes to repeat the course as auditor, retaking examinations, etc., in order to improve a grade.

The “I” grade must be completed within one semester. If facilities (i.e., laboratory) are required to complete the outstanding work but are not available during the next semester, then one year is the maximum time limit, subject to approval by the instructor.

If the agreements made in the “I” grade contract are not observed or if the “I” grade is not cleared in the time specified in the contract, the grade automatically becomes the grade noted on the “I” contract at the time the “I” contract is signed. If no grade is noted on the contract the “I” grade automatically becomes a “WI.” Once the “I” grade is changed to “WI,” no other grade change will be accepted. The “WI” grade will be calculated as an “F” in the student’s GPA. The grade of “I” is considered a penalty grade in the calculation of the term GPA. The grade of “I,” until it is changed, is calculated as if it were the grade of “F.”

**“WI” Grade** The registrar assigns this letter grade to students who received an Incomplete (“I”) and failed to meet the criteria or the deadline specified in the “I” contract. It is calculated as an “F” in the student’s GPA.

**“IP” Grade** The (In Progress) grade is given at the end of preliminary semesters of multiple-term courses such as Thesis, Project, or Research.

**“NE” Grade** The “NE” grade is given only by the dean of students/Student Experience Office or the Office of Graduate Education to students who have been excused from taking a final exam at its scheduled time. In each case, the course instructor is to be informed. (See “Final Examinations” rules listed previously.) If the examination is not taken by the date specified, the grade automatically becomes an “F.” Once the “NE” grade is changed to an “F,” no other grade change will be accepted.

Grades of “NE” given in the fall semester must be made up during the spring semester. “NE” grades given at the end of the spring semester must be made up during the summer recess and not later than two weeks after the beginning of the fall semester. The grade of “NE” is not considered in the calculation of the term GPA.

**“P” and “NC” Grades (Pass/No Credit Option)** Subject to the limitations listed below, undergraduate students may elect to take courses on a pass or no credit basis, for which the grade is either “P” (Pass) or “NC” (Fail). Grade points will not be assigned for these courses and the “P” or “NC” will not be reflected in the grade point average. “NC” is a failing grade and can be cause for academic action. Courses taken on a Pass/No Credit option can count toward credit-hour and distribution requirements if the grade “P” is received. This option allows a student to take courses outside his or her normal curriculum or minor program that, because of grade considerations, the student otherwise might not consider.

A student may take no more than 12 credit hours of courses designated as Pass/No Credit courses. No more than six credits of these may be humanities and social sciences courses used to satisfy the requirements of the undergraduate courses in these fields. A Pass/No Credit course may not be used in the HASS depth requirement. Courses graded Satisfactory/Unsatisfactory only are not included in the above restrictions. For the five-year B. Arch. curriculum, the Pass/No Credit option is extended, giving a maximum of 16 Pass/No Credit credits.

No course previously failed or specifically required by name or required to be chosen from a list of named courses in the student’s curriculum or minor may be taken on a Pass/No Credit basis. Courses at the 6000 level may not be taken on a Pass/No Credit basis.
A student exercising the Pass/No Credit option must file a form with the registrar before the Friday of the 13th week of the semester. Having elected to take a course on this basis, a student may drop the Pass/No Credit designation by notifying the registrar in writing by the Friday of the 13th week of classes for the semester.

This option is not available to graduate students or nonmatriculated students.

*S* and *U* Grades These grades can only be assigned in courses specifically approved for such grading. Examples of such courses are seminar, thesis, or certain general electives.

*W* Grade The grade of “W” is assigned when a student is permitted to withdraw from a course after the deadline to drop a course. Only the Office of Graduate Education or the Academic Standing Committee can permit a student to drop a course after the deadline. If permission is granted, the registrar will assign a grade of “W.”

*Z* Grade The registrar assigns the grade of “Z” if the instructor does not submit the course grade in time to print the semester grade reports. The student should see his or her instructor for a grade.

**Grade point average**

A student's grade point average is determined on the basis of the following numbers assigned to the letter grades: A=4, A-=3.67, B+=3.33, B=3, B-=2.67, C+=2.33, C=2, C-=1.67, D+=1.33, D=1, F=0, I=0, FA=0, WI=0. The grades P, U, S, IP, NE, NC, W, and Z are not considered in computing averages. The grade point average is computed by multiplying the number corresponding to the grade in each course by the number of credit hours for the course, totaling these products for the courses taken, and then dividing the sum by the total number of credit hours for the courses considered.

The grade point average for the term is computed at the end of each term. The cumulative grade point average is also computed at the end of each term for the full period of attendance at the university.

All grades are included in computing the average; even those earned in courses not required for the degree sought. Courses taken at institutions other than those at a consortium college, or through exchange programs are not included in calculating the GPA although they may qualify for credit.

Undergraduate Repeating a Course If an undergraduate repeats a course, both grades are entered on the record. However, course credit will count only once and, although both grades appear on the transcript, the grade received in the repeated course is always the one used in computing the GPA. Senior “F” examination rules remain the same. The grade for a repeated course taken on a Pass/No Credit basis or for which the student receives a grade of “W” or taken at another institution cannot be used in place of the original course grade in calculating the GPA. Students in a premedical or preprofessional program may want to consult with their advisers before repeating a course.

Graduate Repeating a Course If a graduate student repeats a course, both grades are entered on the record. However, course credit will count only once and, although both grades appear on the transcript, the grade received in the repeated course is always the one used in computing the GPA. The grade for a repeated course for which the student receives a grade of “W” or taken at another institution cannot be used in place of the original course grade in calculating the GPA.

**Scholastic Reports**

Grades are reported to the registrar at the end of each semester. Students are responsible for knowledge of their deficiencies and failures and may obtain a copy of their grades from the Registrar’s Office or may view their grades online. Only final semester grades are part of the student’s permanent record. Class rankings for undergraduates are calculated only once a semester, at the time grade reports are printed. Final semester grades and transcripts may be withheld from the student because of an outstanding bill to the Institute or because of pending disciplinary action.

**Curriculum Advising and Program Planning**

A Curriculum Advising and Program Planning (CAPP) report is available online for undergraduate students. This report shows what degree requirements have been met and identifies those requirements that are outstanding.

**Undergraduate Academic Honors**

A student who in any semester attains a grade point average of 3.00 or better and has no grade below C is placed on the Dean’s List for the following semester. Grades below “C” include “I,” “C-,” “D+,” “D,” “F,” “FA,” “U,” and “NC.” No student will be placed on the Dean’s List who takes less than 12 credit hours. Thus, a student must have completed at least 12 credit hours with the grades of A, A-, B+, B, B-, C+ or C.
The Dean's List is compiled at the end of the grading period. No students will be placed on the Dean's List retroactively except in the case of administrative error or late submission of grade reports by a professor. A student will not be placed on the Dean's List upon resolving a grade of “I.”

**Undergraduate Graduation Honors**

Undergraduate students with cumulative grade point averages of 3.50 or higher will receive special recognition with the following inscriptions on their diplomas: “Cum Laude” (3.50-3.69), “Magna Cum Laude” (3.70-3.89), and “Summa Cum Laude” (3.90-4.0).

To be eligible for such recognition, the student must have completed two years in residence in the four-year program or three years in residence in a five-year program.

**Academic Standing**

A student is considered in good academic standing if the student is making satisfactory progress toward his or her educational goals. Students not making satisfactory progress will be suspended or dismissed from the university. The university serves students from diverse educational backgrounds and interests and recognizes the individual differences in educational goals between matriculating and nonmatriculated students, between full-time and part-time students, and between graduate and undergraduate students.

**Undergraduate Academic Probation**

Students are placed on academic probation as a warning that they are in jeopardy of losing their good academic standing. Students are informed of their probationary status by a letter from the director of the Advising and Learning Assistance Center at the end of the semester. Academic and extracurricular restrictions may be placed on them so that they can concentrate on their academic programs.

A student whose grade point average for any term falls below 1.50 is placed on academic probation automatically. In addition, any student whose cumulative grade point average falls below the following specified averages is automatically placed on probation: freshmen – 1.50 at the end of the fall term or 1.80 at the end of the spring term; sophomore – 1.80 at the end of the fall term or 2.0 at the end of the spring term; juniors and seniors -2.0 at the end of the fall or spring term.

**Undergraduate Academic Suspension and Dismissal**

The Committee on Academic Standing reviews the records of students subject to suspension or dismissal. The committee is authorized to suspend or dismiss any student who:

- Fails to qualify for removal from probationary status at the end of a term.
- Has been on probation for two separate terms and is subject a third time to probationary status.
- Fails three or more courses in any one term.

**Undergraduate Disciplinary Suspension or Expulsion**

A student whose behavior is in violation of university regulations is subject to disciplinary action. This may result in disciplinary suspension or expulsion from Rensselaer. These disciplinary actions may become a permanent part of the student's record. A student who is expelled for disciplinary reasons cannot apply for readmission.

**Graduate Academic Suspension and Dismissal**

Students may be required to terminate their graduate studies and withdraw from graduate study if they fail to maintain satisfactory academic or professional standards in any phase of their graduate programs. Conditions imposed at the time of admission must be satisfied by each student. Non-adherence to the schedule of time limits for degrees may constitute a basis for termination.

When such problems occur, the program director notifies the student in writing of its concern about the student’s performance. Such a warning specifies the source of the concern, the applicable program or graduate school rules, and the proposed action. Warnings specify when and on what basis a recommendation for academic dismissal will be considered by the faculty. A probationary period of one semester is normal. (In cases of extremely poor performance, the program faculty may determine that a probationary period is not justified and may move directly to a recommendation for dismissal.)

Following the probationary period, a student who fails to meet the provisions of the warning is considered for dismissal by the faculty. A faculty vote is recorded on any motion to recommend dismissal, and a letter is written to the student stating the faculty action and its rationale.
When termination is recommended, the graduate program director communicates to the Dean of the Office of Graduate Education in writing the specific reasons involved, all warnings communicated to the student, the faculty procedures and actions leading to the recommendation, the recorded faculty vote for dismissal, and the mailing address of the student. The Dean of the Graduate School will write the actual letter of termination to the student. A student who is dismissed from a graduate program is not eligible for readmission or for a change of curriculum except under conditions stated in the letter of dismissal.

International students are required to make normal progress toward their degree in order to maintain their legal status. International students facing serious academic problems that could lead to probation and/or termination are urged to consult with the Office of International Services for Students and Scholars (ISSS) as soon as they are made aware of such problems.

Nonmatriculated Undergraduate Student Eligibility
The Advising and Learning Assistance Center reviews the records of nonmatriculated undergraduates each semester to determine if the student is performing satisfactorily. A student whose academic performance is not satisfactory as determined by the director of the Advising and Learning Assistance Center and the Committee on Academic Standing will not be permitted to continue at Rensselaer. Also, nonmatriculated students are permitted access to courses on a space available basis.

Nonmatriculated Graduate Student Eligibility
The records of nonmatriculated graduate students will be reviewed each semester to determine if the student is performing satisfactorily. If it appears that the student is not performing satisfactorily, the academic department will be consulted, if appropriate, and it may be determined that the student not be permitted to continue at Rensselaer. Also, nonmatriculated students are permitted access to courses on a space-available basis.

Activities Eligibility Requirements
In order to participate in activities sponsored by the Rensselaer Union, the student must pay an activities fee. Certain activities such as intercollegiate athletics may have special requirements such as minimum credit hour registration, graduate or undergraduate status, etc. Students on academic probation risk being dismissed from the university if they continue without improvement and should, therefore, examine carefully time committed to extracurricular activities. Any student pursuing a campus-wide leadership position (Grand Marshal and/or President of the Union) must have a cumulative grade point average of 2.5 or better to be eligible to seek a campus-wide leadership position.

A meeting to review academic performance and potential risk to the student’s status must be arranged between the student and a member of the Student Experience Office by the second week of the semester following that in which the student was placed on academic probation. The student is responsible for arranging this meeting.

To leave the Institute in good standing, an undergraduate must complete the necessary paperwork from the Student Experience Office and a graduate student must submit a letter to the Office of Graduate Education stating the reasons for withdrawal and the student’s last day of residence on campus. Students who withdraw prior to the eighth week of the semester will receive no grades for the semester. Students who are permitted to withdraw after the eighth week of classes will receive the grade of “W” in all courses. A student who must withdraw for medical reasons may be exempt from this rule if the medical director determines that it is advisable for the student to withdraw. Students who withdraw without informing the Student Experience Office or the Office of Graduate Education will receive a grade of “F” in all courses. Undergraduates will be subject to action by the Committee on Academic Standing. Students must meet with their Class Dean before submitting paperwork for a withdrawal from Rensselaer.

Withdrawal From Rensselaer
To leave the Institute in good standing, an undergraduate must complete the necessary paperwork from the Student Experience Office. A graduate student must submit a letter to the Office of Graduate Education stating the reasons for withdrawal and the student’s last day of residence on campus.

Students who withdraw prior to the eighth week of the semester will receive no grades for the semester. Students who are permitted to withdraw after the eighth week of classes will receive the grade of “W” in all courses.

The student who must withdraw for medical reasons may be exempt from this rule if the medical director determines that it is advisable for the student to withdraw.

Students who withdraw without informing the Student Experience Office or the Office of Graduate Education will receive a grade of “F” in all courses. Undergraduates will be subject to action by the Committee on Academic Standing.
**Undergraduate Student Leave of Absence**

Students who wish to spend a period of time away from Rensselaer may request a leave of absence. In order to be considered for a leave, undergraduate students must complete the necessary paperwork from the Student Experience Office, stating the reasons for the request and the length of leave desired. Undergraduate leaves are normally given for up to one year. For financial aid purposes only, a leave of absence is limited. Once the allowable period of time has expired, students are considered withdrawn.

Students may also be placed on an involuntary leave of absence from Rensselaer for four possible reasons: (1) the student is unable to meet financial obligation to the Bursar’s Office. Any outstanding amounts from a prior semester(s) must be paid in full (along with current semester bill) in order for reinstatement. If not, then the student is placed on a mandatory financial leave of absence with an effective date of the first day of classes. (2) It is determined by medical or psychological professional staff that the student should not attend the semester. A mandatory leave of absence is placed on the student record with an effective date based on professional assessment. (3) The Dean of Students Office declares an emergency removal from campus. A mandatory leave of absence is placed on the student record with an effective date to correspond to the actual emergency removal from campus. (4) There is a disciplinary sanction such as a suspension or expulsion. A mandatory separation is placed on the student record with an effective date of when the actual sanction is issued.

Additionally, if a student does not register for classes during a particular semester, they may be placed on an administrative leave of absence effective during that semester. If a student voluntarily or involuntarily is placed on leave, they must go through the readmission process to return to campus, provided they are in clear financial standing and have met all the necessary requirements. Once a student is placed on a leave of absence, the student must verify the re-instatement deadline with the Student Experience Office if they choose to return to Rensselaer.

**Graduate Leave of Absence and Withdrawal**

Graduate students who wish to spend time away from their studies may request a Leave of Absence (LOA) by contacting the Office of Graduate Education. Leaves are generally granted only during the first eight weeks of classes. Tuition refunds are based on the schedule listed in the Tuition and Fees section of this catalog. The maximum length of time granted for an initial leave request is one year. Under extenuating circumstances, students may request an extension for an additional year by contacting the Office of Graduate Education. A leave of absence does not afford extra time to complete the degree. Exceptions to this rule can be requested when the leave is taken for maternity, medical, or military reasons.

The following processes apply to graduate student leave of absence, dismissal, and withdrawal:

1. If a graduate student is unable to meet his or her financial obligation to the Bursar’s Office, any prior semester balances plus the current semester bill must be paid in full before the Bursar will remove student account’s financial hold. Otherwise, the Bursar’s Office will place the student on a mandatory financial leave of absence with an effective date of the first day of classes.

2. If a Rensselaer medical or psychological professional determines that a graduate student should not attend the semester, they will recommend a medical leave of absence to the Office of Graduate Education. The Health Services Department and the Office of Graduate Education will determine the leave’s effective date. The medical director will make the final decision on readmission or continuance in the program for students on medical leave of absence.

3. If the Office of Graduate Education or the Dean of Students Office (DOSO) declares an emergency removal of a graduate student from campus, these offices will determine the effective date of the dismissal, suspension or mandatory leave.

4. If a graduate student is dismissed for disciplinary reasons, the effective date is determined at the time, not based on final appeal.

**Effective Date**

The Health Services Department and the Office of Graduate Education determine the effective date of medical withdrawals. This date shall reflect a date that the withdrawal is actually necessary and shall be the determining factor when calculating refunds. To ensure compliance with Title IV federal funding agencies, **back dating of leaves or withdrawals is not possible for graduate students with Title IV federal loans.**

**Undergraduate Readmission of Students Dismissed for Academic Reasons**

Students who have been dismissed from the Institute for academic reasons may apply for readmission after one full academic term (not including summer school) has elapsed. The Student Experience Office, along with the Committee on Academic Standing, makes all readmission decisions concerning academically dismissed undergraduate students. Requests for readmission should be on file at least two months prior to the term in which readmission is desired. Transcripts and course descriptions of work taken elsewhere must be submitted as part of the readmission process. Applications for readmission should be received from and returned to the Student Experience Office.
Undergraduate Readmission of Students Dismissed for Financial Reasons

Please note that students who are academically dismissed and placed on a financial leave of absence must fulfill the conditions of both statuses prior to return.

Undergraduate Readmission of Students Suspended for Disciplinary Reasons

Students suspended from the Institute for disciplinary reasons may reapply one month prior to the end of their suspension. Approval for readmission may be obtained from the Student Experience Office/Dean of Students.

Undergraduate Readmission of Students in Good Standing

Students who have been permitted to withdraw in good standing or who have been granted a leave of absence will ordinarily be readmitted through the readmission process in the Student Experience Office.

Graduate Readmission

Graduate students desiring readmission within one year of leaving the program must fill out a Graduate Change of Status form, which is available online. A student requesting readmission will be required to have approval of the graduate program and the Office of Graduate Education. Graduate programs and/or the Office of Graduate Education may require reapplication. Students returning from official or unofficial absence must submit a new application if the absence exceeded one year.

Medical Determinations

The medical director will make final decisions regarding readmission or continuance in the university when medical factors are a consideration.

Academic Prizes

The date in parentheses indicates the year in which the prize was established.

The Macdonald Prize (1890) The prize, established by Charles Macdonald, Class of 1857, consists of the net annual income from $2,000. It is awarded at Commencement to a senior in civil engineering who has demonstrated outstanding ability in academic work and gives promise of outstanding professional success.

American Institute of Architects Henry Adams Medal (1914) The American Institute of Architects award is an engraved medal to the top-ranking graduating student in an architecture program accredited by NAAB. A certificate of merit is awarded to the second-ranking graduating student. Formerly called “The School Medal”, the program began in 1914 and was awarded for “general excellence in architecture throughout the four-year course to graduating students of architecture schools recognized by the Institute”. This prize is given for scholastic achievement, character and promise of a successful professional career.

The Macfarlane Prize (1924) The prize, established by Mrs. Walker D. Hines in memory of her father, Graham Macfarlane, Class of 1872, consists of the net annual income from the Macfarlane Fund. It is awarded to the student who has presented the best computer graphics project during the work of the first year.

The Class of 1902 Research Prize (1927) Established by the Class of 1902. It is awarded at Commencement to the senior in the School of Science or Engineering who has completed at least two semesters of undergraduate research and who presents the best research results culminating in a written report, submitted paper, or thesis.

The Ricketts Prizes (1928) The prizes, five in number, consist in each case of the net annual income from $2,000. Three of the prizes were established by Palmer C. Ricketts, Class of 1875, who served Rensselaer for 50 years as instructor, professor, director, and president. They are awarded at Commencement to a senior in mechanical engineering, to a senior in electric power or electrical and systems engineering, and to a senior in chemical engineering. Other prizes were established in 1935 and 1936 by President Ricketts’ widow, Vjera C. Ricketts. They are awarded at Commencement to a senior in the School of Architecture and to a senior in aeronautical engineering. The conditions are the same as those governing the award of the Macdonald Prize.

The Ray Palmer Baker Prize (1937) The prize, established by bequest of Vjera C. Ricketts, widow of President Ricketts, consists of the net annual income from $2,000. It is awarded at Commencement to a senior in management engineering. The conditions are the same as those governing the Macdonald Prize.

The Matthew W. Del Gaudio Award (1937) The New York Society of Architects awards this prize annually to a graduating student in architecture who has shown excellence in total design.
The William Pitt Mason Prize (1939) The prize was established by friends and former students of William Pitt Mason, a graduate in the Class of 1874 and professor of chemistry and chemical engineering at Rensselaer for 50 years. The prize consists of the net annual income from $2,000 and is awarded at Commencement to a senior in the Department of Chemistry. The conditions are the same as those governing the Macdonald Prize.

The Mary A. Earl McKinney Prizes (1941) These prizes, established by Dr. Samuel P. McKinney, Class of 1884, consist of the net annual income from $9,000. They are awarded in the form of first and second prizes in two contests, one for freshmen, and the other for all undergraduates. These contests are designed to test proficiency and improvement in English. The contests were originated by Homer H. Nugent, who served Rensselaer for 27 years as professor of rhetoric and head of the Department of English.

The Caird Prize (1945) Established by James M. Caird, Class of 1895, and Barbara J. Caird, the prize consists of the net annual income from $2,000. It is awarded at Commencement to the senior who has demonstrated outstanding ability in environmental engineering. In a year when no senior is eligible, this award may be made to a graduate student who, by high achievement in academic work and demonstrated qualities of character and leadership, gives promise of outstanding success in professional practice in environmental engineering.

The Matthew Albert Hunter Prize in Metallurgical Engineering (1951) An annual award based on the income from funds contributed by former students of Dr. Hunter, the prize is awarded annually to the senior in materials engineering who has demonstrated outstanding ability in academic work leading to a career in that field.

The Wynant James Williams Prize in Electrical Engineering (1954) An annual award based on the income from funds contributed by friends and former students of Prof. Williams, the prize is awarded annually to a senior in electric power or electrical and systems engineering for outstanding scholarship, personality, and promise.

The Harriet R. Peck Prize (1954) An award established by friends of Miss Peck, head librarian of Rensselaer from 1912 to 1947. Presented to a fifth-year student in the School of Architecture for the best solution of a problem in architectural design. The prize is awarded in selected years.

The Alpha Rho Chi Medal (1955) An annual award established by Alpha Rho Chi, a professional architectural fraternity, the medal is given to a member of the graduating class in the School of Architecture for leadership, service rendered to the school, and promise of professional merit.

The Scott Mackay Award (1958) An annual award based on the income from funds contributed by former students of Prof. Mackay, the award is made to a senior in materials engineering who has given time and effort to the service of others without seeking recognition or acclaim, and who has completed the academic program at Rensselaer creditably.

The Arthur M. Greene Prize (1960) Established by J. Erik Jonsson, Class of 1922, in memory of Dr. Arthur M. Greene, professor of mechanical engineering from 1907 to 1922, this prize consists of the net annual income from $5,000. It is awarded at Commencement to a senior in mechanical engineering who, in the opinion of the professors in the department, has demonstrated the all-around qualities most likely to lead to professional distinction.

The J. Erik Jonsson Prize (1960) Established by J. Erik Jonsson, Class of 1922, the prize consists of the net annual income from $5,000 and is awarded at Commencement to a senior who has spent at least three years at Rensselaer and has achieved the highest academic record in the class.

The Harold N. Trevett Award (1960) An annual award based on the income from funds contributed by friends and former students of Prof. Trevett, the prize is awarded annually to a senior in electric power or electrical and systems engineering for outstanding scholarship in electric power or electrical and systems engineering subjects during the junior and senior years.

The G. Howard Carragan Award (1961) An annual award based on the income from funds contributed by friends and former students of Prof. Carragan, the prize is awarded to a senior in the Department of Physics for outstanding scholarship.

The W. Franklin Spafford Prize (1961) Established by an anonymous donor in honor of the first head of the Department of Management Engineering. This prize is awarded at Commencement to a graduate student in management who has demonstrated high scholastic ability and has made a substantial contribution to that field.

The Joseph L. Rosenholtz Prize (1963) An annual award based on the income from funds contributed by friends and former students of Prof. Rosenholtz, the prize is awarded to a senior for outstanding work in earth sciences. Should no student qualify for the prize in any one year, the funds available for the prize may be used for related purposes as determined by the Board of Trustees.

The Thomas Archibald Bedford Prize (1964) Established by Clay P. Bedford in memory of his father, the prize is awarded at Commencement to a graduate student in civil engineering who has demonstrated high scholastic ability and has made a substantial contribution to the field. The selection is made by the provost upon recommendations from the Office of Graduate Education. Should no student qualify for the prize in any one year, the funds available may be used for related purposes as determined by the Board of Trustees.
The John and Mary Cloke Prize (1964) This prize is an annual award from the income of a retirement gift given to Prof. and Mrs. Cloke by students and associates of Dr. John B. Cloke, a member of the chemistry faculty for 45 years. Prof. Cloke established the prize to be awarded at Commencement to a graduating senior in the Department of Chemistry who is continuing in chemistry, medicine, or biological science, and who has made a distinguished record, especially in the department.

The Livingston W. Houston Citizenship Award (1964) Established by Clay P. Bedford, the prize is given in memory of Livingston Waddell Houston, 11th president of Rensselaer. It is awarded at Commencement to a student who, in the opinion of a committee consisting of the president of the university, the provost, dean of students, director of athletics, and director of the student union, is considered the “First Citizen of the College.” The recipient must rank high in character, leadership, scholarship, and athletic ability. Should no student qualify for the prize in any one year, the funds available for the prize may be used for related purposes as determined by the Board of Trustees.

The Allen B. DuMont Prize (1969) Established by the Allen B. DuMont Foundation in memory of Dr. DuMont, this prize is awarded at Commencement to a graduate student in electrical and systems engineering who has demonstrated high scholastic ability and has made a substantial contribution to that field. Should no student qualify for the prize in any one year, the funds available may be used for related purposes as determined by the Board of Trustees.

The Max Hirsch Prize (1972) The prize, established by Prof. Edith H. Luchins in memory of her father, consists of the net annual income from $2,000. It is awarded at Commencement to a senior in the Department of Mathematical Sciences who has demonstrated outstanding ability in academic work and gives promise of outstanding success in a career in mathematical sciences.

The Michael A. Sadowsky Prize (1972) This prize was established by former students and friends of Dr. Sadowsky, professor emeritus of mechanics. It is awarded at Commencement in selected years to a master’s degree candidate in mechanics for outstanding scholarship and a demonstrated ability in the application of mechanics.

The Ralph Ernest Huston Prize (1973) The prize was established by Antoinette K. Huston and sons, Peter, Kenneth, Richard, and T. Michael, in memory of Dr. Ralph Huston, professor of mathematics from 1934 to 1969. It is awarded at Commencement to the first- or second-year graduate student in the Department of Mathematical Sciences who has demonstrated unusual promise and ability as a teacher. Should no student qualify for the prize in any one year, the funds available may be used for related purposes as determined by the Board of Trustees.

The Charles D. Dyce Prize (1975) The prize was established by friends in memory of Charles D. Dyce, Class of 1972. It is to be awarded to a student in the School of Engineering who, at the conclusion of the freshman or sophomore year, has demonstrated high scholastic ability and involvement in extracurricular activities and indicates potential for constructive leadership.

The Erwin R. Gaerttner Prize (1975) The Gaerttner Prize is awarded to a senior majoring in nuclear engineering or engineering physics who intends to pursue graduate study in that field. The award consists of the annual income from funds contributed by friends and former students of the late Prof. Gaerttner and is bestowed in recognition of general excellence in scholarship, personal character and attitudes, and promise of outstanding performance in research related to nuclear engineering and engineering physics.

The Lt. Charles D. Dyce Award (1976) Established in memory of Lt. Dyce, Class of 1972, this award is presented to a freshman or sophomore cadet in the Army Reserve Officers Training Corps who has demonstrated high leadership potential and outstanding military bearing and whose superior performance has served to support cadet corps activities. Selection is made in a manner prescribed by the chairman of the Department of Military Science.

The Leopold L. Balleisen Prize (1976) Established by Donald H. Balleisen in memory of his father, a graduate in the Class of 1918. For a senior who has won a varsity letter in his or her senior year and one other year and, of those thus qualified, stands highest academically in the senior class.

The Hillard B. Huntington Award (1976) The prize was established by friends and former students of the late Hillard B. Huntington, professor emeritus of physics. It is awarded at Commencement to an outstanding graduate student in physics.

The Lewis S. Coonley Prize (1978) An annual award established by friends and former students of Prof. Coonley, the prize is awarded to one or more graduating seniors to honor achievement that betokens success in the practice of chemical engineering process design.

The Clarence E. Davies Award (1978) Sponsored by the Hudson-Mohawk Section of the American Society of Mechanical Engineers (ASME), in honor of Col. Davies, a 1914 graduate of Rensselaer who was ASME executive secretary from 1934 to 1957, this award is presented at Commencement to an outstanding senior in mechanical engineering.
The Henry J. Nolte Memorial Prize (1978) The prize, established in memory of Henry J. Nolte, who attended Rensselaer in the class of 1919, consists of the net annual income from $1,100. It is awarded at Commencement to a baccalaureate or master's degree candidate in electrical and systems engineering who has done an outstanding engineering research or design project.

The Joaquin B. Diaz Memorial Prize (1978) Established by friends, family, and colleagues in memory of Dr. Joaquin B. Diaz, the Albert Einstein Professor of Science at Rensselaer from 1967 to 1978, this award is presented to a graduate student who shows ability and enthusiasm for research in mathematics.

The Del and Edith Karger Dissertation Prize in Management (1978) This prize is awarded to a graduate student in the School of Management whose original publication is judged an outstanding contribution by a committee of faculty and alumni.

The L. David Walthousen Award (1979) This award is presented annually to a senior in the Department of Nuclear Engineering and Engineering Physics who shows promise of excellence in the experimental aspects of nuclear engineering. The award consists of the annual income from funds contributed by friends and former students of the late L. David Walthousen, supervisor of the RPI Critical Facility.

The Myron P. Laughlin Prize (1980) The prize, established by Myron P. Laughlin, consists of income from a $1,000 mortgage bond. It is awarded to the student who has written the best pre-engineering laboratory report.

W. H. Bauer Doctoral Prize in Chemistry (1981) This prize is awarded to the candidate who has an exceptional graduate record, has carried out meritorious doctoral thesis research and shows outstanding promise in the field of chemistry. The prize is derived from the income earned from an endowment established by friends and colleagues of Walter H. Bauer, professor of chemistry 1934-72 and dean of science 1960-72.

The Willie Stanton Award (1981) Established by the Rensselaer Union, the award is in honor of William P. (Willie) Stanton, Class of 1972 (hon.), a dishwasher and cook who served the academic and social needs of Rensselaer students for over 45 years. It is presented annually to the senior who is judged to have contributed the most to the service of the student body. The selection committee consists of the vice provost for student affairs, the dean of students, and the director of the Rensselaer Union.

The Karen & Lester Gerhardt Prize in Science and Engineering (1982) This prize was established to honor a full-time engineering or science doctoral candidate, who by the originality and insight of his or her work emphasizes the tradition of excellence that is Rensselaer.

The Edwin J. Holstein Memorial Award (1983) This prize was established to recognize outstanding academic achievement in economic science.

The Paul B. Daitch Award (1984) An annual award based on the income from funds contributed by his family, friends, and colleagues in memory of Professor Paul B. Daitch, the prize is awarded at Commencement to the graduating biomedical engineering senior who combines both outstanding scholarship and level of service to RPI and/or the community, in keeping with Dr. Daitch's interest in public service.

The Paul E. Hemke Award (1985) Sponsored by the Northeastern New York Section of the American Institute for Aeronautics and Astronautics, in honor of Dr. Paul E. Hemke who founded the Aeronautical Engineering Department at Rensselaer. The award is presented at Commencement to a senior in Aeronautical Engineering in recognition of outstanding academic achievement and promise for a successful professional career.

The Delmar W. Karger Award in Management (1986) This award is made to the outstanding graduating master's student in management based upon academic record and leadership, as judged by a committee of faculty and alumni.

The Epsilon Delta Sigma Award (1986) An annual award established by Epsilon Delta Sigma, the Honorary Management Society, given to an undergraduate or graduate management student who has demonstrated outstanding service to the School of Management.

The Paul A. McGloin Prize (1989) An annual prize established in honor of Professor Paul McGloin, scholar and teacher in the computer science and mathematical sciences departments from 1955 to 1989. The prize is given to an outstanding senior in computer science.

The Robert McNaughton Prize (1989) An annual prize established in honor of Professor Robert McNaughton, scholar and teacher in the computer science and mathematical sciences departments from 1967 to 1989. The prize is given to an outstanding graduate student in computer science.

The Roland Walker Prize (1989) This prize was established by friends and former students of Roland Walker, professor emeritus of biology. The prize is awarded to a senior in biology for outstanding scholarship.

The Del and Ruth Karger Dissertation Prize in the Department of Decision Sciences and Engineering Systems (1991) The prize is awarded at Commencement to a doctoral degree candidate in DSES whose dissertation is deemed outstanding.

The Delmar W. Karger Award in the Department of Decision Sciences and Engineering Systems (1991) The award is made at Commencement to a master's degree candidate in DSES whose master's work-including a project or thesis-is deemed outstanding.
The U.W. Marx Prize (1991) The award is given by U.W. Marx, a general contractor and construction management firm in Troy, NY. It is awarded for the best undergraduate project in civil engineering during the academic year.

The Walter Eppenstein '52 Graduate Teaching Assistant Award (1991) Established by friends and colleagues of Walter Eppenstein, professor emeritus of physics, to honor his contributions to education at Rensselaer. It is awarded to one or two graduate students for outstanding contribution to our teaching program.

The Charles M. Close '62 Doctoral Prize (1992) The prize is based on income derived from contributions by members of the electrical, computer, and systems engineering faculty in honor of their colleague Professor Charles M. Close. The prize is awarded annually to a doctoral candidate in electrical, computer, and systems engineering who has done outstanding work as a researcher and teacher, and who shows promise of a distinguished academic or research career.

The Robert G. LaFleur Geology Prize (1993) The prize was established by friends of Professor Robert G. LaFleur for students demonstrating an excellent record in, commitment to, and promise in the field of environmental geoscience.

The Edward J. Kilcawley Prize (1994) The prize was established to perpetuate the memory of Professor Edward J. Kilcawley, a visionary environmentalist, a “man before his time” and to reward a graduate student following his field by Frank R. Sherman, BCE Class of 1939, for whom “Kil” was a mentor, an inspiration, and a life-long good friend. It is awarded at Commencement to a recipient of the degree of Master of Civil Engineering who has pursued his studies in environmental issues, is possessed of the qualifications required for the MacDonald Prize, has been elected to memberships in Tau Beta Pi and the Society of the Sigma Xi, and is a native born citizen of the United States.

The Val Carlson ’52, Architect, AIA, Award (1997) This endowment fund established by Val Carlson ’52 is presented annually to the most improved student graduating from the School of Architecture with a Bachelor of Architecture degree. Preference is given to students from the state of Connecticut. If no person from Connecticut qualifies, then students from the New England states will be considered.

The Stanley I. Landgraf Prize ‘46 (1998) An annual prize established to honor Stanley Landgraf, Rensselaer trustee, Acting President, and friend of the Computer Science Department. The prize is given to a computer science major who excels in leadership skills and academic achievement.


The Jack Hollingsworth Prize (1999) An annual prize given to honor Jack Hollingsworth, professor of mathematics. This prize is awarded to a computer science student who made a major contribution to the educational program at Rensselaer.

The Severino Center Award in Entrepreneurship (2000) An annual prize given to an outstanding undergraduate management student with a concentration in technological entrepreneurship.

The Glenn Martin Mueller ’64 Prize (2000) An annual prize established to honor Glenn Martin Mueller, Rensselaer Trustee and graduate, Class of 1964. A leading venture capitalist in Silicon Valley, Glenn was a champion of the entrepreneur, funding many successful start-up companies. This prize is given to a computer science major who is deemed to be the most entrepreneurial.

The George H. Handelman Award for Graduate Study in Applied Math (2000) This award is given to a graduating senior (in any field) who shows promise in applied mathematics and has been admitted to a graduate program in Applied Mathematics.

The Dr. Johanna Maas Chemistry Teaching Assistant Award (2000) This award is presented annually to one or more graduate students for outstanding service in the teaching program of the Chemistry Department. It was established by Sonja Krause, Class of 1954, and others in memory of Dr. Johanna Zelie Maas, chemist, physician, Holocaust survivor, and humanitarian.

Architecture Faculty Award (2001) Faculty award to a graduating student who has demonstrated exceptional all-around capacity and promise for a successful career in architecture.

The Zelda and David G. Gisser Prize in Biomedical Engineering (2002) An annual prize established by Zelda Gisser in memory of her husband, David G. Gisser. It is awarded to a biomedical engineering graduate student whose dissertation is considered exemplary in the area of experimental work.

The Malcolm S. Morse Graduate Research Enhancement Award (2007) Established by Gertrude G. Morse to honor Dr. Pauline Oliveros, Distinguished Research Professor, visionary composer, and founder of the Deep Listening Institute, Ltd. Recipients are either Ph.D. or M.F.A. graduate students of the Arts Department of the School of Humanities, Arts, and Social Sciences at Rensselaer Polytechnic Institute.

Henry Ehrlich Prize in Microbiology and Environmental Sciences (2012) The Henry Ehrlich Prize in Microbiology and Environmental Sciences is awarded for excellence in scholarship to either a graduating senior or graduate student (MS, PhD) in the Department of Biology who plans to pursue a career in microbiology and/or environmental sciences.
Interdisciplinary Studies

In its efforts to shape tomorrow’s leaders, Rensselaer’s faculty has created innovative interdisciplinary curricula. Students are encouraged to work in inter- and cross-disciplinary programs that allow them to combine scholarly work from several departments or schools.

Applied Science

The Master of Science degree traditionally has been in a single discipline, such as chemistry, physics, or mathematics. However, college graduates today and in the future face working environments where jobs increasingly bridge more than one area of specialization. The M.S. in Applied Science Program is based upon Rensselaer’s belief that science graduates need different types of preparation for today’s interdisciplinary world. Students are encouraged, in cooperation with academic advisers, to design a degree program that crosses different subject areas, including at least one field of science. Options exist in many areas of science in which Rensselaer faculty have expertise.

Biochemistry and Biophysics

Two such closely related fields as biochemistry and biophysics are a logical choice for combination into an interdisciplinary degree program. Biochemical and biophysical research is advancing the frontiers of research in the basic life sciences and making possible advances in more applied fields such as medicine and agriculture. Rensselaer’s B.S. in Biochemistry and Biophysics provides exceptional preparation for graduates planning careers in medicine. M.S. and Ph.D. degrees are also available in this interdisciplinary field and are ideal preparation for jobs in biotechnology, pharmaceuticals, and other areas of fundamental research related to medicine.

Bioinformatics and Molecular Biology

Computational biology has changed the way we do biotechnology. Now there is a demand for graduates with strong backgrounds in biology, biochemistry, mathematics, and computer programming. Rensselaer offers an interdisciplinary B.S. degree that covers the theory and practice of bioinformatics and molecular biology, with core topics such as sequence alignment, database searching and design, phylogenetics, molecular modeling, statistics, biotechnology, drug discovery and genomics. M.S. and Ph.D. degrees are also available through one of several departments and programs.

Design, Innovation, and Society

Design, Innovation, and Society (DIS) merges the technical with the creative and stimulates originality. The DIS major combines engineering courses, STS courses, and design studios. The Design, Innovation, and Society degree is offered by the School of Humanities, Arts, and Social Sciences. This program offers a B.S. degree in DIS as well as the opportunity to dual major in Mechanical Engineering, Management, and other curricula.

Ecological Economics, Values, and Policy (Professional Master’s)

The professional master’s program is aimed at early and mid-career professionals in state and local government, secondary education, business, and the nonprofit sector who are looking to upgrade their skills and advance their careers. The program helps students to acquire the skills they will need to address the complex multidisciplinary problems any society faces in such areas as environment and health and sustainable development.

Electronic Media, Arts, and Communication (EMAC)

The EMAC degree combines communication theory and practice with electronic media arts studio and theory. This program combines offerings in the Department of Communication and Media and the Arts Department.

Environmental Science

The challenges of sustaining a habitable Earth, of maintaining and enhancing the quality of the physical environment, and providing energy, food, and shelter for an increasing population will be met by a new generation of environmental scientists. Undergraduate training in this area requires broader perspective than any single science discipline affords, and a transformative education that explores the basic science of natural systems and human modification of the environment. Rensselaer’s B.S. in Environmental Science addresses these challenges with a multifaceted program.
Games & Simulation Arts and Sciences

The GSAS program is a comprehensive B.S. that also offers an opportunity for a dual major. GSAS stresses acquiring both fundamental principles and skills in a range of disciplines and also obtaining some depth in a single area of concentration in game studies. The curriculum provides many team experiences and cycles of design, analysis, and iteration, as well as a formal research component. This core curriculum will help ensure that graduates can develop as leaders in the game industry as well as in other fields that make use of highly interactive media, e.g. training and simulation applications found in business, education, and government; business management in emerging new media fields.

Information Technology and Web Science

Rensselaer’s unique multi-disciplinary degrees offered in the Information Technology and Web Science program allow our students to explore the World Wide Web and other IT technologies from the algorithmic, engineering, and social perspective. Students in the program learn about the physical science underlying the Web and the social science of its impact, as well as the skills involved in running large-scale information systems, developing Web applications, or dealing with the social and policy implications of IT and Web deployments. Students take a core set of courses on Web and IT development and management, as well as developing an expertise in a concentration involving multiple courses from a selection of over 20 options including arts, engineering, management, communications, artificial intelligence, Web systems and medicine among many others. The program leads to a Bachelor of Science in Information Technology and Web Science, a Master of Science in Information Technology, or a Ph.D. in multidisciplinary science with a focus on advanced Web and Informatics Technologies.

Interdisciplinary Science

The most exciting discoveries and innovations today often occur at the boundaries between the traditional science disciplines and result from the application of basic principles and knowledge across many of these disciplines. Rensselaer’s B.S. program in Interdisciplinary Science provides students with the opportunity to explore these boundaries in meaningful ways and to combine this study of science with non-science disciplines such as management, law, education, communication, public service, economics, policymaking, or community affairs.

Interschool Minor in Energy

Rensselaer offers this interschool minor as an opportunity for students in any undergraduate major to learn about a wide variety of issues involved in understanding energy. It includes fundamental courses in architecture, engineering, management, science, and the humanities and social sciences.

Multidisciplinary Science

Today’s college graduates with traditional discipline-oriented backgrounds are discovering that their jobs bridge more than one area of specialization. Rensselaer’s M.S. and Ph.D. programs in Multidisciplinary Science focus on helping graduates perform more effectively in multidisciplinary environments. Students in these programs interact with faculty representing a variety of disciplines. They also participate in interdisciplinary research that crosses at least two science disciplines, or at least one in science and one or more in engineering.

Master of Engineering Program in Systems Engineering and Technology Management (SETM)

The School of Engineering and the Lally School of Management jointly offer a unique Master of Engineering program in Systems Engineering and Technology Management (SETM) through the Department of Decision Sciences and Engineering Systems. This is a 30-credit-hour program leading to the Master of Engineering degree that is open to qualified undergraduates from other institutions, but is primarily intended as a co-terminal degree option for Rensselaer engineering undergraduates. It is designed to provide engineering students with an opportunity to extend their technical depth within their disciplines while providing fundamental background in technical decision making methods and technology management. The program will introduce the metrics of business performance, the analytical modeling tools for applying these metrics in organizational and technical decision making systems, and the critical challenges associated with new models of value creation and business growth across different industries. Graduates of the program will have technical depth in the engineering discipline beyond the Bachelor’s level and be prepared to assume management responsibilities sooner upon entering the professional workforce.
Significant changes are occurring within the discipline and profession of architecture in the areas of globalization, interdisciplinary teamwork, emerging technologies, and an increased awareness of the environment. Together with a strong creative focus on design, these issues are at the core of Rensselaer’s undergraduate and graduate architecture programs. The school offers semester-long international study programs in Italy, India, and China; a studio culture that encourages study and research between disciplines; and the most ambitious applications of information-based design and technology integration while encouraging critical thinking and awareness of human and social consequence. In addition, Architecture’s newest program in Built Ecologies, based at Skidmore, Owings & Merrill in New York City allows both undergraduates and graduates to study and work on the latest advances in sustainable technologies and next-generation building systems and designs. An estimated faculty of 35 includes a complement of clinical and adjunct professors drawn from research and practices across the region centering their instruction on design, which is the core of the professional experience.

These same qualities characterize Rensselaer’s uniquely positioned graduate programs in Architectural Acoustics, Built Ecologies, and Lighting, as well as the three-and-a-half-year professional master’s degree that is designed for those with undergraduate degrees in other fields. Each of these focuses on aspects of technology appropriate to Rensselaer and incorporates program elements of Rensselaer’s nationally renowned Lighting Research Center. The Doctor of Philosophy in Architectural Sciences degree supports research and scholarship across all areas of graduate study.

To both its undergraduate and graduate students, Rensselaer’s School of Architecture offers an outstanding collection of resources and state-of-the-art facilities. Rensselaer’s Architecture Library, the only branch library on the campus, is located at the center of the school and is a major student, faculty, and professional resource. This library contains over 30,000 books and periodicals, both domestic and foreign, as well as a loan collection of over 100,000 slides on contemporary and historical buildings, structural design, building technology, city planning, and fine arts. It also holds a collection of maps and architectural drawings. The collection has grown to include digital resources such as on-line image collections and databases and access to full text research tools as well as acquiring architecture-related material in various media formats such as videotapes, DVDs, and CD-ROMs. (More information can be found at the library’s website: http://library.rpi.edu/architecture).

To prepare students to become leaders in an increasingly complex and changing world, the School maintains a wide range of specialized facilities that support research activity and enhance education with emerging technologies.

The Digital Fabrications Lab, closely linked to the design studios provides the latest technologies for fabrication and prototyping of design work. Dedicated facilities for 3-axis routing/milling, laser cutting, rapid prototyping (3D printing), structural testing and analysis and ceramics research, complements a fully equipped woodworking shop for both students and researchers. The digital lab provides critical fabrication technologies necessary to respond effectively to an increasing emphasis on technology in architecture at this moment in history.

The Digital Futures Computer Lab is the newest addition to the School of Architecture. With the acquisition of (32) high-end workstations, integrated video conferencing, a render farm and a robust software application tools this new lab provides an ideal setting to explore advanced parametric design available in any school of architecture throughout the US. The Digital Futures Computer Lab is directly linked to the Fabrications Lab, and offered in combination empowers our students to work seamlessly between virtual and physical modeling.

Architectural Acoustics research facilities include a testing room with a hemi-anechoic chamber, a binaural listening and auralization test station, computer labs, coupled laboratory spaces with two 24-channel loudspeaker systems, video projection, and INET 2 connection for multimodal (audio/visual/haptic) telepresence research, scale-model reverberation and anechoic chambers, specialized acoustic laboratory equipment, advanced acoustics vibration measurement systems, laser doppler vibrometers, and acoustic modeling and computation software.

The Lighting Research Center (LRC), housed in a 30,000 square foot facility in the historic Gurley Building in downtown Troy, has state-of-art equipment and the ability to perform research in diverse areas of lighting. The LRC also maintains the necessary measurement
equipment, computer-aided optical design capabilities, and workshop required to produce and evaluate fully functional prototypes and models. These facilities and existing equipment represent one of the best-equipped university-based lighting laboratories in the United States.

The Laboratory of Human-Environment Interaction Research; the Solar and Microclimate Laboratory, field study facilities, and various other laboratories associated with research at the Center for Architecture Science and Ecology (CASE) round out a robust research and testing capability.

In addition to the School of Architecture’s rich array of well-equipped facilities, the Polytechnic research university setting at Rensselaer provides students, faculty, and the researchers access to many other facilities, inter- and cross-disciplinary opportunities.

This combination of excellent programs contemporary and well-equipped facilities and exemplary educators providing top-tier instruction and mentorship to our students collectively represents the essential attributes required for a leading architectural program in the beginning of the 21st century.

Equipment, Supplies, and Travel
Design studios form the core of architectural education at Rensselaer. Project based instruction with a faculty to student ratio of approximately 1 to 12 provides an inspired setting where synthesis of knowledge and creativity are celebrated as a holistic project. Most studio courses do not require textbooks, but rely heavily on software, printing, and modeling. Students should anticipate costs associated with the purchase of materials. First-year students will have an opportunity to purchase a basic kit with the tools needed for their design studio. A technology fee is assessed to cover some, but not all, of the software and services provided to the students. Travel and field trips to nearby cities are also a regular and strategic part of the design curriculum. Students should also be prepared to cover costs associated with regional travel.

Degrees Offered

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<td>Concentration in Lighting</td>
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| Lighting | M.S |

Overview of Undergraduate Programs

The School of Architecture offers a five-year Bachelor of Architecture degree. The Bachelor of Architecture is a professional degree accredited by the National Architecture Accrediting Board. Approximately 60 students are admitted directly into the program each year.

As a professional program designed for those ready to begin architectural study in the first year, the School of Architecture’s admissions decisions are based on the following criteria: overall academic excellence, creativity (demonstrated through work in the arts and other associated areas), and clear evidence of an inspired individual committed to receiving a rigorous exploratory and comprehensive education.

Application Requirements

The School encourages visiting the campus and the Greene Building, home of the School of Architecture, along with a faculty interview. Architecture candidates are required to submit a creative portfolio with their application. The School of Architecture prefers that applicants use the online portfolio system https://rpi.slideroom.com/ to upload digital files. A digital submission makes it easier for all applicants to format their material as well as accelerates the evaluation process for prospective students applying as freshmen or transfers into the B. Arch. Professional Program. Students with unusually strong academic profiles may be reviewed without the portfolio (GPA of 3.5). Please note that such cases are exceptionally rare and that in all cases a portfolio is preferred. For portfolio requirements visit www.arch.rpi.edu/about_directions.htm.

Transfer Students

We welcome students who have completed architecture course work at other schools to apply as transfer students to Rensselaer. Upon acceptance, transfer students are placed at an appropriate level in the professional program based on a review of their transcript, course descriptions, and work portfolio.
Overview of Graduate Programs

Rensselaer’s School of Architecture offers both master’s and doctoral level graduate programs.

Master’s Programs

The School of Architecture offers a number of distinct master’s degrees. The Master of Architecture I is a first professional degree. It is accredited by the National Architecture Accrediting Board for students already holding at least a baccalaureate degree in another field. This degree’s course of study parallels much of the course and studio requirements for the Bachelor of Architecture program. Approximately 12 students are admitted to this program annually.

The remaining master’s programs are advanced degrees in architecture, architectural sciences, and related fields. They include:

- Master of Architecture II
- Master of Science in Architectural Sciences (Concentration in Architectural Acoustics)
- Master of Science in Architectural Sciences (Concentration in Built Ecologies)
- Master of Science in Architectural Sciences (Concentration in Lighting)
- Master of Science in Lighting

Doctoral Programs

The Ph.D. in Architectural Sciences is a multidisciplinary and interdisciplinary degree supporting research and scholarship across the many topics arising from the theory and practice of architecture and the built environment. It is open to candidates with a professional degree in architecture and those with degrees in related design fields from science, engineering, and the humanities.

Although the discipline of architecture has a strong and complex knowledge base, its essential nature causes it to synthesize the knowledge produced in many other fields, from sociology and history to information technology and the performance of materials. The degree is aimed at producing a context for the advanced study and research between architecture and appropriate areas of science, engineering, and the humanities.

Those pursuing doctoral study in Architectural Sciences at Rensselaer may select from three areas of concentration. They include:

- Ph.D. in Architectural Sciences (Concentration in Architectural Acoustics)
- Ph.D. in Architectural Sciences (Concentration in Built Ecologies)
- Ph.D. in Architectural Sciences (Concentration in Lighting)

as well as in emerging areas of specialization in aspects of architecture and technology.

Research Innovations and Initiatives

Communication Acoustics

The School of Architecture faculty is renowned for its acoustic consulting expertise and academic research in areas of communication acoustics such as advanced techniques for computational modeling of room acoustics. Current research includes the modeling and perception of coupled acoustical spaces, perception of early reflections due to scattering of sound by rough surfaces and the fine structure of reverberation, room sound coloration, and telepresence questions involving cross-modal interaction between visual and acoustical stimuli, as well as interaction between tactile and aural stimuli.

Acoustics of Concert Halls and Other Performance Venues and Classrooms

The School of Architecture faculty is also renowned for its acoustic consulting expertise in designing performance venues and worship spaces. Architecture faculty and graduate students have traveled to different halls, such as Bass Performance Hall in Fort Worth, Texas; Boston Symphony Hall, Boston, Mass.; Troy First Niagara Savings Bank Hall, Troy, N.Y.; and Saint Patrick’s Church, Watervliet, N.Y.; to measure acoustical properties and acoustical energy coupling with monaural and binaural receivers. A more recent emphasis is on classrooms where poor acoustics are detrimental to learning. Research and design in this area includes computer modeling and experimentation with scale models as well as measurement and analysis in existing facilities. Ease of Hearing in Various Classroom Geometries, a recently completed thesis project, involved modeling various geometries using acoustics prediction software. Other studies concern sound propagation and scattering using physical scale models, diffusivity of reverberation, etc.

Auralization

The acoustical analog of visualization aims to recreate sound fields from computational models of spaces. Current core research includes the development of more accurate mathematical models for room acoustics, determination of accurate scattering and diffraction coefficients for
performance-hall design and modeling, and subjective studies on the effect of sound quality on human performance, including productivity, ease of hearing, and hearing comfort.

**Electronic Enhancement of Acoustical Communication Over Large Distances**
This work focuses on the development of “acoustic telepresence systems” that will provide an unmatched auditory sense of presence across distances. This research is an essential aural counterpart to current research in computer-mediated visual technologies, with possible applications in teleconferencing, distance education, games, and virtual reality.

**Measurement Techniques for Room Acoustics**
New measurement technologies can be used for more effective representation of sound fields, leading to a better understanding of physical phenomena and aiding acousticians in the design process.

**Synthetic Sensing and Synthetic Environments**
Current research includes the experimental development of alternative sensory methods for individuals and the development and testing of immersive and augmented electronic environments for teleperformance and design collaboration. A guiding principle of the research is the complementary nature of media, computation, space, and the body rather than the substitution of human skills or spatial conditions with computer technology.

**Computational Acoustics and Computer-mediated Design Processes**
This research area is primarily concerned with Computer-Aided Design and the redefinition of the design process. The computer is envisioned as a medium for opening up new possibilities for architectural and urban design, rather than a tool for performing well-known tasks more quickly and cheaply. New design algorithms, new roles of computing in the client-designer-builder network, and new design processes are at the core of research in this area.

**Product and Transmission Sound Quality**
The product sound quality approach is firmly based in psychoacoustics and psychology. Using jury evaluations, the sound perception of humans is investigated with the ambition of finding new, psychoacoustically relevant sound metrics. The research includes simulation and modeling of the sound quality for products such as automobiles or appliances. Work in transmission sound quality focuses on the effect of transmission inaccuracies of speech systems, linear and nonlinear distortion in microphones and loudspeakers, and in related applications.

**Light and Health**
The Lighting Research Center continues to expand research initiatives in the area of light of health. Investigations include the role of lighting in the mitigation of diseases and disorders such as Alzheimer’s disease and Seasonal Affective Disorder and the interaction of lighting with the human circadian and other biological systems. This research has far-reaching implications in the areas of medical research, photobiology, biotechnology, engineering, and related sciences.

**Solid State Lighting**
Solid state lighting is one of the fastest growing areas in lighting technology today with wide implications for all areas of lighting including architecture, transportation, and information technology. The Lighting Research Center has developed core competencies in this area and works to expand research in solid state lighting development and application.

**Energy Policy**
With growing need for electricity nation-wide and increasing societal pressure to avoid building new generation plants and transmission lines, there is increasing need for research in the area of “demand/response” technologies. These technologies can be used to decrease electric demand at peak times quickly without negatively impacting employee comfort or productivity. Lighting plays a key role in this area, and the Lighting Research Center research assists the development of demand/response technologies and policies.

**Intelligent Roadway Systems**
With the increasing complexity and congestion of roadways throughout the United States and the development of new communication and information technologies, lighting plays a key role in the transmission of information to drivers. The Lighting Research Center researches the development of lighting as part of intelligent roadway systems.

**Innovation of Emerging Building Techniques**
Research includes the technologies and infrastructural systems driven by sustainable approaches to ecologies and building within them towards the development of radically new buildings systems, structures, and environments that are informed by the behavior of natural systems and/or performance characteristics of emergent technologies.

**Dynamic Shading Window System (DSWS)**
DSWS uses a newly developed solar-energy technology to convert the sun’s light and diverted heat into storable energy that can be used to efficiently heat, cool, and artificially light an office building. Photovoltaic devices convert light into power to run tracking motors embedded in the building’s interior walls. The remaining energy is used for heat, air conditioning, and artificial lighting. Surplus energy can be stored.
The advent of thinner, smarter materials allows application of existing technologies to systems that are more effective and visually unobtrusive. Tiny one square centimeter solar cells are one of the new technologies being incorporated in the DSWS.

**Active Building Envelope (ABE)**

The patented Active Building Envelope (ABE) system uses a photovoltaic (PV) system to collect and convert sunlight into electricity. That power is delivered to a series of thermo-electric (TE) heat-pumps that are integrated into a building envelope. Depending on the direction of the electric current supplied to the TE heat-pump system, the sun's energy can be used to make the inside space warmer or cooler. ABE systems operate on the micrometer scale using thin-film photovoltaic and thin-film thermo-electric materials, potentially resulting in extremely thin (less than 500 µm) ABE-surfaces, functioning as a thermal coating system for both new and existing building surfaces. The ABE system on the micrometer scale leads to a new class of materials whose thermal conductivity would no longer be determined by thickness. Research in this area focuses on the design and optimization of a prototype on the micrometer scale.

**Design Research—An Interdisciplinary Model**

With the intention of innovating solutions that address the complexity of pressing ecological problems facing our built environments, the built ecologies program positions the interdisciplinary role of architectural design as a catalyst for inspired collective invention. The discipline of Architecture has conventionally been an assimilator and integrator of information and technologies that span many scales and knowledge bases, from infrastructural engineering to material science, and synergistically cross-pollinating highly specialized emerging technologies. With a dedication to the discovery of new knowledge and innovative application of new techniques and technologies to infrastructure and building design, the program catalyzes the transfer of scientific knowledge and technology between disciplines and industries. The aim is to support investigations into, and dissemination of emergent sustainable approaches and technologies of building design, construction, and maintenance.

**Faculty * **

**Dean**

Douglas, E.—M. Arch. (Harvard University); digital design and fabrication.

**Associate Dean**

Mistur, M.—M.S. (Rensselaer Polytechnic Institute); architectural design, emerging technology, interdisciplinary Architecture and Engineering practices.

**Professors**

Goebel, J.—M.A. (Staatliche Hochschule fur Music and Theater); music composition and performance.

Dyson, A.—M.Arch. (Yale University); architectural design, structures technology, multidisciplinary design theory and ecology.

Leslie, R.—M.Arch. (Rensselaer Polytechnic Institute); lighting, daylighting, architecture, environmental comfort technologies.

Narendran, N.—Ph.D. (University of Rhode Island); solid state lighting, light emitting diode (LED) fiber-optic sensors, geometric and physical optics.

Rea, M.—Ph.D. (Ohio State University); vision science, non-visual effects of light, circadian rhythms, lighting engineering, photometry, light pollution, agricultural lighting, and transportation lighting.

**Associate Professors**

Bell, D.—M.Arch. (University of Virginia); architectural design, theory, and history.

Braasch, J.—Ph.D. Engineering & Music (Ruhr-Bochum University, Germany); architectural acoustics, psychoacoustics.

Figueiro, M. G.—Ph.D. (Rensselaer Polytechnic Institute); light and health, human factors in lighting and energy efficiency.

Krueger, T.—Ph.D. (RMIT, Melbourne, Australia); human-environment interaction, architecture of extreme environments, design.

Markov, I.—Ph.D. (Cornell University); structures, systems, forms, masonry, practice.

Oatman, M.—M.F.A. (University at Albany); drawing, design, painter and installation artist.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Vollen, J.—M.Arch. (Cranbrook Academy of Art); emerging material technologies, digital fabrication, advanced systems integration based on natural analogues.

Xiang, N.—Ph.D. (Ruhr University, Bochum, Germany); architectural acoustics, acoustic signal processing.

Assistant Professors
Combs, L.—M. S. AAD (Columbia University); building and city design, experimental structures, efficient material systems research, computation and materialism, and environmental structures.

Crembil, G.—M.Arch. (Cranbrook Academy of Art); architectural design, tactical technology.

Perry, C.—M.Arch. (Columbia University); interdisciplinary design, technology futurism, responsive systems.

Saunders, A.—M.Arch. (Harvard University); architectural design, emerging technologies and surface logic.

Stark, P.R.H.—Ph.D. (Harvard University); building and energy physics, materials science and emerging technologies.

Titus, A.—M.F.A. (University of Chicago), B.Arch (Cooper Union for the Advancement of Science and Art) architectural and artistic studio practice.

Watson, J.—M. Landscape Arch. II (Harvard University); design, material technology, cultural landscapes.

Lecturers
Comodromos, D.—M.S. AAD (Columbia University); architectural design; practice and politics; materials and construction.

Ghoche, R.—M.Arch II (McGill University); history/theory of architecture.

Gindlesparger, M.—M.Arch. (University of Arizona); digital fabrication and rapid prototyping; prototyping and testing of advanced building systems.

Ngai, T.—M.Arch. (Harvard University); architectural design, emerging technologies, emerging practice.

Oksiuta, Z.—(Department of Architecture of the Warsaw Technical University, Department History of Art, Technical University, Aachen, Germany); next generation biological habitats.

Emeritus Faculty
Boyce, P.—Ph.D. (University of Reading); human factors.

Haviland, D.—M.Arch. (Rensselaer Polytechnic Institute); building industry, management, economics.

Kroner, W.—M.Arch. (Rensselaer Polytechnic Institute); resources and sustainable architecture, advanced building technologies, futurism, and architectural design.

Parsons, P.—B.Arch. (Cornell University); architectural design, theory, and history.

Pertuiset, N.—Hons. Dipl. Arch. and Theory (Architectural Association); architectural design and theory.

Quinn, P.—M.Arch. (University of Pennsylvania); theory and architectural design, institutional and community facilities.

Adjunct and Visiting Faculty
Bierman, A.—M.S. (Rensselaer Polytechnic Institute); mesopic vision, color vision, lighting controls, measurement of lighting efficiency.

Brons, J.—M.S. (Rensselaer Polytechnic Institute); lighting design, sustainable/green lighting practice, lighting evaluation, outdoor lighting.

Bitonti, E.—M.Arch. (Pratt Institute); architecture design, computational and algorithmic design.

Brooks, T.—MPL (Yale University); architectural acoustics.

Bullough, J.—Ph.D. (Rensselaer Polytechnic Institute); psychological and biological effects of light, lighting for transportation, technology transfer.

Carvalho, J.—M.S. AAD (Columbia University); RA; architectural design, design methodology, building and environmental systems.

Dayem, A.—M.Arch. (Columbia University); RA; architectural research and design, design methodologies.

Frering, D.—M.S. (North Adams State College); lighting education, energy-efficient lighting, lighting economics.
Freyssinier–Nova, J.P.—M.S. (Rensselaer Polytechnic Institute); solid-state lighting, lighting design and applications, energy efficiency, technology transfer.

Holmes, O.—B.S. Mechanical Engineering (Syracuse University); HVAC, building systems, energy management.

Hower, E.—M.Arch, MLA (University of Pennsylvania); architecture and landscape architecture design, research, and computational methodologies.

Leitao, C.—M.S. Arch. (Columbia University); architecture design, ubiquity and networks, advanced materiality and space.

Liu, E.—M.S. AAD (Columbia University); architectural design, design methodologies, fabrication, design visualization and animation.

Perez-Guembe, E.—M.S. AAD, AAR (Columbia University); architectural research and design, design methodology.

Pocorobba, J.—B.Arch. (Rensselaer Polytechnic Institute); architecture design, practice.

Rehm, M.C.—M.S. AAD (Columbia University); architectural design and algorithmic consulting.

Reilly, S.—B.Arch. (Rensselaer Polytechnic Institute); architectural design, practice, preservation technology.

Snyder, J.—M.S. (University of Nevada, Reno); lighting, energy efficiency, product testing.

Rizzo, P.—M.S. (Rensselaer Polytechnic Institute); lighting design, with focus on energy-efficiency, sustainability, and universal design.

Sykes, D.—MA IEEE, AAAS (Cornell University); technological innovation and social change.

Vetcher, F.—M.Arch. (Princeton University); architectural design and development.

Wadhwa, A.—M.S. Lighting (Rensselaer Polytechnic Institute); architectural lighting design, systems integration and new technologies, sustainable systems, green practices, luminaire design.

Bedford Visiting Professor

Stein, M.—Diploma – Ing. (University of Stuttgart); structural engineer lightweight design, cooperation between architects and engineers.

Undergraduate Programs

The five-year Bachelor of Architecture (B.Arch.) curriculum centers on the design studio and culminates in a year-long research and design project. Theoretical, technological, and computational and historical issues are progressively integrated into studio projects beginning in the first year. Projects range in scale and form, but relate to issues in contemporary culture with a focus on globalization and urban contexts.

This degree program is described in detail below.

Students in the School of Architecture undergraduate program are required to complete courses in the sciences, humanities, arts and social sciences as part of the Institute core requirements. The core courses are structured to provide exposure and breadth of education. A series of professional electives and free elective courses provide students the opportunity to pursue specific interests in greater depth, to minor, or to pursue other special interests.

In addition to Institute-wide academic regulations outlined earlier in this catalog, the following pertain to the bachelor’s program in architecture:

• **Advancement in Design**—Students not passing a required design course (including Final Project 1 and 2) may not advance to the next course in the design sequence. The architecture faculty will review students earning grades of D or lower in required design courses. A student earning a D or lower in any subsequent required design course must either repeat the course or take another course specified by the faculty before advancing to the next course in the design sequence. Students who fail to earn a grade of C or better in the repeated or specified course, or who earn a third grade of D or lower in design, may not continue in the design sequence. A student earning an F in any course must repeat the course in addition to completing any remedial actions specified by the faculty after a second grade of D or lower in a required design studio.

• **Grades of “IP”**—In Final Project 1 or 2 IP grades will convert to a grade of “F” three years after the issue of the “IP” grade. Students applying for readmittance to complete Final Project 1 or 2 after three years will be required to restart the three-course, 12-credit final project sequence (including Methods Seminar (1 credit). (This regulation applies to students who took Final Project 1 and/or 2 prior to 2009).
• Retention of Student Design Work—All student drawings and models produced as part of the instructional program are the property of the Institute. The School of Architecture reserves the right to obtain any or all work produced by the students in the school for a temporary or permanent time period.

**Baccalaureate Programs**

**Bachelor of Architecture (B. Arch)**

This five-year undergraduate professional program is a first professional degree accredited by the National Architectural Accreditation Board. The program is for a limited number of qualified students committed to the study of architecture. These students are admitted directly to the professional degree program and begin studies in architecture in the first year.

The National Architectural Accreditation Board (NAAB) accredits the Rensselaer School of Architecture’s Bachelor of Architecture program and its Master of Architecture program. Pursuant to the requirement of the NAAB, the following statement is included in the catalog:

In the United States, most state registration boards require a degree from an accredited professional degree program as a prerequisite for licensure. The National Architectural Accrediting Board (NAAB), which is the sole agency authorized to accredit U.S. professional degree programs in architecture, recognizes three types of degrees: the Bachelor of Architecture, the Master of Architecture, and the Doctor of Architecture. A program may be granted a 6-year, 3-year, or 2-year term of accreditation, depending on the extent of its conformance with established educational standards.

Doctor of Architecture and Master of Architecture degree programs may consist of a pre-professional undergraduate degree and a professional graduate degree that, when earned sequentially, constitute an accredited professional education. However, the preprofessional degree is not, by itself, recognized as an accredited degree.

Rensselaer Polytechnic Institute, School of Architecture offers the following NAAB accredited degree programs:

- B.Arch (168 undergraduate credits)
- M.Arch I (pre-professional Degree + 112 credits)
- Next accreditation visit for all programs: 2016

Rensselaer’s B.Arch. program incorporates and interconnects the following important elements:

- Design—Design and the design studio form the core of all architecture degree programs. The design studio brings together the many aspects of architecture and presents a wide range of design issues, beginning with the development of the tools, skills, and judgments that underlie the production of architecture.

- The skills area emphasizes that the hand is as important as the computer in the development and representation of ideas. The ability to freely manipulate space, surface, structure, and texture is central to the formation of architecture. The tools component develops confidence in the technologies that form architecture and are essential support to creativity. Finally, the judgments aspect is developed through projects premised on the continual evolution of architecture as a manifestation of the social, economic, political, and technological forces within a culture. All design studios draw broadly on the exceptional range of urban and architectural contexts near the campus; from the historic towns in upstate New York to great cities of the region such as New York, Boston, Montreal, and Philadelphia.

- In the design studio there are no singular, provable, or perfect answers to any of the problems presented. Students explore and develop their design proposals based on their growing knowledge of architecture and their emerging abilities. Early semester-long studios introduce students to a full-range of issues, skills, and judgments encountered in design and initiate and reinforce design as critical inquiry. The remaining studios focus on significant concerns in architecture. They are “vertical” in that they include students in different class years, and present choices of projects and faculty. Among these is the Design Development Studio, a comprehensive design studio in which a prior project is subjected to detailed structural, mechanical, construction materials, and professional practice considerations.

- History and Theory—A required six-course sequence presents the diversity of architectural works and ideas relative to the contexts within which architecture emerges and exposes students to key historical and theoretical issues in the discipline. Following this sequence, students may take additional advanced architectural history/theory electives as a part of their professional or free electives.

- Technology and Building Science—Technological issues are introduced from the beginning as essential to the conception and creation, delivery, and performance of architecture. New technologies can also be understood as generative of both form and inhabitable space. A series of six required technology courses considers both qualitative and quantitative views of building technologies. These include statics and strength of materials; basic structures and framing; design of wood, steel, and concrete structures; criteria for selecting building materials and systems; environmental and ecological systems; building systems, including heating, ventilation, air conditioning, plumbing, and electrical systems; sensory environments, including the luminous, acoustical, and tactile dimensions of space; codes and contract
documents. Following this sequence, students may take additional advanced technology and building science electives as a part of their professional or free elective selections. Integration of technological considerations is central to many of the studios with a focused emphasis on integrating building technologies especially in the required upper level Design Development Studio.

- **Computational Design**—Computational proficiency is central to the future of architecture. From the first year, students are able to expand their knowledge and skill through course work, which integrates computing concepts and applications—in some cases within the design studios—and through independent experimentation in the many computer labs at the School and Institute. In addition to the general computation labs, the School offers high-end multimedia environments within the many design studios. These labs are also complemented with a commitment to equipping the fabrication center with the latest and most sophisticated tools for fabrication and physical prototyping of design work. We currently have a range of equipment varying from a 3axis CNC mill, two laser cutters, a 3D printing, and vacuum-forming as well as access to water and plasma cutters. Students have access to the latest in three-dimensional design software, critical visualization tools, and more specific evaluation based software.

- **Computational Design**—Computational proficiency is central to the future of architecture. From the first year, students are able to expand their knowledge and skill through course work, which integrates computing concepts and applications—in some cases within the design studios—and through independent experimentation in the many computer labs at the School and Institute. In addition to the general computation labs, the School offers high-end multimedia environments within the many design studios. These labs are also complemented with a commitment to equipping the fabrication center with the latest and most sophisticated tools for fabrication and physical prototyping of design work. We currently have a range of equipment varying from a 3axis CNC mill, two laser cutters, a 3D printing, and vacuum-forming as well as access to water and plasma cutters. Students have access to the latest in three-dimensional design software, critical visualization tools, and more specific evaluation based software.

These elements are provided through both required courses as well as many professional electives and topics in such areas as architectural and urban history and theory, technology, computing, building economics, computational design, community design, practice and management, architectural lighting, and acoustics in architecture. Professional degree students must complete at least 12 credits from these offerings by either building on a specific interest or by sampling the breadth and diversity inherent in the field. In addition to regularly offered electives (described in the back of this catalog), the faculty offers a number of topics or experimental courses as professional electives. Sample courses include, but are not limited to:

- Advanced Ceramic Composite Lab
- Advanced Architectural Modeling
- Analogical Models: Contemporary Art Theory and Practice
- Architectural Acoustics 1 and 2
- Bedford Technology Seminar
- Between Dissociation and Merging
- Biological Habitat
- Built Ecologies 1
- Built Ecologies 2
- Duchamp Sem: Anarchism Umped
- Electronic Media: Critical Visualization
- Electronic Media: Physical Design Processes
- Environmental History and Theory
- Environmental Parametrics
- Extreme Drawing
- Eyes to the Ground - Spatial Studies in Counter Culture
- Human Factors in Lighting
- Indigenous Landscape Systems
- Informal Urbanism
- Latin American Architecture
- Lighting Design
- Lighting Technologies and Applications
- Living Versus Artificial Living
- Modular Thinking
- New Evolutions
- Performatve Morphologies
- Procedural Materialism: Emerging
- Satorial Tecnics
- Seminar in Sensory Culture
- Structural Morphology
- Surface as Structure as Form
- Sustainable Building Design Metrics
- Techniques of Digital Fabrication
- The Man Next Door: A. Hitchcock + the Arch of Fear
- Tool Theory
- Twisted Siblings - Examinations of Contemporary Relationships Between Painting and Architecture
- The Man Next Door: Alfred Hitchcock and the Architecture of Fear
- Towards a Social Ecology in Architecture
- Urban Data Analysis and Visualization

The five-year B.Arch. program concludes with a year-long individually developed and comprehensive final project in the context of optional research studio and thematic contexts provided by faculty. The first semester of the final project integrates a Research Methods seminar. An integrated design research phase continues throughout the first and the second semesters.

The final project is an opportunity to develop a point of view about architecture and its place in the world; to question conventions, habitual responses, and routine approaches to architectural design; and to investigate issues that the student sees as significant to architecture.
A sample template of the B.Arch. curriculum structure is provided below. Please note that special circumstances such as participating in a semester abroad or a semester at CASE in New York City may involve some variation from this template.

**BACHELOR OF ARCHITECTURE CURRICULUM**

**FIRST YEAR**

<table>
<thead>
<tr>
<th>Term</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>ARCH 2110</td>
<td>The Building and Thinking of Architecture 1(^2)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ARCH 2200</td>
<td>Design Studio</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH 1500</td>
<td>Calculus for Architecture, Management, and HASS</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>ARCH 2120</td>
<td>The Building and Thinking of Architecture 2(^2)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ARCH 2210</td>
<td>Architecture Design 1</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>ARCH 2510</td>
<td>Materials and Design</td>
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<tr>
<td></td>
<td>PHYS 1050</td>
<td>General Physics</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci Elective(^1)</td>
<td>4</td>
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**SECOND YEAR**

<table>
<thead>
<tr>
<th>Term</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>Fall</td>
<td>ARCH 2130</td>
<td>Contemporary Design Approaches</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ARCH 2220</td>
<td>Architecture Design 2</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>ARCH 2330</td>
<td>Structures 1(^3)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ARCH 2350</td>
<td>Construction Systems</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci Elective(^1)</td>
<td>4</td>
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<tr>
<td>Spring</td>
<td>ARCH 2140</td>
<td>The Building and Thinking of Architecture 3(^2)</td>
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<td>ARCH 2230</td>
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<td>6</td>
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<tr>
<td></td>
<td>ARCH 2360</td>
<td>Environmental and Ecological Systems(^3)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Math Elective(^4)</td>
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**THIRD YEAR**

<table>
<thead>
<tr>
<th>Term</th>
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<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>ARCH 4140</td>
<td>Modernity in Culture and Architecture</td>
<td>4</td>
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<tr>
<td></td>
<td>ARCH 4330</td>
<td>Structures 2(^3)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci Elective(^1)</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>ARCH 4250</td>
<td>Architecture Design 5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>ARCH 4560</td>
<td>Materials and Enclosures</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ARCH 4740</td>
<td>Building Systems and Environment(^3)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci Elective(^1)</td>
<td>4</td>
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</table>

**FOURTH YEAR**

<table>
<thead>
<tr>
<th>Term</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>ARCH 4260</td>
<td>Architecture Design 6</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>ARCH 4690</td>
<td>Case Studies: Investigations into Architectural Knowledge</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Professional Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>ARCH 4040</td>
<td>Cities/Lands</td>
<td>4</td>
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<tr>
<td></td>
<td>ARCH 4300</td>
<td>Design Development</td>
<td>6</td>
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<td></td>
<td>ARCH 4540</td>
<td>Professional Practice(^5)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

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\(^1\) HASS Institute communications intensive requirement (see Class Hour Schedule for approved courses); Final Project 1 and Final Project 2 will fulfill the Architecture major communications intensive requirement.

\(^2\) Four credits of the HASS core requirements are embedded within The Building and Thinking of Architecture sequence: ARCH 2110 and ARCH 2120.

\(^3\) Four credits of the Institute core Science requirements are embedded within the technology sequence: ARCH 2330, ARCH 2360, ARCH 4330, and ARCH 4740.

\(^4\) In general, the recommended course is MATH 1620 offered only in the spring.

\(^5\) Taken in the same semester as ARCH 4300.
The degree requires 168 credit hours.

All undergraduate students should develop a Plan of Study with their faculty adviser.

Additional Requirements

In regard to the above template, please note that studios are sequential with the exception of the Design Development studio, which may be taken any time after Architecture Design 4 and before B.Arch. Final Project 1. Students are required to complete eight credits in Math, 12 in Science, and 20 in Humanities, Arts, and Social Sciences from an extensive list of course offerings (see Institute core requirements for greater detail). In addition, students have 12 credits of professional electives, and 12 credits of free electives which may be used to further focus on a concentrated area of study, pursue a minor or dual major, or as a means of further broadening exposure to a range of disciplines.

Discipline specific sequences embedded in the curriculum are detailed below.

Technology courses: ARCH 2330 Structures 1 is sequential and prerequisite to ARCH 4330 Structures 2; and ARCH 2360 Environmental and Ecological Systems is sequential and prerequisite to ARCH 4740 Building Systems and Environment.

ARCH 2200 Design Studio, ARCH 2210 Architecture Design 1, ARCH 2220 Architecture Design 2, ARCH 2230 Architecture Design 3, and ARCH 2420 Architecture Design 4, and ARCH 2330 Structures 1, ARCH 2360 Environmental and Ecological Systems, ARCH 4330 Structures 2, ARCH 4740 Building Systems and Environment are prerequisites to the ARCH 4300 Design Development studio. ARCH 4740 Building Systems and Environment may be taken concurrently with the ARCH 4300 Design Development studio.

ARCH 2110 The Building and Thinking of Architecture 1, ARCH 2120 The Building and Thinking of Architecture 2 are prerequisites to ARCH 2130 Contemporary Design Approaches.

ARCH 2120 The Building and Thinking of Architecture 2 and ARCH 2130 Contemporary Design Approaches are prerequisites to ARCH 4140 Modernity in Culture and Architecture.

ARCH 2110 The Building and Thinking of Architecture 1, ARCH 2120 The Building and Thinking of Architecture 2, ARCH 2130 Contemporary Design Approaches, ARCH 2140 The Building and Thinking of Architecture 3, ARCH 2230 Architecture Design 3, and ARCH 4140 Modernity in Culture and Architecture are prerequisites to ARCH 4040 Cities Lands.

ARCH 4140 Modernity in Culture and Architecture, ARCH 4330 Structures 2, ARCH 4300 Design Development, and ARCH 4560 Materials and Enclosures are prerequisites to ARCH 4690 Case Studies.

Bachelor of Building Sciences B.S.

[This program is no longer enrolling new students.]

Minor Programs

A minor consists of an approved 16-credit program. Minors in other disciplines offered at Rensselaer are available to students and are highly encouraged. The most common minors are in the Schools of Management, Humanities, Arts, and Social Sciences, and Science. A minor in Civil Engineering has been especially designed for Architecture majors with some overlap in courses.

The School of Architecture offers minor options for both School of Architecture students and students majoring in other Rensselaer programs. These options are described in the Programs section of this catalog.
Architectural Acoustics Minor

The minor in architectural acoustics is open to all Rensselaer students interested in advanced study focusing on the optimization of acoustical quality of performance spaces and other aurally sensitive environments. After completing the minor, the student will be well prepared for an entry level position dealing with acoustics issues in architectural practice, in acoustical consulting, or as a preparation for graduate studies in acoustics, for example in the Graduate Program in Architectural Acoustics at Rensselaer Polytechnic Institute. The program consists of 16 credits. Proficiency in Calculus I is necessary to comprehend the basics of architectural acoustics. Approval required by director of program.

The courses required are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH 4840</td>
<td>4</td>
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<tr>
<td>ARCH 4850</td>
<td>4</td>
</tr>
<tr>
<td>ARCH 4860</td>
<td>3</td>
</tr>
<tr>
<td>ARCH 6840</td>
<td>2</td>
</tr>
<tr>
<td>ARCH 6890</td>
<td>3</td>
</tr>
</tbody>
</table>

Architectural History Minor

The minor in architectural history is open to all Rensselaer students interested in the history of architecture as a socio-cultural phenomenon that examines architecture as a cultural artifact. It consists of ARCH 2110 The Building and Thinking of Architecture 1 and upper division architectural history courses. Students who wish to obtain a minor in architectural history must receive approval of their course selections from the program adviser.

Architecture Minor

A minor in architecture is directed toward Rensselaer students interested in architecture as a socio-cultural phenomenon and/or those envisioning a career in some segment of the building industry. The minor program provides an exposure to architecture—what it is, what it includes, its history, how it is accomplished; and to architects—who they are and how they think and work. ARCH 2110 Building and Thinking of Architecture 1 is required but students may select the remainder of the courses from Architecture to build a concentration in architecture that supports their own disciplinary interests.

Lighting Minor

The minor in lighting gives students the awareness and the confidence to extend their creative work through controlled use of light. The program covers human responses to light, both visual and non-visual, and the means by which light is produced and controlled. Interactions of light with form, texture, and color are examined in the contexts of daylight, electric lighting, and their integration.

The courses required are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGHT 4230</td>
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<tr>
<td>LGHT 4770</td>
<td>4</td>
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<tr>
<td>LGHT 4840</td>
<td>3</td>
</tr>
<tr>
<td>LGHT 4940</td>
<td>1 to 6</td>
</tr>
</tbody>
</table>

Special Undergraduate Opportunities

Study Abroad Programs

International study is a defining aspect of Rensselaer’s architectural education. The School of Architecture offers international semester long programs of study in Italy, India, and China. These programs are fully integrated with the requirements of the undergraduate degree and have been established in three world cities that will challenge and help to define the future of architecture. Each of these programs is open, by competitive application, to students in their fifth to eighth semester. Limited numbers of students (B.Arch.) are selected each year on the basis of academic accomplishment. In addition to a Rensselaer faculty member who travels with and directs the program, adjunct faculty in the host city or institution also provide instruction. There is a program fee for participation in each of these programs, which are described briefly below.

• Italy Program—The Italian studies program includes a design studio based part of the time in Turin and part of the time in Rome, an examination of the architectural development of Turin and Rome, courses in Italian language and culture, and travel throughout Italy. The program seeks to deepen appreciation of historic cities and the layers of culture that have played a seminal role in the development of Western culture and architecture. The Turin workshop component involves collaboration with students and faculty from the Polytechnic of Turin.

• India Program—The program is based in the School of Architecture CEPT at Ahmedabad, India, a highly respected school for the study of architecture and urbanism. The program offers joint studios in design with CEPT faculty and students, and travel through northern and southern India. It offers students the opportunity to travel, study, and apply the lessons learned from Indian architecture and history and theory within the context of a major research center.
• China Program—The semester in Shanghai is based at the School of Architecture at Tongji University, one of the great institutions of China. The program offers joint design studios with Chinese faculty and students, courses in Chinese history and culture and short and long-term architectural sightseeing tours through central China.

In addition, the School of Architecture offers many short-term summer and mid-semester study abroad programs to places of special architectural interest. In recent years, these have included visits to Shanghai, Hong Kong, ShenZhen, London, Paris, Berlin, Stuttgart, Tokyo, Osaka, Lausanne, Buenos Aires, and San Paolo, Madrid, Seville, and Barcelona.

Exchange Programs
Additional independent exchange and study abroad opportunities are available through the office of International Programs.

New York Program
A semester long program located in New York City is based at Rensselaer’s Center for Architecture Science and Ecology [CASE] hosted by the global architecture firm Skidmore, Owings & Merrill’s (SOM). The program allows both B.Arch. and M.Arch. 1 students to study in a collaborative interdisciplinary research environment focused on the development of advanced next-generation building systems and sustainable technologies.

Summer Studios
The school offers two six-week studios in the summer session that are open to accepted transfer and entering Master of Architecture students.

Co-op Experiences
Architecture students may insert co-op work experiences into their program of study. Work opportunities are available in a wide range of situations, from architecture firms large and small to design groups in industry or institutions. Co-op experiences are an invaluable introduction to practice and strengthen the learning experience. Co-ops can sometimes earn credit toward the professional Intern Development Program (IDP) requirement.

Lectures and Exhibits
The lecture and exhibition series presents the work of internationally recognized theoreticians and practitioners, providing students and faculty with exposure to current and critical ideas influencing the profession. Lectures and exhibitions are open to all Rensselaer students, faculty, and the local professional community.

Graduate Programs
The School of Architecture graduate programs include both professional (M.Arch. I) and post-professional (M.Arch. II) design programs and research-based programs in the Architectural Sciences at the master’s and doctoral levels.

Design-Based Programs
The Master of Architecture professional program (M.Arch.I) is a NAAB-accredited program leading to the licensed practice of Architecture or to teaching and is open to qualified students holding a minimum of a baccalaureate degree in any discipline.

The post-professional program (M.Arch.II) is open to qualified applicants who have already gained a professional degree in architecture. This one-year, 30-credit degree program opens opportunities for specialized practices or to teaching.

The program allows for the crafting of specialized curricula prepared in consultation with the program director and the faculty as well as in prepared templates that specify a course of study in which the School has particular research interests and expertise.

Research-Based Programs
The School of Architecture offers several research degrees at the master’s and doctoral levels. The Master of Science, Master of Science in Architectural Sciences, or Ph.D. in Architectural Sciences degrees offer the opportunity for advanced, focused, and intellectually rigorous study in Architectural Acoustics, Built Ecologies, or Lighting.
Requirements for all Graduate Programs

Applicant Requirements
For specific information regarding admission to the School of Architecture’s graduate programs contact the Institute’s Office of Graduate Admissions.

Courses and Grade Requirements
Continuation in the graduate program requires satisfactory performance by the student. Satisfactory performance is not limited to the academic record, but includes other appraisals of the student's academic record, ability in areas such as teaching and research, and collegial interaction within a community of research and scholarship.

The minimum average of all grades used for credit toward an advanced degree must be B. If a student's grades fall below a 3.0 average, the Office of Graduate Education may request that the Graduate Program Director conduct a formal review to determine whether continuation is warranted. The student's adviser, with the consent of the Graduate Program Director, may recommend to the Office of Graduate Education that a student whose performance is unsatisfactory be dropped from the graduate program. A student who has accumulated two failing grades will be dropped from the graduate program. See the Master of Architecture I section for additional requirements pertaining to the professional program.

Master’s Programs

Master of Architecture I – Professional Program
The curriculum for this professional degree program parallels the B.Arch. program, albeit in an accelerated manner. It features a distinct pedagogical core through an advanced history and theory course sequence. On average, this degree is completed in three and a half years (one summer plus three academic years).

The M.Arch.I degree provides a balanced education in architectural design, history, theory, and technology. As a professional program, it centers on the design studio where projects address myriad design issues through multiple strategies ranging from the design of carefully crafted objects to architecture, landscape architecture, and urban design.

The National Architectural Accreditation Board (NAAB) accredits the Rensselaer School of Architecture’s Master of Architecture three and a half-year program. The following statement is included in the catalog, pursuant to NAAB requirements:

In the United States, most state registration boards require a degree from an accredited professional degree program as a prerequisite for licensure. The National Architectural Accrediting Board (NAAB), which is the sole agency authorized to accredit U.S. professional degree programs in architecture, recognizes three types of degrees: the Bachelor of Architecture, the Master of Architecture, and the Doctor of Architecture. A program may be granted a 6-year, 3-year, or 2-year term of accreditation, depending on the extent of its conformance with established educational standards.

Doctor of Architecture and Master of Architecture degree programs may consist of a pre-professional undergraduate degree and a professional graduate degree that, when earned sequentially, constitute an accredited professional education. However, the preprofessional degree is not, by itself, recognized as an accredited degree.

Applicants to this program must have a bachelor’s degree. It is strongly recommended that candidates have within their undergraduate studies a course in free hand or life-study drawing and eight to 10 courses in humanities and social sciences, one year of mathematics with a course in calculus, a course in physics, and additional courses in the sciences. Course work in the arts and art history is also desirable. A portfolio of creative works and critical commentary on those works is required for admission. Application is made to the Institute’s Office of Graduate Admissions. Students with previous architecture courses will be considered for advanced standing in this program. Enrollment in the initial summer studio is usually necessary to determine placement in the design sequence. For information regarding program tuition and financial aid, please refer to the Tuition and Financial Aid section of this catalog.

Rensselaer’s M.Arch.I program incorporates and interconnects the following important elements:

- Design—The design studio forms the core of all architecture degree programs. The design studio brings together the many aspects of architecture and presents a wide range of design issues, beginning with the development of the tools, skills, and judgments that underlie the production of architecture.

- The skills area emphasizes that the hand is as important as the computer in the development and representation of ideas. The ability to freely manipulate space, surface, structure, and texture is central to the formation of architecture. The tools component develops confidence in the technologies that form architecture and are essential support to creativity. Finally, the judgments aspect is developed through
projects premised on the continual evolution of architecture as a manifestation of the social, economic, political, and technological forces within a culture. Typically, the design studios draw on the exceptional range of urban and architectural contexts near the campus; from the historic towns in upstate New York to great cities of the region such as New York, Boston, Montreal, and Philadelphia.

- In the design studio there is no singular, provable, or perfect answer to any of the problems presented. Students explore and develop their design proposals based on their growing knowledge of architecture and emerging abilities. Initial studios introduce students to a full-range of issues, skills, and judgments encountered in design and initiate and reinforce design as critical inquiry. The advanced studios consider larger-scale, more complex, or significant problems in architecture. They include students from across the professional programs. Students select projects and faculty, thereby allowing them to direct their education. The Design Development Studio is a comprehensive design studio in which a prior project is subjected to detailed structural, mechanical, construction materials, and professional practice considerations.

- History and Theory—A required six-course sequence presents the diversity of architectural works and ideas relative to the contexts within which architecture emerges and exposes students to key historical and theoretical issues in the discipline. Following this sequence, students may take additional advanced architectural history/theory electives as a part of their professional or free electives.

- Technology and Building Science—Technological issues are introduced from the beginning as essential to the conception and creation, delivery, and performance of architecture. New technologies can also be understood as generative of both form and inhabitable space. A series of six required technology courses considers both qualitative and quantitative views of building technologies. These include statics and strength of materials; basic structures and framing; design of wood, steel, and concrete structures; criteria for selecting building materials and systems; environmental and ecological systems; building systems, including heating, ventilation, air conditioning, plumbing, and electrical systems; sensory environments, including the luminous, acoustical, and tactile dimensions of space; codes and contract documents. Following this sequence, students may take additional advanced technology and building science electives as a part of their professional or free elective selections. Integration of technological considerations is central to many of the studios with a focused emphasis on integrating building technologies especially in the required upper level Design Development Studio.

- Computation Design—Computational proficiency is central to the practice of architecture. From the first year, students are able to expand their knowledge and skill through course work, which integrates computing concepts and applications—in some cases within the design studios—and through independent experimentation in the many computer labs at the School and Institute. These labs are also complimented by a facility for the fabrication and physical prototyping of design work. We currently have a range of equipment varying from a 3-axis CNC mill, two laser cutters, a 3D printer, and a vacuum-forming machine, as well as access to water and plasma cutters. Students have access to the latest in three-dimensional design software, critical visualization tools, and more specific evaluation based software.

These elements — Design, History and Theory, Technology and Building Science, and Computation — are provided through the required courses as well as many professional electives and topics in such areas as architectural and urban history and theory, technology, computing, building economics, community design, practice and management, architectural lighting, and acoustics in architecture. M.Arch students may augment their required courses with either regularly offered electives described in the back of this catalog or special topics or experimental courses. Sample courses include, but are not limited to:

- Advanced Ceramic Composite Lab
- Advanced Architectural Modeling
- Analogical Models: Contemporary Art Theory and Practice
- Architectural Acoustics 1 and 2
- Architectural Aesthetics
- Bedford Technology Seminar
- Between Dissociation and Merging
- Biological Habitat
- Built Ecologies 1
- Built Ecologies 2
- Design Philosophies: Towards a New Technique
- Duchamp Sem: Anarchism Umped
- Electronic Media: Critical Visualization
- Electronic Media: Physical Design Processes
- Emergent Design Philosophies and Techniques
- Environmental History and Theory
- Environmental Parametrics
- Extreme Drawing
- Furniture Exploration
- Human Environment Interaction
- Human Factors in Lighting
- Latin American Architecture
- Lighting Design
- Lighting Technologies and Applications
- Materials Systems and Productions
- Modular Thinking
- Morphogenetic Structures
- Performative Morphologies
- Project Distortion
- Seminar in Sensory Culture
- Surface as Structure as Form
- Sustainable Building Design Metrics
- The Culture of Transparency
- The Man Next Door: Alfred Hitchcock and the Architecture of Fear
The M.Arch.I program culminates with an individually initiated, planned, and developed thesis. Planning begins in the second year and involves an exchange of ideas with and a critique by a faculty adviser and review committee. Resulting proposals may emerge from a synthesis of previous work applying gained knowledge to advanced issues, or alternatively, make use of experiences to date as a base from which to explore and to innovate. This final year begins with a short competition project in which all participate. An integrated design research phase then lasts the remainder of the first and throughout the second semester.

The thesis is an opportunity to develop a point of view about architecture and its place in the world, to question conventions, habitual responses, and routine approaches to architectural design, and to investigate issues that the student demonstrates as significant to architecture.

The M.Arch.I curriculum sample template is provided under Programs.

MASTER OF ARCHITECTURE I CURRICULUM

Summer Sessions 1–2

The program begins with a 12-week summer session that provides full immersion in architectural design. The summer studio is small and characterized by intense and highly individualized student-faculty interaction. The graduate professional student uses the summer session to prepare for entry into design at the second-year level in the fall; it also provides an opportunity to evaluate his or her design capacity.

<table>
<thead>
<tr>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARCH 2600 Graduate Design Studio ................................................. 6</td>
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<tr>
<td>ARCH 2610 Graduate Architecture Design 1 ............................................ 6</td>
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FIRST YEAR

**Fall**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>ARCH 2110 The Building and Thinking of Architecture 1 ................................... 4</td>
</tr>
<tr>
<td>ARCH 2330 Structures 1 ........................................................................ 4</td>
</tr>
<tr>
<td>ARCH 2350 Construction Systems .......................................................... 2</td>
</tr>
<tr>
<td>ARCH 2620 Graduate Architecture Design 2 ............................................ 6</td>
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**Spring**

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>ARCH 2120 The Building and Thinking of Architecture 2 ................................... 2</td>
</tr>
<tr>
<td>ARCH 2360 Environmental and Ecological Systems ......................................... 4</td>
</tr>
<tr>
<td>ARCH 2630 Graduate Architecture Design 3 ............................................ 6</td>
</tr>
<tr>
<td>ARCH 6110 Design Explorations 1 ........................................................... 4</td>
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</table>

SECOND YEAR

**Fall**

<table>
<thead>
<tr>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ARCH 2130 Contemporary Design Approaches ................................................ 2</td>
</tr>
<tr>
<td>ARCH 4330 Structures 2 ........................................................................ 4</td>
</tr>
<tr>
<td>ARCH 4360 Graduate Architecture Design 4 ............................................ 6</td>
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<tr>
<td>ARCH 6120 Design Explorations 21 .......................................................... 4</td>
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**Spring**

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</thead>
<tbody>
<tr>
<td>ARCH 2140 The Building and Thinking of Architecture 3 ................................... 2</td>
</tr>
<tr>
<td>ARCH 4300 Design Development ............................................................... 6</td>
</tr>
<tr>
<td>ARCH 4540 Professional Practice2 ............................................................ 2</td>
</tr>
<tr>
<td>ARCH 4560 Materials and Enclosures .......................................................... 2</td>
</tr>
<tr>
<td>ARCH 4740 Building Systems and Environment ........................................... 4</td>
</tr>
</tbody>
</table>

1 ARCH 6120 and ARCH 6130 address a variety of significant theoretical issues and are taught together. Topics alternate each year.

2 Taken in the same semester as ARCH 4300.
The degree requires 112 credits.

A Plan of Study is required for all graduate students. Admission with advanced standing can fulfill a significant number of the required 112 credits, especially for students who have been enrolled in undergraduate pre-architecture programs or non-accredited professional programs. Advanced standing requires approval by the School’s Graduate Program Director and the Office of Graduate Education. The final approval of advanced standing will be recorded on the student’s Plan of Study.

Additional Requirements

In addition to the Institute-wide academic regulations outlined in this catalog, the following pertain to graduate programs in architecture:

- Academic Progress—To earn the professional M.Arch. degree, students must maintain a 3.0 or higher average in the following courses: Design Explorations (ARCH 6110, ARCH 6120 and ARCH 6130) and six credits of 6000-level electives. Students whose cumulative averages for all course work drop below 3.0 will be reviewed for satisfactory progress. The architecture faculty, as part of its academic review process, will review professional M.Arch. students earning grades of C+ or below. A student earning a C+ or below in a subsequent required design course must either repeat the course or take another course specified by the faculty before advancing to the next course in the design sequence. Students who fail to earn a grade of B or better in the repeated or specified course or who earn a third C+ or lower in design may not continue in the design sequence.

- Retention of Student Work—All student drawings and models created as part of the instructional program are the property of the Institute until the instructor releases them. The School of Architecture, at its option, may retain certain works for academic purposes.

During their second year, M.Arch.I students participate in a semester-long program in New York City at Rensselaer’s Center for Architecture Science and Ecology (CASE), hosted at the renowned architecture firm Skidmore, Owings, & Merrill (SOM). The program allows M.Arch.I students to study in a collaborative interdisciplinary research environment focused on the development of advanced, next-generation building systems and sustainable technologies.

In certain cases, M.Arch.I students may participate in a semester-long program of study abroad. Students interested in international programs must develop a Plan of Study with the Graduate Program Director that insures the completion of required coursework in an appropriate sequence. A program fee is required.

In regard to the above template, please note that although studios are generally sequential, ARCH 4300 Design Development studio should be taken after the completion of the ARCH 4360 Graduate Architecture Design 4 studio and before ARCH 6990 Thesis.

- Technology courses: ARCH 2330 Structures 1 is sequential and prerequisite to ARCH 4330 Structures 2; ARCH 2360 Environmental and Ecological Systems is sequential and prerequisite to ARCH 4740 Building Systems and Environment.

- ARCH 2600 Graduate Design Studio, ARCH 2610 Graduate Architecture Design 1 through ARCH 4360 Graduate Architecture Design 4; and the ARCH 2330 Structures 1, ARCH 2360 Environmental and Ecological Systems, and ARCH 4330 Structures 2 series are prerequisites to ARCH 4300 Design Development studio. ARCH 4740 Building Systems and Environment may be taken concurrently with ARCH 4300 Design Development studio.

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1 ARCH 6120 and ARCH 6130 address a variety of significant theoretical issues and are taught together. Topics alternate each year.
2 Taken in the same semester as ARCH 4300.
3 At least 6 of the 16 required elective credit hours must be 6000.
4 Third-year M.Arch. students register for 5 credits of Master’s Thesis in the Fall and 6 credits in the Spring.

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104 SCHOOL OF ARCHITECTURE
Master of Architecture II Post-Professional Program

Within the Master of Architecture programs, there is the opportunity to develop a curriculum specific to an applicant’s interest if there is corresponding expertise in the faculty. This degree requires 30 credits, including the required methods seminars. The Master’s Project or Thesis consists of three to nine credits. The remaining credits are taken as concentration electives chosen with the faculty adviser and are detailed on a Plan of Study filed in the first semester. Specific concentrations and Plans of Study may be prescribed by the School of Architecture.

In addition to the Institute-wide academic regulations outlined in this catalog, all student drawings and models created as part of the instructional program are the property of the Institute until the instructor releases them. The School of Architecture, at its option, may retain certain works for academic purposes. The M.Arch.II is not a professional degree and will not lead to the establishment of a license to practice architecture in the United States or an NCARB certificate.

MASTER OF ARCHITECTURE I CURRICULUM

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH 6810</td>
<td>Research Design Seminar ................................................ 2</td>
</tr>
<tr>
<td>ARCH 6980</td>
<td>Master’s Project1 ................................................... 1 to 9</td>
</tr>
<tr>
<td>or</td>
<td>ARCH 6990</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH 6900</td>
<td>Graduate Thesis Seminar ................................................ 2</td>
</tr>
<tr>
<td>ARCH 6980</td>
<td>Master’s Project .................................................... 1 to 9</td>
</tr>
<tr>
<td>or</td>
<td>ARCH 6990</td>
</tr>
</tbody>
</table>

This degree requires 30 credit hours.

Master of Science in Architectural Sciences

Concentration Areas

Architectural Acoustics
Applicants to the M.S. in Architectural Sciences (Concentration in Architectural Acoustics) are not required to submit a portfolio. A 30-credit, one-year degree offers an intense program of advanced study in architectural acoustics, emphasizing the room acoustics of both large and small venues, such as automobile, household, and sound control and maximization of performance spaces. Applicants require a B.A. or B.S. in Architecture, Architectural Engineering, Music and Acoustics, or comparable fields.

Built Ecologies
Applicants to the M.S. in Architectural Sciences (Concentration in Built Ecologies) are required to submit a portfolio and a focused goal statement. This one-year, 30-credit hour program, is designed to provide knowledge of, and creative expertise in, the design of buildings, systems, structures and environments as informed by the dynamic behavior of natural systems and emergent technologies. Applicants should have at least an undergraduate degree in architecture, or engineering; or have a graduate degree in a related field, with demonstrated interest in areas relating to built systems and/or the environment. The program is located in New York City.

Lighting
Applicants to the M.S. in Architectural Sciences should submit a statement of goals and objectives as well as a statement of research interests. They are also urged to complete two college-level math courses before applying to the program. This one-year, 30-credit hour program of study provides an education that cultivates both a scientific and artistic understanding of the many issues involved in the development of lighting and designing with light.

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1 In certain cases, prescribed plans of study may require master’s thesis or project credits in the spring semester only.
Architectural Sciences (Concentration in Architectural Acoustics) M.S.

This program of advanced study focuses on the optimization of acoustical quality of performance spaces and other aurally sensitive environments. Research in this area improves understanding of how a space is designed to achieve the best acoustics for a given purpose. The program is geared toward students with a bachelor’s degree who have interests in acoustics, music, architecture, and/or engineering. Rensselaer offers numerous state-of-the-art facilities related to study in this area including a Hemi-anechoic testing room with a Binaural listening test station, the School of Architecture Fabrication Center, and Rensselaer’s Libraries and Information Services.

CONCENTRATION IN ARCHITECTURAL ACOUSTICS CURRICULUM

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH 4840 Architectural Acoustics 1</td>
<td>4</td>
</tr>
<tr>
<td>ARCH 6810 Research Design Seminar</td>
<td>2</td>
</tr>
<tr>
<td>ARCH 6840 Engineering Acoustics</td>
<td>2</td>
</tr>
<tr>
<td>ARCH 6860 Applied Psychoacoustics</td>
<td>3</td>
</tr>
<tr>
<td>ARCH 6870 Sonics Research Laboratory 1</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH 4850 Architectural Acoustics 2</td>
<td>4</td>
</tr>
<tr>
<td>ARCH 6830 Graduate Thesis Seminar: Acoustics</td>
<td>1</td>
</tr>
<tr>
<td>ARCH 6880 Sonics Research Laboratory 2</td>
<td>2</td>
</tr>
<tr>
<td>ARCH 6890 Aural Architecture</td>
<td>3</td>
</tr>
<tr>
<td>ARCH 6980 Master’s Project</td>
<td>1 to 9</td>
</tr>
<tr>
<td>or ARCH 6990 Master’s Thesis</td>
<td>5-6</td>
</tr>
</tbody>
</table>

The degree requires 30 credit hours.

Architectural Sciences (Concentration in Built Ecologies) M.S.

The program is offered to graduate architects and engineers, or others in comparable fields who are interested in researching architectural design in the context of emergent technologies moving built environments in the direction of clean, self-sustaining eco-systems. Students completing the M.S. will:

- Demonstrate general competence and base knowledge of the major principals governing dynamic bioclimatic design and the physics of energy and material science.
- Productively work within an inter-disciplinary design environment.
- Have acquired thorough knowledge of a chosen area of emergent technologies as it affects and informs design possibilities for the built environment.
- Demonstrate critical rigor and competence in the technical analysis of design problems.
- Possess the ability to apply such technical analysis to design problems and project new solutions based on the cross-referencing of information sets from multiple-disciplines.
- Display competence in the use of relevant computing platforms that facilitate the cross-referencing of such information across disciplines and scales.
- Be able to critically situate the above with an awareness of the broader socio-political implications, importance, and relevance of these efforts.

To foster an immediate intelligent and productive discourse in a concentrated one-year interdisciplinary program that joins students and faculty from a variety of backgrounds and expertise, a common reading list is issued upon admission to the program for critical evaluation and response to the material prior to start of the program. During the fall semester, each student develops a Plan of Study with his or her adviser for review and approval by the Graduate Program Director. The Plan must include the anticipated courses, concentration, and area of research interest for further development.
CONCENTRATION IN BUILT ECOLOGIES CURRICULUM

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARCH 6310 Environmental History and Theory</td>
<td>3</td>
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<tr>
<td>ARCH 6320 Built Ecologies 1</td>
<td>3</td>
</tr>
<tr>
<td>ARCH 6340 Material Systems and Productions</td>
<td>3</td>
</tr>
<tr>
<td>ARCH 6350 Design Research Studio</td>
<td>4</td>
</tr>
<tr>
<td>ARCH 6810 Research Design Seminar</td>
<td>2</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH 6330 Built Ecologies 2</td>
<td>3</td>
</tr>
<tr>
<td>ARCH 6360 Interdisciplinary Research Studio</td>
<td>4</td>
</tr>
<tr>
<td>ARCH 6900 Graduate Thesis Seminar</td>
<td>2</td>
</tr>
<tr>
<td>ARCH 6980 Master’s Project</td>
<td>1 to 9</td>
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<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>ARCH 6990 Master’s Thesis</td>
<td>5-6</td>
</tr>
</tbody>
</table>

**Summer**

Thesis/Project Completion + Presentation

The degree requires 30 credit hours.

**Architectural Sciences (Concentration in Lighting) M.S.**

The concentration in lighting within the Master of Science in Architectural Sciences allows students from a variety of disciplines to pursue a multidisciplinary graduate degree related to lighting practice. Geared toward the needs of professionals either currently working or wishing to pursue careers in the lighting industry or design fields, this one-year, 30-credit-hour degree exposes students to a wide range of topics within lighting including the physics of light, lighting technology, human factors, design, and application. Students concentrate their research or design work in a particular area of interest by pursuing a master’s project. Course content and curriculum in the lighting concentration is continually updated to include the latest advances in lighting research, technology, and design to assure that students receive a “cutting-edge” lighting education.

The M.S. in Architectural Sciences with a concentration in lighting is housed within the Lighting Research Center (LRC), the world’s largest university-based research and education institution dedicated to lighting, which includes an expert faculty and staff of lighting researchers and designers. The concentration in lighting includes 24 credits of formal course work taken over two semesters and a six-credit culminating master’s project.

CONCENTRATION IN LIGHTING CURRICULUM

Note: Any student intending to continue to the Ph.D. program must include ARCH 6810 Research Design Seminar (2 credits) in the Plan of Study before taking the candidacy exam.

<table>
<thead>
<tr>
<th>Fall</th>
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<tbody>
<tr>
<td>LGHT 4230 Lighting Design</td>
<td>4</td>
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<tr>
<td>LGHT 4840 Human Factors in Lighting</td>
<td>3</td>
</tr>
<tr>
<td>LGHT 6830 The Physics of Light</td>
<td>4</td>
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<tr>
<td>LGHT 6980 Master’s Project</td>
<td>3</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>LGHT 4770 Lighting Technologies and Applications</td>
<td>4</td>
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<tr>
<td>LGHT 6760 Lighting Workshop</td>
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<td>LGHT 6770 Light and Health</td>
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<td>or</td>
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<td>LGHT 6780 Lighting Leadership Seminar</td>
<td>4</td>
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<tr>
<td>LGHT 6980 Master’s Project</td>
<td>3</td>
</tr>
</tbody>
</table>

The degree requires 30 credit hours.

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1 The Interdisciplinary Research Studio is comprised of a design research investigation and may consist of a faculty led group project or be part of an ongoing interdisciplinary faculty research project approved by the program committee.

2 Both the Master’s Thesis and the Research Project are individual projects that will be conducted alongside or within current research streams at the School or Institute, however, the research project may also be conducted within a larger interdisciplinary research group or project.
Master of Science in Lighting

The School of Architecture, in association with the Lighting Research Center, offers a 48-credit, two-year curriculum leading to the Master of Science in Lighting degree. This program is based in the internationally renowned Lighting Research Center (LRC), the world’s largest university-based research facility dedicated to lighting.

The Master of Science in Lighting is the premier master’s level graduate degree offered in the field of lighting. This multidisciplinary degree allows students to work closely with faculty at the LRC to study the various disciplines involved in lighting research and design. The two-year program allows for a comprehensive, “hands-on” study of lighting which culminates in a thesis project in the second year during which each student studies a particular area of interest in-depth directly with a faculty adviser.

The M.S. in Lighting is geared toward students who wish to gain a broad education in lighting research and applications while working closely with LRC faculty. Students will participate in a variety of research and design projects over the two years of the program. Students completing the M.S. in Lighting degree can go on to careers in the lighting industry, or can continue on to further study in the Ph.D. in Architectural Sciences with a Concentration in Lighting, or Ph.D. degree options offered by other schools at Rensselaer, to prepare for university and/or advanced research careers.

The curriculum is normally completed in four semesters. Facilities and equipment specific to this program include the Lighting Research Center laboratories, various other Rensselaer laboratories, field study facilities, optical tools, the Laboratory for Human-Environment Interaction Research, the School of Architecture Workshop, and Rensselaer’s Libraries and Information Services.

M.S. LIGHTING CURRICULUM

FIRST YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>LGHT 4230</td>
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<td>Lighting Design</td>
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<tr>
<td>LGHT 4840</td>
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<tr>
<td>Human Factors in Lighting</td>
<td>3</td>
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<td>LGHT 6830</td>
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</tr>
<tr>
<td>The Physics of Light</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>Credit Hours</td>
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<tr>
<td>LGHT 4770</td>
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<tr>
<td>Lighting Technologies and Applications</td>
<td>4</td>
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<tr>
<td>LGHT 6750</td>
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<tr>
<td>Lighting Research Design</td>
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<td>LGHT 6770</td>
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<tr>
<td>Light and Health</td>
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SECOND YEAR

<table>
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<tr>
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<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ARCH 6810</td>
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<tr>
<td>Research Design Seminar</td>
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<tr>
<td>LGHT 6780</td>
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</tr>
<tr>
<td>Lighting Leadership Seminar</td>
<td>4</td>
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<tr>
<td>LGHT 6940</td>
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</tr>
<tr>
<td>Advanced Individual Projects in Lighting</td>
<td>1 to 6</td>
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<td>LGHT 6990</td>
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<tr>
<td>Master’s Thesis</td>
<td>1 to 9</td>
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</table>

<table>
<thead>
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<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARCH 6900</td>
<td></td>
</tr>
<tr>
<td>Graduate Thesis Seminar</td>
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<td>LGHT 6760</td>
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<td>Lighting Workshop</td>
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<td>LGHT 6940</td>
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<tr>
<td>Advanced Individual Projects in Lighting</td>
<td>1 to 6</td>
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<td>LGHT 6990</td>
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<tr>
<td>Master’s Thesis</td>
<td>1 to 9</td>
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</table>

The degree requires 48 credit hours.

Doctoral Programs

Rensselaer’s Ph.D. program in Architectural Sciences offers concentrations in Architectural Acoustics, Built Ecologies, and Lighting or other areas of specialization in which faculty have particular interest or expertise. This research degree supports the multidisciplinary and interdisciplinary investigation of a wide range of topics arising from the theory and practice of architecture and the configuration of the built environment. The School of Architecture offers the Doctor of Philosophy degree to candidates who are prepared to undertake innovative and substantive research that adds to the body of knowledge drawn on by the design disciplines. The degree provides a context for advanced study and research which combines architecture and appropriate areas of science, engineering, and the humanities. Students in the master’s program may continue into the Ph.D. in Architectural Sciences, subject to written approval by the department and Graduate Program Director. Upon successfully completing the M.S. requirements and passing the candidacy exam at the end of the summer of the first year, students may enter doctoral studies in the second year.
Each of the Ph.D. in Architectural Sciences degree concentrations have different course requirements. Significant cross-disciplinary study is encouraged not only to build on advanced work in architecture and technology emerging in the School, but also to form a program of study that draws widely on Rensselaer’s strength in other disciplines. Individual Plans of Study are defined between student and adviser and approved by the Graduate Program Director. A candidate for the doctoral degree must complete a Plan of Study with satisfactory grades containing 72 credit hours beyond the bachelor’s degree, including four credits of Doctoral Seminars, additional coursework as required, and a dissertation. Twenty-four credit hours may be transferred from the master’s degree to satisfy the basic Institute course requirements for the doctoral degree.

The dissertation must consist of a minimum of 30 and a maximum of 52 credits as approved by the doctoral committee and Graduate Program Director. At least two-thirds of the total credit hours, excluding dissertation, must contain the suffix numbers 6000–7999 with the further limitation that no more than 15 credit hours of 4000-4990 courses are to be allowed. Undergraduate courses below the 4000 level may not be used for credit toward graduate degrees, although some may be required to make up missing prerequisites.

All candidates must successfully take a qualifying exam for entry into doctoral study.

The Institute requires, without exception, degree completion for full-time students within five years for those entering with a master’s degree and within seven years for those entering with an undergraduate degree.

**Architectural Sciences (Concentration in Architectural Acoustics) Ph.D.**

Advanced study in Architectural Acoustics represents a unique opportunity for students to combine existing coursework with research in an educational experience that integrates scientific, computational, cognitive, and psychological research with experimental applications. The work is both multidisciplinary in scope and application-oriented, relating closely to design and to the needs of practitioners and industry.

Architectural Acoustics is an interdisciplinary field of science tied intimately to the design and optimization of buildings and interior spaces, wherein the physical sound and noise field of a space and its corresponding aural quality are primarily determined by architectural parameters such as shape, volume, surface, and structure properties. The acoustical quality of spaces and products is relevant not only for cultural venues but also for any environment that values human health, performance, and productivity. Architectural Acoustics is necessary for the accurate and realistic simulation of virtual spaces for prototyping, education, training, and design, as well as for noise and vibration control engineering. In addition, advanced acoustic modeling leads to new developments of “aural architecture” and noise control and evaluation.

Architectural Acoustics thus encompasses and links many traditionally disparate disciplines to the discipline of design: physics, hearing perception, mathematics, computer modeling, engineering, music, psychological and physiological acoustics, noise and vibration, cognitive science, and electro-acoustics. Thus the Ph.D. in Architectural Acoustics can also involve communication acoustics in its widest sense.

Examples of current research topics include:
- architectural acoustics, acoustics in performing arts spaces
- modeling and numerical predictions of both room and environmental acoustics properties
- noise and vibration, sound quality and design
- acoustical measurement techniques
- signal processing in acoustics
- physical acoustics
- communication acoustics

**Architectural Sciences (Concentration in Built Ecologies) Ph.D.**

The Doctor of Philosophy (Ph.D.) in Architectural Sciences with a concentration in Built Ecologies is an interdisciplinary educational and research degree designed to develop knowledge and expertise in the development of radically new building systems, structures and environments that are informed by the behavior of natural systems and/or performance characteristics of emergent technologies. Performance-driven design techniques seek new solutions to building system design based on the understanding that the built world should operate as an ecology and operate synergistically with larger ecologies. It seeks to address the global need for accelerated innovation and implementation of vastly-improved, energy-efficient, sustainable built environments.

Current research focuses on next generation building systems that make substantial advances in urgently needed areas such as clean, on-site energy generation, and fresh indoor air and water reclamation though ecological system integration, sustainable development and emerging bioclimatic design strategies.
Current Research Areas:

- Active Building Envelope (ABE)
- Dynamic Shading Window Systems (DSWS)
- Building Integrated Passive Dehumidification Strategies
- Phytoremediation of Indoor and Outdoor Air Quality
- Building Integrated PhasDevelopment of biomaterials for building construction and performance
- Passive Designing, developing and testing integrated building systems using emerging materials and technologies to achieve increased levels of building performance
- Developing tools for the design and evaluation of high performance building systems
- Performing in-situ or laboratory tests on innovative building systems
- Determining the ecological benefits or liabilities of building systems and technologies

**Architectural Sciences (Concentration in Lighting) Ph.D.**

The Ph.D. in Architectural Sciences with a Concentration in Lighting is a multidisciplinary degree encompassing the many disciplines that make up the field of lighting including physics, optics, psychology, physiology, photobiology, engineering, architecture, and design. These fields are brought together within the context of scientific inquiry, research, and discovery. Students’ research in the program is supported by all the assets of the Lighting Research Center (LRC), the nation’s preeminent center for research and education in lighting.

Students wishing to concentrate their doctoral studies in lighting will complete at least 30 credit hours of formal coursework covering the physics of light, human factors in lighting, lighting technology, design, and leadership. Following the completion of formal courses, students will concentrate their studies and research in a particular area of scientific inquiry under the guidance of an LRC faculty dissertation adviser. In consultation with an adviser, each student will formulate an individual Plan of Study and select areas of research concentration from areas including:

- Transportation lighting
- Human factors in lighting
- Solid-state lighting
- Light and health
- Energy-efficiency and energy policy

Graduates with a Ph.D. in Architectural Sciences with a Concentration in Lighting can pursue careers as faculty at colleges and universities, in research laboratories, or in other capacities within the lighting industry.

**Course Descriptions**

Courses directly related to all Architecture curricula are described in the Course Description section of this catalog under the department code ARCH or LGHT.
School of Engineering

Dean: David V. Rosowsky
Associate Deans: Tarek Abdoun, Kurt Anderson, Linda S. Schadler
School of Engineering Home Page: http://www.eng.rpi.edu

Rensselaer’s School of Engineering is committed to educating engineers prepared to solve society’s grand technical challenges with integrity and excellence.

With the vision of being a top tier school of engineering with global reach and global impact, the school is committed to technological excellence and to providing a superior education that leads to highly successful careers for its students.

In addition, the school has a mission to educate the leaders of tomorrow for technology-based careers; to celebrate discovery and the responsible application of technology; to create knowledge and global prosperity.

Graduates of the school become leaders in engineering ready to solve real world practical problems. Its students have a solid foundation in math, science, and engineering fundamentals, complemented by in-depth training in their technical field. Through hands-on learning, laboratory experiences, and multidisciplinary design opportunities, they gain valuable experience in the practical application of that technical knowledge. The school enhances their skills in innovation, leadership, and communication, and ensures that they have a broad exposure to humanities, social sciences, and ethics so that they practice engineering in a socially responsible and ethical manner. Also instilled are curiosity, innovation, and the love of learning.

Highly cognizant of how rapidly technology and engineering are changing, Rensselaer continually enhances and revitalizes its curricula and facilities. Recent examples include the new building for biotechnology and interdisciplinary studies, a new wind tunnel, current development of a state-of-the-art electrical engineering undergraduate laboratory, and the nanotechnology characterization core.

The School of Engineering faculty members are committed to undergraduate and graduate education, and all hold the highest attainable degree in their fields. They are active in highly impactful and pioneering engineering research and act as key consultants to industry and the government.

Two other features that help distinguish a Rensselaer education are the mobile computing program and the studio classrooms. All undergraduate students are required to have laptop computers and the campus has primarily wireless connectivity. The classrooms take advantage of that connectivity both for content delivery, discovery based learning, and contact between faculty and students. The studio classrooms are equipped with highly advanced interactive learning tools, provide the small comfortable environment that enhances the School of Engineering’s personalized approach to teaching, maximizing student interaction among classmates and professors, and encouraging hands-on, collaborative projects.

Teamwork is yet another aspect of real-world engineering practice that Rensselaer cultivates through both its coursework and facilities. A prime example is the Institute’s 11,000 square-foot O.T. Swanson Multidisciplinary Design Laboratory (MDL). This distinctive, first-class facility consists of a state-of-the-art design space, rapid prototyping and fabrication space, and a system integration space for both mechanical and electrical as well as electromechanical products. Here, students work in cross-disciplinary teams on a variety of industry-and service organization-sponsored and entrepreneurial projects, all with practical and real-life applications.

Augmenting the course experience for both undergraduate and graduate students are research facilities, internships, and the opportunity to study abroad. The school’s experimental research facilities are state-of-the-art and are complimented by one of the largest academic computing facilities in the world. All research foci can be found at http://www.rpi.edu/research.

Sponsoring both undergraduate and graduate research are a variety of government (federal and state) agencies as well as private industry. As a result of focusing research on topics of significant commercial interest, Rensselaer, in relation to other major university engineering programs, has one of the largest fractions of support from private industry.

Rensselaer offers research opportunities in major interdisciplinary research centers, which primarily involve School of Engineering faculty and students. Among these centers are the Center for Automation Technologies and Systems (CATS), Center for Biotechnology and Interdisciplinary Studies, the Center for Integrated Electronics (CIE), NYS Center for Future Energy Systems (CFES), The Rensselaer
Nanotechnology Center, the Scientific Computation Research Center (SCOREC), and the Computational Center for Nanotechnology Innovations (CCNI). More information about these centers is available at http://www.rpi.edu/research.

In addition to the major Institute centers, the School of Engineering conducts research in its own multidisciplinary centers. These include the Center for Infrastructure, Transportation and the Environment (CITE), the Center for Modeling Simulation and Imaging in Medicine (CeMSIM), the Center for Earthquake Engineering Simulation (CEES), the Center for Flow Physics and Control Research, the Center for Ultra-wide-area Resilient Electric Energy Transmission Networks (ERC), and the Smart Lighting Engineering Research Center (ERC).

All departments offer both undergraduate and graduate curricula and degree programs in their fields. In the list below, programs associated with post-baccalaureate degrees only are indicated by (G).

Degrees Offered and Associated Departments

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Overview of Undergraduate Programs

Baccalaureate Program

In general, the Bachelor of Science program is intended for students seeking careers in engineering-related areas or as a basis for advanced study in engineering or in fields other than engineering. To obtain a B.S. in an engineering field, students must fulfill the general requirements listed in the Academic Information and Regulations section of this catalog and satisfactorily complete the prescribed engineering curriculum. Certain courses, such as one-credit-hour non-engineering courses graded on a satisfactory/unsatisfactory basis or more than six credit hours of ROTC courses, cannot be applied toward the degree requirements. Also noteworthy is that courses in accounting, industrial management, finance, entrepreneurship, and personnel administration that are offered by the School of Management, as well as ROTC courses, will not satisfy the humanities and social sciences requirement, but may be taken as free electives.

Although many students enter at the freshman level and achieve all their educational objectives at Rensselaer, a significant number find it accommodating and advantageous to enter at intermediate levels. Entrance into the engineering program is particularly attractive to graduates of two-year colleges. Rensselaer also has articulation agreements with a number of four-year universities for “3-2” programs. All such students enter with advanced standing and credit according to their credentials.

Professional Program

For most students, specialization and determination of the degree program that matches their individual career goals develops in earnest during the third year. At this point, a student may pursue either a fourth year for their Bachelor of Science (B.S.) degree in an engineering specialty or, if accepted by the Office of Graduate Education for the Professional Program, undertake a coherent program integrating advanced undergraduate and graduate study leading to the Master of Engineering (M.Eng.) degree in a specific field, and receiving a Bachelor of Science along the way. This professional program offers post-baccalaureate studies specifically intended as preparation for professional engineering practice. Graduates of other colleges and universities may be admitted with advanced standing (the Professional
Program excepted) if they have appropriate accredited baccalaureate engineering degrees or the equivalent. Admission to a professional degree program is based on demonstration of adequate preparation and competence. The faculty in each curriculum judges qualifications for admission. Application should be made directly to the Office of Graduate Education.

Engineering Core Curriculum

At Rensselaer, the core engineering program includes the math and science courses that form the foundation for all engineering curricula, as well as the elements of the curriculum that are common to all engineering students throughout all four years. There is considerable flexibility within the first two years to allow students who are undeclared as to their choice of engineering field or discipline an opportunity to clarify their interests. Such students can, by using the electives in the first two years, sample various disciplinary offerings to aid in choosing which engineering field to pursue.

The core engineering curriculum in a general format is presented under Program. Specific curricula leading to the Bachelor of Science degree for each field of specialization are presented under the corresponding disciplinary headings for students who are certain of their disciplinary choices and wish to begin specializing earlier than the third year.

Although undergraduates normally are not allowed to take graduate-level courses (levels 6000–9000) except by special permission of the instructor, a student admitted to the Professional School may be required to take certain courses in the 6000–9000 range and may elect other such courses with the approval of his or her adviser.

All School of Engineering students entering Rensselaer directly from high school begin their curricula with the core engineering program. The primary objective of this program is to provide students with a liberal education and to develop a broad scientific and technical foundation for their future specialization. This predisciplinary-specific program usually extends through the third semester but may extend into the third academic year. During this phase, the primary focus is on the foundations of engineering as a unified field. The foundation in mathematics, physics, chemistry, and biology, combined with the specified engineering sciences (e.g., strength of materials or thermal-fluids, etc.) satisfies basic technical knowledge requirements without regard to the intended field of specialization. In the humanities, arts, and social sciences area, courses not only enrich the student as an individual but also provide the perspective professionals need to make decisions that will affect society.

The electives within the core engineering program, together with the required basic content, give each student the opportunity to refine his or her goals and develop a broad and solid foundation. Elective courses also allow undeclared students to sample professionally oriented courses from several curricula so as to make a more enlightened choice of major. A student can also choose electives to provide a broader base or use them to focus on a particular field at an early stage. An imaginative student, with faculty counsel, can develop any number of creative study programs. It is also possible to major in one branch of engineering and obtain a concentration in a second branch.

Students need not begin specializing in a particular area until the fourth semester of study. However, when choosing electives, students must consider that each engineering discipline requires certain courses be taken earlier as field (or discipline) prerequisites.

To provide proper guidance, each student is assigned a faculty adviser who is knowledgeable in core engineering matters and can help the student plan a program to best meet his or her educational and career objectives. Once a student identifies a specific curriculum to pursue, a new adviser, who is particularly aware of the opportunities for advanced study in this area, is assigned.

The combination of the core engineering program with the subsequent discipline-specific courses provides a coherent yet flexible curriculum that allows students to obtain an engineering education at all levels in multiple focus areas. The overall School of Engineering program is structured to permit students to select plans of study that fit their individual goals, aptitudes, and interests. It also enables students to enter and leave at points most appropriate to their individual plans and to facilitate entrance at intermediate levels in the undergraduate and graduate programs.

All elements of the curriculum, including both core and discipline-specific courses, are under continuous review to ensure the application of new pedagogies and teaching methods and the introduction of courses covering the latest technological and computing and analysis advances. Topics such as quality, ethics, cultural sensitivity, safety, environmental impact, and contemporary issues related to science and engineering, are constantly integrated into curricula. Additionally included in Rensselaer engineering curricula is the topic of entrepreneurship. Through these efforts, Rensselaer ensures that leadership, interpersonal communications, teamwork, problem formulation, system synthesis, critical thinking, and problem-solving skills are practiced and enhanced.

To provide a clear picture of what prospective engineering students can expect in their first two years at Rensselaer, a template showing how the core engineering program proceeds can be found in the Programs section of this catalog.
**Special Undergraduate Opportunities**

**Undergraduate Research Experience**
At Rensselaer, involving undergraduates in real-world engineering research is of paramount importance. Through the Undergraduate Research Program (URP), described in the Educational Resources and Programs section of this catalog, undergraduates work directly with faculty and/or graduate students on projects requiring critical inquiries. These studies involve exciting areas of leading-edge technological research and have the potential to result in groundbreaking discoveries. Involvement in undergraduate research can be arranged strictly for the experience, for credit, or for pay. Students apply through direct contact with faculty seeking students via Web site or campus advertisements.

**Cooperative Education**
By carefully structuring their programs and taking courses during the summer, some students may augment their academic course work with work experience through the Cooperative Education program. Studies and work assignments are scheduled after consultation with their curriculum adviser. Through careful planning and effective use of summer courses, some co-op students complete their academic program in four years. Some delay graduation for a full academic year to obtain additional work experience. Additional information on Rensselaer’s Cooperative Education Program can be found in the Student Life section of this catalog under the Center for Career and Professional Development.

**Study Abroad/Exchange Programs**
Study abroad has become an integral part of a well-rounded undergraduate experience. Students who spend time abroad will gain a deeper understanding not only of the culture in which they will be living, but also the culture of the U.S. and its place in today’s global society. A period of study abroad allows students to develop a broader perspective on their academic field of study while earning credit towards a Rensselaer degree.

Rensselaer offers a variety of study abroad and exchange opportunities at top universities and institutes around the world. Most semester opportunities require junior standing and a minimum GPA of 3.0. Occasionally, students choose to study abroad for an entire academic year. Most study abroad and exchange programs are managed by the Office of International Programs.

For more information, please contact the Office of International Programs, Karen Dvorak, dvorak2@rpi.edu or Jamie Obst at violaj2@rpi.edu. Additional information may be found at [http://undergrad.rpi.edu](http://undergrad.rpi.edu) (click on Office of Intl. Programs tab).

The schools chosen for this new program will be renowned in the field of engineering education, will teach in English, have diversified curriculum course offerings, have a large base of international students, and be willing to exchange undergraduate engineering students with Rensselaer. Students interested in this program must demonstrate superior academic records, maturity, and a willingness to fully participate in this exchange program. This new program will be strongly recommended for all Engineering students.

At the present time, Rensselaer’s School of Engineering also advocates a voluntary international experience as an ideal means to promote a broad-based engineering education, develop the “citizen engineer,” and provide undergraduate students with a global perspective. To facilitate such opportunities, the School has helped formulate and actively participates in the Global Engineering Education Exchange (Global EE) program. Oriented primarily to undergraduate students, this program offers them the chance to spend one or two semesters at an international university which could be followed by an industrial internship in that country. Preferred timing for this experience is the junior year, and students normally apply in the fall or spring of their sophomore year.

Global EE offers students the chance to study and learn in the native language of the host country. Additional opportunities allow students to pursue foreign study opportunities at universities where the courses are presented and taught in English. As a result, while students may benefit from knowledge of a foreign language, it is not a requirement for participation in this program. Refresher language instruction in French and German is usually given in the summer preceding the fall semester for those who have prior language experience and will be studying in the foreign language. Approximately 37 U.S. universities and over 50 universities in the rest of the world participate in the Global EE program. People interested in the Global EE program should contact Karen Dvorak, dvorak2@rpi.edu or Jamie Obst at violaj2@rpi.edu. The Global EE Web site can be found at [www.iie.org](http://www.iie.org).
Overview of Graduate Programs
The School of Engineering offers four graduate degrees through which students may achieve their objectives. These include the Master of Science (M.S.), Master of Engineering (M.Eng.), Doctor of Engineering (D.Eng.), and Doctor of Philosophy (Ph.D.) degrees.

Master's Programs
Both the M.S. and M.Eng. degree programs focus on engineering fundamentals at advanced levels, and both include significant elective opportunities that permit students to individualize their study plans. Either program provides an excellent basis for further graduate work in engineering, and neither includes a foreign language requirement.

The Master of Engineering program is designed primarily for students preparing for professional practice and does not require a thesis. Admission is based on the student's demonstration of adequate preparation and competence. Applications for admission should be transmitted to the Office of Graduate Education. Note that many students complete a Master of Engineering and then pursue a Ph.D.

The Master of Science program encompasses diverse educational needs and is designed primarily for students intending to obtain a Ph.D. degree. Admission requires a baccalaureate degree in an area appropriate to the individual's proposed plan of graduate study and could conceivably be outside the field of engineering. Those who do not have a B.S. in Engineering, however, may be required to complete some extra course work that does not qualify for graduate credit. Depending on the department in which the degree is being pursued, a thesis may be required.

Doctoral Programs
A doctoral student formally affiliates with the department where activities most closely relate to his or her advanced study goals. However, the range of inquiry may cut across department and school lines, so that research opportunities are extremely broad, and students can pursue highly individualized programs. There are no foreign language requirements.

The Doctor of Engineering degree is characterized by the special nature of the thesis. Thus the student, working with an adviser, proposes an engineering problem of substance and develops a solution. The student must demonstrate ability to apply scientific principles to meet engineering needs, with due regard to social and economic factors and within a reasonable time constraint. The presentation and defense of his or her conclusions before a doctoral subcommittee and guests serves as the final examination for the degree.

The Doctor of Philosophy program is the traditional degree with a thesis that involves substantial original research. The program follows the general rules of the Office of Graduate Education.
Biomedical Engineering

Department Head: Deepak Vashisht

Department Home Page: http://www.eng.rpi.edu/bmed/

Biomedical engineers are typically involved in research and design. They discover new knowledge that they apply to designing new engineering devices and systems for the fields of medicine and biology. Among the devices that biomedical engineering (BMED) has produced are noninvasive body imaging systems, critical-care monitoring instruments used in intensive care units, and a wide spectrum of implants, such as artificial joints, oral implants, and vascular grafts, all of which are used to replace diseased tissues. With new discoveries related to stem cells, genomics, and proteomics, BME is increasingly involved in cellular and molecular biology for basic research and design of new devices and technologies. Biomedical engineers are helping to advance the new field of tissue engineering. In this capacity, they use basic knowledge about the cellular/molecular processes of tissue regeneration to help design replacement tissues and organs. At Rensselaer, a key focus is functional tissue engineering, which encompasses the biology and engineering necessary to understand, characterize, synthesize, and shape the required mechanical and functional behavior of living tissues.

Founded upon a strong engineering base, the BMED curriculum combines significant life science content with courses that bring engineering solutions to medical needs. BMED students may select from a variety of concentrations to develop knowledge and skills in key areas of biomedical engineering including biomechanics, biomaterials, cell and tissue engineering, implant design, bioimaging, instrumentation, and computational analysis and modeling of biological systems.

Research Innovations and Initiatives

Biomolecular Science and Engineering
Biomolecular science is one area in the life sciences which focuses on the understanding of cellular processes at the molecular level and modifications of extracellular matrix (ECM). Developing an understanding and using this knowledge for manipulating cell and matrix processes in order to predict, prevent or ameliorate medical conditions are key components of biomolecular science and engineering. Research in biomolecular science deals with applications ranging from drug development and delivery, proteomics, to tissue engineering.

Biomedical Imaging
Biomedical imaging produces internal images of patients, animals or tissue samples for basic research, preclinical and clinical applications. The focuses are on x-ray and optical tomographic imaging, multi-modality techniques, and their utilities of fundamental, translational and healthcare significance. Research and training involve the entire process from innovation, instrumentation, to validation for real-world impact. We have close collaborative ties with medical schools, and are in strong academic-industrial partnerships such as with the GE Global Research Center.

Musculoskeletal Engineering
The musculoskeletal well-being of aging individuals is a key factor affecting quality of life. As medical advances continue to extend people’s lifespans, the need for musculoskeletal engineering becomes paramount. In response to this critical need, our faculty are investigating, modeling and/or regenerating bone, cartilage, intervertebral discs, muscle, tendon, ligament and skin. This program promotes musculoskeletal research and discovery from molecules to mice to humans. We bring together and prepare future musculoskeletal engineers with expertise in multiscale biomechanics, biomaterials, cell and tissue engineering, in vivo matrix injury models, stem cells and regenerative medicine, and proteomics.

Neural Engineering
Injuries and disease to the nervous system affect all age groups and cost billions of dollars every year in medical expenses and reduced quality of life. Using neurological engineering – a combination of neuroscience and engineering – faculty and students are developing new approaches to address the functional repair of both large-gap peripheral nerve and spinal cord injuries. This program prepares engineers with training in the areas of cell and tissue engineering, molecular control of neurite guidance, complex multi-cellular models of injury and repair, proteomics, neural stem cells and rational biomaterial design.

Systems Biology and Biocomputation
Systems biology is the coordinated study of biological systems, at the cellular, organ, or whole body level, which aims at achieving a systems-level understanding of biological processes. Systems biology lies at the interface of engineering, computer science, and molecular/cell biology and involves sophisticated computational and high-throughput experimental approaches. One of the key outcomes of systems biology is the development of biomedical models describing the system. These models can be used to test hypotheses in silico, or to design drug targets or intervention strategies.
Vascular Engineering
Vascular disease is the leading cause of heart attack and stroke worldwide. Our researchers are dedicated to development of novel diagnostic and therapeutic agents needed to alleviate the pain and suffering associated with these diseases. Faculty and their students are integrating bioengineering tools with vascular biology to understand the pathophysiological mechanisms of vascular disease, and they are developing methods to guide blood vessel regeneration. Researchers apply multidisciplinary approaches from biomechanics, biomaterials, molecular imaging, cell and tissue engineering to study vascular development and disease at the molecular, cellular, and organ levels.

Faculty *

Professors

Cramer, S.—Ph.D. (Yale University); expert in the fields of chromatographic bioprocessing and separation science (Joint with Materials Engineering).

De, S.—Ph.D. (Jadavpur University, India); computational mechanics, multiscale computations, haptics, soft tissue mechanics, virtual reality-based surgical simulations and computer aided interventional planning. (Joint with Mechanical, Aerospace and Nuclear Engineering).

Dordick, J.—Ph.D. (Massachusetts Institute of Technology); enabling the efficient and selective interaction of biomolecules with synthetic nanoscale building blocks to generate functional assemblies (Joint with Chemical and Biological Engineering).

Dunn, S.—Ph.D. (University of Maryland and Free University of Amsterdam, Netherlands); Vice Provost and Dean of Graduate Education.

Garcia, A.—Ph.D. (Cornell University) Sr. Constellation Professor. (Joint with Physics; Applied Physics and Astronomy).

Hahn, J.—Ph.D. (University of Texas at Austin) systems biology, modeling and control of complex dynamic systems, sensitivity analysis of nonlinear and uncertain systems, model reduction (Department Head).

Linhardt, R.—Ph.D. (The Johns Hopkins University); Constellation Chair, Professor (Joint with Chemistry and Chemical Biology).

Plopper, G.—Ph.D. (Harvard University Medical School); extracellular matrix dependent cellular responses (human mesenchymal stem cells and breast cancer cells) including growth, differentiation and migration. (Joint with Biology).

Vashishth, D.—Ph.D. (University of London, UK); in vitro/in vivo model systems to investigate modifications of bone matrix proteins and their relationships to fracture and bone biology.

von Maltzahn, W.W.—Ph.D. (University of Hannover, Germany) serving as Associate Vice President for Research.

Wang, G.—Ph.D. (State University of New York at Buffalo) Biomedical imaging, x-ray computed tomography, optical molecular tomography, omni-tomography, other inverse problems, and informetrics.

Xu, G.X.—Ph.D. (Texas A&M University); Multiscale human computing applications on radiation modeling. (Joint with Mechanical, Aerospace, and Nuclear Engineering).

Yacizi, B.—Ph.D. (Purdue University); Statistical signal and image processing pattern recognition, inverse problems in medical imaging. (Joint with Electrical, Computer, and Systems Engineering).

Associate Professors

Corr, D.—Ph.D. (University of Wisconsin); wound healing and biomechanics in orthopaedic soft tissue, muscle mechanics and modeling and cell-based tissue engineering.

Hahn, M.—Ph.D. (Massachusetts Institute of Technology) scaffold-directed mesenchymal stem cell differentiation; vascular tissue engineering; osteochondral regeneration; vocal fold tissue engineering.

Intes, X.—Ph.D. (Universite de Bretagne Occidentale – France); biophotonics and biomedical instrumentation. Research is on functional imaging of the breast and brain, fusion with other modalities, and fluorescence molecular imaging.

Kotha, S.—Ph.D. (Rutgers University); research interests lie broadly in the area of developing novel multi-functional materials and devices to understand and control cell/ tissue function.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Ledet, E.—Ph.D. (Rensselaer Polytechnic Institute); complex in vitro and in vivo models to define the role of biomechanics in degenerative diseases of the musculoskeletal system.

Thompson, D.M.—Ph.D. (Rutgers University); quantitative and mechanistic examination of the microenvironment of the nervous system to promote functional repair following spinal cord and/or large-gap peripheral nerve injury.

Assistant Professors

Cooper, J.A. Jr.—Ph.D. (Drexel University); biomaterials; regenerative medicine, tissue engineering, stem cell biology, bioimaging, bioreactors, and biosensors.

Dai, G.—Ph.D. (Massachusetts Institute of Technology); cardiovascular biomechanics and vascular biology; role of biomechanical forces in cardiovascular disease processes; 3-D cell printing technology for stem cells and tissue engineering applications.

Gilbert, R.—Ph.D. (University of Michigan) research focus shifted towards the development of novel biomaterial constructs for tissue repair.

Wan, L.Q.—Ph.D. (Columbia University) cell chirality; BioMEMS; stem cell mechano-biology; functional tissue engineering; cartilage biomechanics and bioimaging.

Research Faculty

Mehta, S.—Ph.D. (University of Texas Southwestern Medical Center); biotechnology management and entrepreneurship. (Research Assistant Professor).

Affiliated Faculty

Cheney, M.—Ph.D. (Indiana University); professor of mathematical sciences; applied mathematics, differential equations, mathematical computed tomography.

Isaacson, D.—Ph.D. (New York University); professor of mathematics and computer science; electric current computed tomography.

Adjunct Faculty


Monastersky, G.—Ph.D. (Rutgers University and UMDNJ) research interests have included human embryonic stem cell biology, mammalian gene regulation and expression, transgenic animal disease models, cancer cell biology, pharmacogenomics and reproductive biology.

Schalk, G.—Ph.D. (Rensselaer Polytechnic Institute); brain-computer interface research; Research Scientist V, Wadsworth Center, NYS Health Department.


Uhl, R.—M.D. (Jefferson Medical College); hand and upper extremity surgery, trauma surgery; education methods, fracture fixation, fracture healing; Orthopaedic Residency Program Director - Division of Orthopaedic Surgery, Albany Medical College.

Vincent, P.A.—Ph.D. (Albany Medical College); regulation of endothelial cell function by adherens junctions, vascular biology; Professor and Associate Director and Graduate Director – The Center for Cardiovascular Science, Albany Medical College.

Emeritus Faculty

Bizios, R.—Ph.D. (Massachusetts Institute of Technology); cellular bioengineering, cell/biomaterial interactions, biomaterials.

Newell, J.C.—Ph.D. (Albany Medical College); cardiopulmonary physiology, systems modeling, impedance imaging.

Ostrander, L.E.—Ph.D. (University of Rochester); information processing, biomedical signal analysis, human factors in medical equipment design.

Zelman, A.—Ph.D. (University of California, Berkeley); membrane transport phenomena, food processing.

Spilker, R.L.—Sc.D. (Massachusetts Institute of Technology); development of computational methodologies and computer simulation tools for the mathematical modeling of physiological function to solve complex biomedical problems.

Zelman, A.—Ph.D. (University of California, Berkeley); membrane transport phenomena, food processing.

Undergraduate Programs

Department Mission
To educate the biomedical engineering leaders of tomorrow who will apply fundamental engineering principles to the responsible solution of problems in biology and medicine, to contribute to human disease management, and to bring engineering innovation and technology to the clinic while creating knowledge and enhancing global prosperity.

Objectives of the Undergraduate Curriculum
Graduates of the Biomedical Engineering Program will within five years of graduation:

1. be engaged in professional practice in industry, academia, or government related to biomedical engineering; and/or
2. have enrolled in an academic program pursuing a graduate, medical, law, business, or other professional post-graduate degree.

Students may achieve these objectives through completion of the baccalaureate program leading to the B.S. degree. To ensure selection of the appropriate concentration and courses to meet individual interests and goals, students should consult their academic adviser as early as possible. The Biomedical Engineering Program at Rensselaer is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Baccalaureate Program
In lieu of the general core engineering program presented earlier, students who identify biomedical engineering as their discipline may follow the program outlined below. This curriculum requires a minimum of 128 credits.

<table>
<thead>
<tr>
<th>FIRST YEAR</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
</tr>
<tr>
<td>CHEM 1100</td>
<td>Chemistry I</td>
</tr>
<tr>
<td>ENGR 1100</td>
<td>Introduction to Engineering Analysis</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
</tr>
<tr>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>BIOL 2120</td>
<td>Introduction to Cell and Molecular Biology</td>
</tr>
<tr>
<td>ENGR 1200</td>
<td>Engineering Graphics and CAD</td>
</tr>
<tr>
<td>MATH 1020</td>
<td>Calculus II</td>
</tr>
<tr>
<td>PHYS 1100</td>
<td>Physics I</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECOND YEAR</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
</tr>
<tr>
<td>CSCI 1190</td>
<td>Beginning C Programming for Engineers</td>
</tr>
<tr>
<td>ENGR 2050</td>
<td>Introduction to Engineering Design</td>
</tr>
<tr>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
</tr>
<tr>
<td>PHYS 1200</td>
<td>Physics II</td>
</tr>
<tr>
<td></td>
<td>Concentration I</td>
</tr>
<tr>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>BMED 2100</td>
<td>Biomaterials Science and Engineering</td>
</tr>
<tr>
<td>BMED 2300</td>
<td>Biomedical and Bioinstrumentation</td>
</tr>
<tr>
<td>BMED 2540</td>
<td>Biomechanics</td>
</tr>
<tr>
<td>ENGR 2600</td>
<td>Modeling and Analysis of Uncertainty</td>
</tr>
</tbody>
</table>
THIRD YEAR

Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4290</td>
<td>Human Phys Systems</td>
<td>4</td>
</tr>
<tr>
<td>BMED 2200</td>
<td>Modeling of Biomedical Systems</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Concentration II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

Spring

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED 4500</td>
<td>Advanced Systems Physiology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Concentration III</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Concentration IV</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Professional Development II</td>
<td>2</td>
</tr>
</tbody>
</table>

FOURTH YEAR

Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED 4010</td>
<td>Biomedical Engineering Laboratory</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Concentration V</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Free Elective I</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Free Elective III</td>
<td>3</td>
</tr>
</tbody>
</table>

Spring

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED 4600</td>
<td>Biomedical Engineering Design</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 4010</td>
<td>Professional Development III</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Free Elective IV</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Concentration VI</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

The total credit hours for the degree is 128–130.

BMED Core Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED 2100</td>
<td>Biomaterials Science and Engineering (Second Year - Spring)</td>
<td>4</td>
</tr>
<tr>
<td>BMED 2200</td>
<td>Modeling of Biomedical Systems (Third Year - Fall)</td>
<td>4</td>
</tr>
<tr>
<td>BMED 2300</td>
<td>Bioimaging and Bioinstrumentation (Second Year - Spring)</td>
<td>4</td>
</tr>
<tr>
<td>BMED 2540</td>
<td>Biomechanics (Second Year - Spring)</td>
<td>4</td>
</tr>
<tr>
<td>BMED 4010</td>
<td>Biomedical Engineering Laboratory (Third or Fourth year)</td>
<td>4</td>
</tr>
<tr>
<td>BMED 4500</td>
<td>Advanced Systems Physiology (Third Year - Spring)</td>
<td>4</td>
</tr>
<tr>
<td>BMED 4600</td>
<td>Biomedical Engineering Design (Fourth Year - Spring)</td>
<td>3</td>
</tr>
</tbody>
</table>

Biomaterials Concentration

BMED Required Biomaterials Concentration courses (Three courses required) | Credit Hours |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 1600</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2250</td>
<td>4</td>
</tr>
<tr>
<td>MTLE 2100</td>
<td>4</td>
</tr>
</tbody>
</table>

BMED Elective Biomaterials Concentration: (Two technical electives to be chosen from this list) | Credit Hours |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED 4240</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4410</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4420</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4450</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4451</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4560</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4650</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6410</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6420</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6450</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6500</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6560</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 2250</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4050</td>
<td>3</td>
</tr>
</tbody>
</table>

One course to be chosen from the approved technical electives of any of the three concentrations.

2 The same course can NOT count as both an elective and a required course.
### Biomechanics Concentration

<table>
<thead>
<tr>
<th>BMED Required Biomechanics concentration courses: (Three courses required)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED 4580 - Biomedical Fluid Mechanics (Fourth Year - Fall)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6480 - Biomedical Fluid Mechanics (Fourth Year - Fall)</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 1600 - Materials Science for Engineers (Second Year - Fall)</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2250 - Thermal and Fluids Engineering I (Third Year - Fall)</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BMED Elective Biomechanics concentration: (Two technical electives to be chosen from this list)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED 4420 Clinical Orthopaedics and Contemporary Research (Fall)</td>
<td>4</td>
</tr>
<tr>
<td>BMED 4610 Biomechanics II (Fall)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4650 Intro to Cell and Tissue Engineering (Third Year - Spring)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4660 Muscle Mechanics and Modeling (Spring)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4680 Biomedical Fluid Mechanics (Fall)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6420 Clinical Orthopaedics and Contemporary Research (Fall)</td>
<td>4</td>
</tr>
<tr>
<td>BMED 6480 Biomedical Fluid Mechanics (Fall)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6650 Intro to Cell and Tissue Engineering (Spring)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6660 Muscle Mechanics and Modeling (Spring)</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 2010 Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 2410 Signals and Systems</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 2350 Embedded Control</td>
<td>4</td>
</tr>
</tbody>
</table>

One course to be chosen from the approved technical electives of any of the three concentrations.

### Bioimaging/Bioinstrumentation Concentrations (Three Required Courses)

<table>
<thead>
<tr>
<th></th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 2010 Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 2410 Signals and Systems</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 2350 Embedded Control</td>
<td>4</td>
</tr>
</tbody>
</table>

### BMED Bioimaging Concentration: (Two technical electives to be chosen from this list)

<table>
<thead>
<tr>
<th></th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED 4961/6960-ECSE 6963 Biological Image Analysis (Spring)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4965/MANE 4340 Physics of Radiology</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6960/MANE 6480 Health Physics and Medical Aspects of Radiation</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4440 Biophotonics</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6440 Biophotonics</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4530 Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4540 Introduction to Image Processing</td>
<td>3</td>
</tr>
<tr>
<td>MANE 4340 Physics of Radiology</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6480 Health Physics and Medical Aspects of Radiation</td>
<td>3</td>
</tr>
</tbody>
</table>

### BMED Bioinstrumentation concentration: (Two technical electives to be chosen from this list)

<table>
<thead>
<tr>
<th></th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED 4965/MANE 4340 Physics of Radiology can be taken as 1 elective</td>
<td>3</td>
</tr>
<tr>
<td>ESCE 2050 or ESCE 2210</td>
<td>4</td>
</tr>
<tr>
<td>BMED 4410 BioMEMs (Spring)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4440 Biophotonics (Fall)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6410 BioMEMs (Spring)</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6440 Biophotonics (Fall)</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 2050 Introduction to Electronics</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 2210 Microelectronics Technology</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4050 Advanced Electronic Circuits (Spring)</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4909 Mechatronics (Fall)</td>
<td>3 credit hours, 5 contact hours</td>
</tr>
<tr>
<td>ECSE 5050 Advanced Electronic Circuits (Spring)</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 2300 Electronic Instrumentation</td>
<td>4</td>
</tr>
<tr>
<td>MANE 4340 Physics of Radiology (Fall)</td>
<td>3</td>
</tr>
</tbody>
</table>

One course to be chosen from the approved technical electives of any of the three concentrations

### Humanities, Arts, and Social Sciences Electives

In this area, electives are based on the Institute and School of Engineering requirements. Students are urged to select humanities, arts, and social science sequences with adequate breadth and depth in subject areas. Students desiring minors in humanities, arts, or social sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.
Biomedical Engineering and Management Minor (Minor and M.S. in Management)

1.) Students who identify biomedical engineering as their discipline and in addition would like to obtain a minor in Management will complete a total of 132 credits, fulfilling Management's requirements for a minor with the following five courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 1100</td>
<td>Introduction to Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 2300</td>
<td>Fundamentals of Accounting for Decision Making</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 2320</td>
<td>Managerial Finance</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4110</td>
<td>Operations Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4430</td>
<td>Marketing Principles</td>
<td>4</td>
</tr>
</tbody>
</table>

Satisfying BMED free elective requirements

Twelve of these credits can be used to satisfy BMED free elective requirements. See the BME Web site at bme.rpi.edu for a detailed curriculum template.

2.) Upon completion of the five courses listed above students will have fulfilled the undergraduate course requirements for admission into the Master’s in Management in Technology Commercialization and Entrepreneurship offered by the Lally School of Management. Applications to the Master’s in Management program should be submitted to the Lally School of Management not earlier than the spring semester of the second year. For more information about the M.S. in Management in Technology Commercialization and Entrepreneurship, visit the BME Web site at bme.rpi.edu.

Biomedical Engineering and Medicine

Students who identify biomedical engineering as their undergraduate major and are planning to pursue the M.D. degree are recommended to follow a curriculum that requires a minimum of 129 credits and that will allow students to satisfy all premed requirements by the end of the third academic year, preparing them for the MCAT exams. For a detailed curriculum template, see the Web site at bme.rpi.edu.

The Biomedical Engineering Department, in conjunction with Albany Medical College, also offers the Physician Engineer (PE) program in which students are able to earn a B.S. in biomedical engineering from Rensselaer and an M.D. from Albany Medical College. The program could be completed within seven to eight years (seven, with an increased engineering course load), and includes an optional research component. The MCAT requirement will be waived for this combined program.

A program is also being developed for students to pursue a B.S./M.D./Ph.D. with an expected completion time of 10 years. At the graduate level, an M.D./Ph.D. program is being drafted, targeted to students with previous research experience and a B.S. in Engineering.

For an update on the current status of these programs, visit the BMED Web site at bme.rpi.edu.

Graduate Programs

The department offers programs leading to M.S. and Ph.D. degrees. Persons seeking admission to any of these graduate degree programs in biomedical engineering should complete an on-line application and have their Graduate Record Examination (GRE) test scores and transcripts sent to the Graduate Admissions Office.

Master’s Programs

Master of Science

The Biomedical Engineering M.S. degree can be obtained with or without a thesis. There are three possible M.S. degree options: M.S. with Thesis, M.S. with Project and Coursework-only M.S. The latter option is recommended for students who do not plan further graduate studies. The thesis and project options are advised for students who plan to obtain a higher graduate degree or have a strong interest in research. The master’s thesis should contribute new knowledge to the field of study and is reviewed by the Masters’ committee and submitted to the OGE for review.

Students pursuing the M.S. (with or without thesis) must complete a minimum of 30 credit hours. The minimum number of credits for coursework for a M.S. with thesis is 24 and 26 for a non-thesis M.S. At least four BME classes at the 6000-level are required for the coursework and no more than two classes at the 4000-level can be included. Additionally, one course in the life sciences (biology or physiology) and one course in advanced math are required. In consultation with their adviser, students must develop a Plan of Study that satisfactorily meets Institute requirements and Departmental requirements.
Doctoral Programs

Matriculation into the doctoral program is based upon prior demonstration of a high level of academic achievement in graduate and/or undergraduate work. Advanced study and research are conducted under the guidance of a faculty member in the Department of Biomedical Engineering and an interdisciplinary dissertation committee. A total of 72 credits (30 course work credits and 42 credits of research) are required to meet the Department's and the Institute's residency and thesis requirements. A maximum of eight credits at the 4000 level (a maximum of two courses) may be applied to the 30 coursework requirement, with the remainder of the courses at the 6000 level. Students must have a 3.5 for Advancement to the Doctoral Status and maintain a 3.0 GPA or better to meet the Institute's requirements. These requirements are formalized in a Plan of Study that is prepared in consultation with the student's research adviser.

Please note that students have no more than seven years to complete their Ph.D. Students who entered the program with a Master's have no more than five years to complete their Ph.D.

The minimum course work requirements for a Ph.D. are distributed as follows:

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Mathematics or Statistics (1 course)</td>
<td>3-4</td>
</tr>
<tr>
<td>Advanced Life Sciences (1 course)</td>
<td>3-4</td>
</tr>
<tr>
<td>(Advanced Biology or Advanced Physiology)</td>
<td></td>
</tr>
<tr>
<td>Technical Depth Courses* (5-7 courses)</td>
<td>18-21</td>
</tr>
<tr>
<td>Advanced laboratory techniques 3-4 (1 course)</td>
<td>30</td>
</tr>
</tbody>
</table>

Course Descriptions

Courses directly related to all Biomedical Engineering curricula are described in the Course Description section of this catalog under the department codes BMED, CHME, ECSE, MTLE, and MANE.

Elective courses can be chosen from a recommended list of BME courses and other engineering and/or science courses at Rensselaer in consultation with the adviser.

For a detailed listing of approved courses in advanced mathematics, statistics, life sciences, laboratory techniques, and engineering depth, see the BMED Web site at http://bme.rpi.edu/.

Chemical and Biological Engineering

Department Head: Shekhar Garde

Director, Industrial Liaison Program: B. Wayne Bequette

Coordinator of Undergraduate Studies: Joel Plawsky

Coordinator of Graduate Studies: Ravi Kane

Department Home Page: http://cbe.rpi.edu/

The chemical conversion of resources into new, more useful forms has been the traditional concern of chemical engineering. In recent years, chemical engineering has played a major role in high technology advances in biotechnology, sustainable energy, and novel materials processing. In addition, a critical concern with the depletion of resources has developed, leading to increased efforts to conserve, recycle, and find environmentally friendly alternatives.

The major educational objective in the Howard P. Isermann Department of Chemical and Biological Engineering is to prepare students to enter their engineering practice dealing with chemical as well as physical processes to meet the challenges of the future. The curriculum, which builds on chemistry, biology, mathematics, basic sciences, and engineering science, culminates in professional applications in which theory is tempered by engineering art and economic principles. Through this curriculum, graduates are prepared equally well for professional practice or for advanced study.

Opportunities for creative and satisfying practice in chemical and biological engineering can be found in conception, design, control, or management of processes involving chemical and/or biochemical transformations. These processes range from the more conventional conversion of crude oil into petrochemicals and plastics, to the microbiological transformation of hardwood chips into specialty alcohols, or...
to the creation of semiconductor devices from silicon wafers. Diverse career choices exist not only in the chemical industry, but in virtually all processing industries, including agricultural, biotechnology, chemical, food, nuclear, semiconductor processing, and environmental operations. By emphasizing basic principles, the program prepares its graduates for positions spanning the spectrum of activities from research and development, to process and project engineering, to production, or to technical marketing.

Research Innovations and Initiatives

Biochemical and Biomedical Engineering
Research projects in biochemical engineering emphasize biocatalysis, bioseparations, and metabolic engineering. Fundamental and applied aspects of enzyme technology, mammalian cell culture, membrane sorption and separation, displacement chromatography, and salt-induced precipitation are important areas of focus. New designs involving aqueous and nonaqueous enzyme technology are being developed, as are new types of membrane-entrapped-enzyme and animal-cell-suspension reactors, which are being built, tested, and analyzed. Metabolic engineering processes are being used to develop high-rate bacterial fermentations and overproducing hybridoma cultures for producing chemical intermediates and monoclonal antibodies, respectively. Control theory of biological processes and an optical biosensor for metal detection are also being pursued. Projects in biomedical engineering involve the design of polymeric inhibitors of bacterial toxins and viruses, and the use of microfabrication tools to modulate the interaction of mammalian cells with their environment for applications in tissue engineering.

Separation and Bioseparation Processes
Research projects in separation and bioseparations employ fundamental concepts for solving applied problems in the biological and environmental fields. Current projects emphasize interactions of proteins with synthetic membranes and chromatographic media, high throughput screening, combinatorial and computational chemistry, spectroscopy, chip technology, proteomics, modification of polymeric surfaces for bioseparations and environmental applications, and the recovery of proteins from complex biological solutions using fusion affinity adsorption, pressure-driven membrane processes, displacement chromatography, and expanded-bed adsorption. Other projects focus on the design and synthesis of high-performance artificial membranes inspired by biological membranes, for environmental processes and chemical production.

Molecular Modeling and Simulations
Monte Carlo and molecular dynamics simulations are being used in combination with statistical mechanical theories to understand thermodynamics, structure, and kinetics of biomolecules in aqueous solutions. Special emphasis is placed on understanding and relating water structure near different solutes and in different environments to resulting interactions (e.g., hydrophilic and hydrophobic interactions). Theory and molecular simulations are also used to study the effects of geometrical and chemical heterogeneity on molecular transport and reaction in porous catalysts, sorbents and membranes, and to apply this knowledge to their rational design.

Advanced Materials
Research interests are centered on developing and understanding the phenomena involved in producing advanced materials for the optical, electronic, catalytic and allied industries. Thermodynamic, transport, and chemical processes governing the formation and subsequent behavior of these materials are under active investigation. Research areas include the rationale design and synthesis of hierarchically structured porous catalysts with maximized yields and selectivity toward the desired products.

Interfacial Phenomena
Problems under investigation include interfacial resistance to mass transfer and the interaction between surface forces and interfacial convection. Work in the interfacial area is concerned with heat, mass, and momentum transfer in multicomponent, ultrathin, liquid films. Research includes studies on condensation and evaporation in the contact line region, distillation from ultrathin films, lubrication, surface-tension-driven instabilities in atomically clean liquid metals, pattern formation in dendritic growth, protein-solid interaction, and the design of biocompatible surfaces.

Polymers
A large polymer research program focuses on polymer reaction engineering including devolatilization and heat transfer. Current work emphasizes bulk polymerizations in tubular reactors and segregation phenomena in stirred tank reactors. Under study are ways of enhancing heat transfer to fluids in laminar flow and the application of polymer devolatilization technology to unconventional substances. The recovery of commingled scrap plastics by selective dissolution is a major activity. Other active areas include structure-property relationships, rheology, extrusion, and a large interdisciplinary program on biocatalysis in polymer synthesis and modification.

Process Control and Design
A major focus of this research is the development of realistic, robust control strategies for multivariable chemical processes having parameter and process uncertainties. Such strategies are created to exploit the dynamic properties inherent in the systems. Integration of the modeling, design, and control of specialty chemical and pharmaceutical processes is of particular interest.
Heat Transfer
Topics of interest include free convection stability, forced convection (particularly in laminar flow systems), fluid-to-particle heat transfer in fluidized and spouted beds, and boiling. Studies on heat and mass transfer at interfaces are also under way.

Thermodynamics
Activities include molecular simulation, the analysis and correlation of phase-equilibrium data, the development and evaluation of fluid-phase equations of state, and the study of topics in solution thermodynamics.

Mass Transport
Research is in progress on simultaneous heat and mass transfer in porous media; effects of surface roughness and chemical heterogeneity on diffusion; the effects of interfacial phenomena on mass transfer; diffusion and mixing in laminar flow systems; transient dispersion processes in capillaries, porous media and open channels; and crystal growth phenomena.

Fluid Mechanics
Projects in this area involve the mechanics of fluidized beds, spouted beds, bubbles, low Reynolds number hydrodynamics, kinetic theory, two-phase flow, and surfactant behavior in organic-aqueous systems.

Interdepartmental Research
Several research areas involve participation and cooperation with other departments. Such areas include polymer studies with the Materials Science and Engineering and Chemistry Departments, fermentation and other biochemical research with the Biology Department, studies in fluid mechanics with the Mathematics Department, polymer membrane fabrication with the Chemistry Department, and research on lubrication and other interfacial phenomena with the Mechanical Engineering Department. Additional information on research in these areas is found in the catalog sections for those departments.

Research Related Facilities
The department maintains extensive research and instructional laboratories which house myriad special and unique equipment developed for specific studies, as well as extensive analytical and optical instrumentation and computers. Major instrumentation such as a GC/mass spectrometer, an X-ray fluorescence analyzer, an ion chromatograph, HPLC systems, and a laser zee particle characterization system make Rensselaer’s laboratories one of the most comprehensively equipped university centers for research in the areas described above. Many faculty in the Chemical and Biological Engineering Department have their research labs located in the Center for Biotechnology and Interdisciplinary Studies, which is equipped with an impressive array of core imaging, analytical, and spectroscopy tools. The department research programs also use a number of major university facilities including the electron optics laboratory and the polymer laboratories in the Materials Research Center.

Faculty *

Professors
Belfort, G.—Ph.D. (University of California, Irvine); membrane sorption and separations engineering, biocatalysis, biosensors, magnetic resonance flow imaging.

Bequette, B.W.—Ph.D. (University of Texas, Austin); chemical process modeling, control, and optimization, biomedical and drug infusion systems.

Cramer, S.M.—Ph.D. (Yale University); biochemical engineering, chromatographic separations.

Dordick, J.S.—Ph.D. (Massachusetts Institute of Technology); biochemical engineering, enzyme technology, polymer chemistry, bioseparations.

Garde, S.—Ph.D. (University of Delaware); water and aqueous solutions, protein solvation and biomolecular interactions, thermodynamics.

Kane, R.S.—Ph.D. (Massachusetts Institute of Technology); bionanotechnology, biomedical engineering, polymers, surfaces, nanomaterials.

Plawsky, J.L.—Sc.D. (Massachusetts Institute of Technology); optical, nonlinear and electro-optic, crystalline, glassy materials, transport phenomena.

Kane, R.S.—Ph.D. (Massachusetts Institute of Technology); biomedical engineering, polymers, surfaces, nanomaterials.

Plawsky, J.L.—Sc.D. (Massachusetts Institute of Technology); optical, nonlinear and electro-optic, crystalline, and glassy materials.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Associate Professors
Koffas, M.—Ph.D. (Massachusetts Institute of Technology); metabolic engineering, biocatalysis and natural products, and cellular physiology.

Tessier, P.M.—Ph.D. (University of Delaware); protein thermodynamics, protein self-assembly and aggregation, and bionanotechnology.

Assistant Professors
Chakrapani, V.—Ph.D. (Case Western Reserve University); semiconductor photochemistry, solar energy conversion, advanced materials.

Collins, C.H.—Ph.D. (California Institute of Technology); protein engineering and synthetic microbial ecosystems.

Karande, P.—Ph.D. (University of California, Santa Barbara); high throughput screening, drug discovery, and peptide engineering.

Underhill, P.T.—Ph.D. (Massachusetts Institute of Technology); fluid dynamics, polymers, molecular simulation, biophysics, microfluidics, complex fluids.

Research Associate Professor
Zhang, F.—Ph.D. (University of Leeds); molecular interaction kinetics, biophysics, and glycomics.

Adjunct Faculty
Baysal, N.—Ph.D. (Bogazici University); modeling and simulations, unit operations.

Belfort, M.—Ph.D. (University of California, Irvine); molecular biology.

Coppens, M-O.—Ph.D. (University of Gent, Belgium); reaction engineering, nanomaterials, nano-biotechnology, mathematical modeling (chaos and fractals), and nature inspired chemical engineering.

Dalakos, G.—Ph.D. (Rensselaer Polytechnic Institute); design and optimization of chemical engineering processes.

Mousa, M.—Ph.D. (Ohio State University); development of novel therapeutic and diagnostic agents.

Emeritus Professors
Bungay, H.R., III—P.E., Ph.D. (Syracuse University); water resources, biochemical engineering.

Fontijn, A.—D.Sc. (University of Amsterdam, Netherlands); combustion, high-temperature kinetics, gas phase reactions, atmospheric chemistry.

Gill, W.N.—P.E., Ph.D. (Syracuse University); transient dispersion processes, reverse osmosis systems, crystal growth phenomena, surface-tension-driven flow.

Littman, H.—Ph.D. (Yale University); fluidization, fluid-particle systems.

Wayner, P.C., Jr.—Ph.D. (Northwestern University); heat transfer, interfacial phenomena.

Joint Appointments - Professors
Garcia, A.E.—Ph.D. (Cornell University); theoretical and computational aspects of biomolecular dynamics.

Hirsa, A.—Ph.D. (University of Michigan); fluid mechanics, experimental gas dynamics.

Linhardt, R.L.—Ph.D. (The Johns Hopkins University); carbohydrate chemistry, medicinal chemistry and biocatalysis.
Undergraduate Programs

Objectives of the Undergraduate Curriculum

The Howard P. Isermann Department of Chemical and Biological Engineering bachelor’s degree program is designed to prepare students for continued learning and successful careers in industry, government, academia, and consulting. Within a few years of graduation our alumni are expected to:

• be gainfully employed in a professional capacity and promoting the responsible application of technology to enhance the common good.
• be preparing for leadership roles in society by furthering their proficiency in engineering practice or by preparing for professional practice in related disciplines via further graduate or professional study.

Students may achieve these objectives through completion of either the baccalaureate program leading to the B.S. degree or the professional program leading to the M.Eng. degree. Both programs are described in detail in the Programs section of this catalog.

The Chemical Engineering degree program at Rensselaer is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Baccalaureate Program

The chemical engineering program comprises a minimum of 39 courses, which include three free electives and three area electives: one in advanced chemistry, one in advanced chemical engineering, and one in a nonchemical engineering area. On completion of three years of the baccalaureate program, the student may continue to the fourth year or be admitted to the professional program. While individual variations may be made in the course sequence in consultation with a faculty adviser, all listed courses and elective credits in the curricula must be satisfactorily completed to qualify for the specified degrees. A program outline that indicates required courses and electives is provided below. The complete curriculum totals 132 credit hours.

### FIRST YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHME 1010</td>
<td>Introduction to Chemical Engineering 1, 2</td>
</tr>
<tr>
<td>CHEM 1110</td>
<td>Chemistry I with Advanced Lab</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
</tr>
<tr>
<td>PHYS 1100</td>
<td>Physics I</td>
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<td>HASS Elective</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
</tr>
<tr>
<td>ENGR 1100</td>
<td>Introduction to Engineering Analysis</td>
</tr>
<tr>
<td>ENGR 1400</td>
<td>Engineering Communications 1, 2</td>
</tr>
<tr>
<td>MATH 1020</td>
<td>Calculus II</td>
</tr>
<tr>
<td>HASS Elective</td>
<td></td>
</tr>
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### SECOND YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2250</td>
<td>Organic Chemistry I</td>
</tr>
<tr>
<td>CHME 2010</td>
<td>Material, Energy, and Entropy Balances</td>
</tr>
<tr>
<td>CSCI 1190</td>
<td>Beginning C Programming for Engineers</td>
</tr>
<tr>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
</tr>
<tr>
<td>PHYS 1200</td>
<td>Physics II</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>CHME 2020</td>
<td>Energy, Entropy, and Equilibrium 3</td>
</tr>
<tr>
<td>CHEM 2260</td>
<td>Organic Chemistry II</td>
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<tr>
<td>ENGR 2600</td>
<td>Modeling and Analysis of Uncertainty</td>
</tr>
<tr>
<td>Free Elective</td>
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<tr>
<td>HASS Elective</td>
<td></td>
</tr>
</tbody>
</table>

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1 These required courses may be taken in either order.
2 May be replaced by ENGR 1300, although CHME 1010 is recommended.
3 One credit comes from PD I, for which either STSS 4940 or PSYC 4170 may be selected.
### THIRD YEAR

#### Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHME 4010</td>
<td>Transport Phenomena I</td>
<td>4</td>
</tr>
<tr>
<td>CHME 4030</td>
<td>Chemical Process Dynamics and Control</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 4530</td>
<td>Modern Techniques in Chemistry</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
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#### Spring

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>CHME 4020</td>
<td>Transport Phenomena II</td>
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</tr>
<tr>
<td>CHEM 4420</td>
<td>Microscopic Physical Chemistry</td>
<td>4</td>
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<tr>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Professional Development II*</td>
<td>2</td>
</tr>
</tbody>
</table>

### FOURTH YEAR

#### Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHME 4040</td>
<td>Chemical Engineering Separations</td>
<td>3</td>
</tr>
<tr>
<td>CHME 4150</td>
<td>Chemical Engineering Laboratory I</td>
<td>3</td>
</tr>
<tr>
<td>CHME 4500</td>
<td>Chemical Reactor Design</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Chemical Engineering Elective</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Spring

<table>
<thead>
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<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHME 4050</td>
<td>Chemical Process Design</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 4010</td>
<td>Professional Development III</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Lab Elective*</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Engineering Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Chemistry Elective</td>
<td>3</td>
</tr>
</tbody>
</table>

### Electives

As is evident in the above outline, the B.S. program includes several types of electives, three of which are specifically designated. These designated electives are subject to the following constraints:

- The chemistry elective must be in advanced chemistry or in an advanced chemistry-related subject.
- The chemical engineering elective must be in chemical engineering or in an approved, advanced chemical engineering subject.
- The engineering elective cannot be a chemical engineering course; it must be at least 2000-level and contain four credits of engineering topics.
- The engineering elective cannot be ENVE 2110 or ENGR 2250.

The curriculum clearance officer, who maintains a list of appropriate courses, must approve selection of these three constrained electives. The three free electives are completely unconstrained.

### Humanities, Arts, and Social Sciences Electives

In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities, arts, and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities, Arts, and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

### Professional Program

Students who, at the end of their third year, apply and are accepted to this program will complete 10 additional courses beyond the baccalaureate degree and will be awarded the M.Eng. degree. This program is described in detail in the Master of Engineering program.

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*3 One credit comes from PD I, for which either STSS 4840 or PSYC 4170 may be selected.

*4 Choice of CHME 4160 or CHME 4170.
Graduate Programs

The Chemical and Biological Engineering Department offers the Master of Science, the Master of Engineering, and the Doctor of Philosophy degrees, each of which is tailored to fulfill the varying educational needs of its graduate students.

All graduate programs offer flexibility. Students are advised to plan programs that use course choices and electives to obtain in-depth studies in one or more subspecialties of their degree majors. Cross-disciplinary studies using courses offered by other departments or schools at Rensselaer are encouraged.

In addition, all graduate degree programs are arranged individually, and students are encouraged to use electives to conduct intensive studies in one or more subdisciplines or specialties. The M.S. and Ph.D. programs are particularly flexible. However, each student's program must include the following courses:

- CHME 6570 Chemical and Phase Equilibria (fall)
- CHME 6610 Mathematical Methods in Chemical Engineering I (fall)
- CHME 6510 Advanced Transport Phenomena I (spring)
- CHME 6640 Advanced Chemical Reactor Design (spring)

Master's Programs

The master's degree represents an intermediate level of academic preparation. It is often the optimal degree for careers in engineering design.

Chemical and Biological Engineering M.Eng.

The M.Eng. degree involves formal course work only and does not require a thesis. This degree is awarded on completion of 30 credits of course work.

Program Requirements

For a student with an accredited B.S. degree in chemical engineering, the program includes the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHME 6510</td>
<td>Advanced Transport Phenomena I</td>
<td>3</td>
</tr>
<tr>
<td>CHME 6570</td>
<td>Chemical and Phase Equilibria</td>
<td>3</td>
</tr>
<tr>
<td>CHME 6610</td>
<td>Mathematical Methods in Chemical Engineering I</td>
<td>3</td>
</tr>
<tr>
<td>CHME 6640</td>
<td>Advanced Chemical Reactor Design</td>
<td>3</td>
</tr>
<tr>
<td>Electives</td>
<td></td>
<td>18</td>
</tr>
</tbody>
</table>

Additional Requirements

Of the electives, at least two must be chemical engineering courses and at least two must be non-chemical engineering courses. A feature of this M.Eng. program is the opportunity to concentrate in one of the subspecialties of chemical engineering. These areas include (but are not limited to) biological engineering, process systems engineering, materials engineering, and polymer engineering.

Chemical and Biological Engineering M.S.

The M.S., which requires a thesis, may be used for professional entry, but is also well suited to students who wish to measure their ability to get a Ph.D. without commitment of extra time beyond that required for an M.S. A special optional master's program is available for this purpose.

For the M.S., 30 credits of graduate-level studies, including six credits for the thesis, are normally required. However, the thesis requirement may vary from three to nine hours at the discretion of the department. The 24 hours of approved course work must include at least 15 credits of 6000-level courses. A formal thesis defense is not required.

Students who wish to follow the optional master's program should plan to take the Ph.D. comprehensive examination during their second semester of full-time graduate studies. The examination may be taken a maximum of two times. Passing students may register for an additional three credits of CHME 6990 Master's Thesis, and formal course work requirements for the master's degree are reduced to 21 hours. The student also has the option of proceeding directly toward a Ph.D. without completing the master's thesis. This option will normally reduce the time required for a Ph.D. by about six months. Students who elect to proceed in this manner will receive an M.S. degree, with thesis requirements waived, after two years of satisfactory full-time study and acceptance of the dissertation proposal.
Doctoral Programs
The Ph.D. degree represents the highest level of academic preparation. With it, a student can expect to maintain technical competence and contributions throughout a professional career. It is usually the preferred degree for research and development in industry and government and for teaching.

Within the Chemical and Biological Engineering Department, 72 credits of graduate-level studies, including the dissertation, are required for a Ph.D. The emphasis is on advanced study in a specialty with major focus on the dissertation. A doctoral student must pass a comprehensive examination, prepare a dissertation proposal and the dissertation itself, and present and defend the dissertation.

Course Descriptions
Courses directly related to all Chemical and Biological Engineering curricula are described in the Course Description section of this catalog under the department code CHME.

Civil and Environmental Engineering
Department Head: Chris Letchford
Associate Head Academic Affairs: Michael O'Rourke

Department Home Page: http://www.cee.rpi.edu

Civil and environmental engineers are responsible for providing the world's constructed facilities and the infrastructure on which modern civilization depends. These facilities can be large and complex and require that the engineer be broadly trained and able to deal with the latest technologies. Both civil and environmental engineers work to ensure that the impact of these facilities on the environment is considered and minimized.

Civil and environmental engineers focus on the analysis, design, construction, maintenance, and operation of physical systems both large and small. To ensure the proper construction and care of these complex systems and environments, Rensselaer civil and environmental engineers develop a full range of skills in design, analysis, fabrication, communication, management, and teamwork. The current rebuilding of the world's roads, bridges, water and sewer systems, and other physical facilities has heightened society's awareness of the profession and given it added prominence. The growing panoply of sensors, instrumentation, intelligent facilities, and new materials is also highlighting the high-tech character of the discipline, creating new educational challenges and redefining the skill set that civil and environmental engineers need to succeed.

At Rensselaer, civil engineering has a long and distinguished history. In 1835, the Institute became the first U.S. school to issue a civil engineering degree. Among its graduates are William Gurley (1839) and Lewis E. Gurley (1845) partners in W&LE Gurley, Troy, N.Y., one of the first manufacturers of precision surveying instruments. Other world-renowned Rensselaer civil engineering graduates include:

- Francis Collingwood, Jr. (1855), honored by civil engineering's Collingwood Prize
- Washington Roebling (1857), builder of the Brooklyn Bridge
- Seijiro Hirai (1878), a president of the Imperial Railways, Japan
- George Ferris (1881), designer of the Ferris wheel
- Frank C. (1880) and Kenneth H. Osborn (1908), founders Osborn Engineering and designers of major-league, municipal, and collegiate stadiums producing many major league baseball stadiums, including Fenway Park, home of the Boston Red Sox, which celebrated its centenary in 2012 and is the last surviving example of Osborn era of sports stadia
- Milton Brumer (1923), construction manager for the Verrazano Narrows Bridge
- Werner Ammann (1928), former partner, Ammann and Whitney
- Clay Bedford, Sr. (1925), general supervisor of the construction of the Bonneville and Grand Coulee Dams
- Ralph Peck (1934), co-author with Karl Terzaghi of the internationally-known book Soil Mechanics in Engineering Practice
- James Mitchell (1951), international soils mechanics expert

Today, Rensselaer civil and environmental engineers continue to be found at all levels in both private and public sectors throughout the world.
A long-standing tradition at Rensselaer is educational programs in environmental problem solving. An early contribution to this field was the water analysis work of William Pitt Mason (1874), the pioneer of such activities in the U.S. in the late 1800s. Edward J. Kilcawley, a Rensselaer civil engineering professor who introduced environmental engineering as an option in the mid-1940s and as a degree program in the mid-1950s, contributed visionary environmental engineering concepts.

In addition to those in the Department of Civil and Environmental Engineering, there are faculty members with teaching and research interests in environmental problem solving in the Departments of Chemical Engineering, Chemistry, Earth and Environmental Sciences, and Mathematical Sciences.

**Research Innovations and Initiatives**

**Earthquake Engineering (Civil)**
Rensselaer's earthquake engineering research program is concerned with seismic analysis and design methodologies that mitigate the negative impact of earthquakes on buildings, bridges, and pipelines (water, sewer, gas, and oil). It also focuses on analytical relationships that support decision-making and advance the state of the art in design codes, a key to future sustainability and durability. In these areas, Rensselaer’s earthquake engineering research is among the best in the world. The Institute has a major geotechnical centrifuge facility and a 1 g shaking table for structural system testing. The geotechnical centrifuge facility, fourth largest in the U.S. and among the 20 largest in the world, has in-flight 2-D shaking and robotic capabilities. Both the centrifuge and the shaking table are the major experimental components of CEES (Center for Earthquake Engineering Simulation), a School of Engineering Interdisciplinary Research Center (see Center for Earthquake Engineering Simulation). CEES is one of the 15 experimental nodes of NEES (Network for Earthquake Engineering Simulation), an NSF Collaboratory initiative aimed at revolutionizing earthquake engineering research in the United States.

**Structural Engineering (Civil)**
Design and analysis of bridges, buildings, and other large-scale facilities; material selection and specification; structural technology selection; dynamic and static structural modeling and analysis; environmental loads on structures, including: snow, wind, and earthquakes.

**Geotechnical Engineering (Civil)**
Behavior of soils and foundations under cyclic and dynamic loads; design methods to accommodate natural and man-made vibrations; geostochastics; soil dynamics, stability of earth slopes, structures, and dams, geoenvironmental engineering, landfill design, groundwater and groundwater contaminant transport, geotechnical centrifuge modeling, blasting, and disaster recovery.

**Transportation Engineering (Civil)**
This area of research includes design, analysis, maintenance, and operation of transportation systems and facilities; intelligent transportation systems, especially highway networks, goods distribution systems, and transit systems; real-time, multiobjective network management and control, including route guidance and dynamic traffic assignment; signal control systems; network management strategies; multiobjective routing and scheduling; and logistics decision making under uncertainty.

**Computational Mechanics (Civil)**
Studies involve modeling and simulation of engineering systems for analysis and design, computational micromechanics and multiple-scale modeling, automated finite element and discrete element modeling techniques, system identification and inverse problems, and adaptive analysis procedures and design systems using knowledge-base techniques.

**Pollutant Fate and Transport (Environmental)**
Research areas are assessment of pathogen loading and transport in water supplies and treatment systems, fate of hydrophobic organics in sediment, environmental chemistry of PAHs, molecular modeling in environmental chemistry, and structure activity relationships.

**Water Treatment (Environmental)**
Researchers investigate the influence of natural organic matter properties and water chemistry on the formation of disinfection byproducts, understanding fouling mechanisms in the use of membrane processes in water treatment, membrane modifications for water treatment, adsorption processes and hybrid processes for removal of DBP precursors.

**Site Remediation and Bioremediation (Environmental)**
Research areas include combined advanced oxidation and biological treatment for sediment and soil slurry systems, in-situ degradation of chlorinated organics in groundwater, and solid phase treatment reactors for soils, slurries, and municipal solid wastes.

**Research Facilities**
Rensselaer’s centrifuge was commissioned in 1989 and began conducting physical model simulations of soil and soil structure systems subjected to in-flight earthquake shaking in 1991. In over two decades of successful operation, the facility has published results of some 500 earthquake-related model simulations, served as the basis for many M.S. and Ph.D. theses at Rensselaer, and contributed to Institute faculty and student research as well as that of dozens of visiting scholars and outside users from around the world. Recently the centrifuge facility
was upgraded to a 150 g-ton overall capacity and enhanced with Web-based teleobservation and teleoperation wireless sensors, as part of its integration into NEES (Network for Earthquake Engineering Simulation), a national NSF-supported Collaboratory. Two modern telecontrol and teleconference rooms located close to the centrifuge facilitate collaboration and real-time experiments with the rest of NEES through a high-speed Internet connection. The geotechnical centrifuge is currently a main part of CEES, a School of Engineering Interdisciplinary Research Center.

The Rensselaer 1 g seismic shaking table, located in the Structural Dynamics and Earthquake Engineering Laboratory (SDEEL), part of the Jonsson Engineering Center High Bay Laboratory, is utilized to evaluate the behavior of scale-model structures subjected to dynamic loading. The shaking table, 1.6 m x 2.6 m in plan, is driven by a servo-controlled hydraulic actuator and is capable of reproducing a variety of input motions, including random motion for system identification testing and historical earthquake records for seismic testing. A variety of dynamic measurement sensors are available in the laboratory along with a spectrum analyzer and data acquisition system to process and record the measured signals.

Environmental Engineering students and faculty have access to the Environmental Engineering laboratories, and the W.M. Keck Foundation Water Quality Laboratory, both located in the Materials Research Center building. Facilities are also available in other laboratories on campus, such as the Rensselaer Biotechnology Center. The Environmental Engineering laboratories include the NSF-MRI Colloid and Particle Characterization Laboratory, offering a Brookhaven BI-90 differential light scattering instrument for nanoparticle characterization, a Coulter Multisizer II particle counter with a range of apertures for analysis of particles over a size range of 0.3 to over 100 microns, and a Quantachrome Autosorb-1A-MP gas adsorption analyzer with a 1-torr pressure transducer and multi-gas capabilities, to characterize particle surface area and porosity. Other major analytical equipment available in the Environmental Engineering laboratories includes UV-visible spectrophotometers; Hewlett Packard gas chromatographs with FID, TCD and ECD detection; a Shimadzu A17 GC with FID and ECD detectors; a Hewlett-Packard 1100 high performance liquid chromatograph with a quaternary pump, an on-line degasser, an autosampler, a temperature-controlled column station, and with UV, fluorescence, and electrochemical detection; a Shimadzu HPLC with UV detector and an autosampler; a Shimadzu TOC-5000 low-level organic carbon analyzer. The department recently constructed a microbiology lab that is fully equipped with instruments and facilities needed to enrich, isolate, cultivate and analyze aerobic and anaerobic microorganisms that are important contributors to environmental biogeochemical processes.

Faculty *

Professors

Abdoun, T.—Ph.D. (Rensselaer Polytechnic Institute); geotechnical engineering, geotechnical centrifuge modeling, earthquake engineering.

Baveye, P.—Ph.D. (University of California, Riverside); water resources, soil and water engineering.

Dobry, R.—Sc.D. (Massachusetts Institute of Technology); geotechnical engineering, soil dynamics, earthquake engineering, seismic analysis.

Gorby, Y.—Ph.D. (University of New Hampshire); microbiology, geomicrobiology, electronmicrobiology, and bioremediation.

Holguin-Veras, J.—PE., Ph.D. (The University of Texas at Austin); intelligent transportation networks, intermodal transportation, transportation planning and modeling, transportation economics.

Letchford, C.—PE., C.P. Eng., D. Phil. (Oxford University); wind engineering, bluff body aerodynamics, structural dynamics.

O'Rourke, M.J.—PE., Ph.D. (Northwestern University); structures, lifeline earthquake engineering, snow loading on structures.

Rosowsky, D.—PE., Ph.D. (The Johns Hopkins University); structural reliability, performance of wood structural systems, design for natural hazards, stochastic modeling of structural and environmental loads, and probability-based codified design.

Shephard, M.S.—Ph.D. (Cornell University); computational mechanics, parallel processing, adaptive finite element techniques, automatic mesh generation.

Wallace, W.A.—Ph.D. (Rensselaer Polytechnic Institute); decision support systems, the process of modeling, environmental management, disaster management.

Zimmie, T.F.—PE., Ph.D. (University of Connecticut); geoenvironmental engineering, geotechnical engineering, groundwater hydrology, flow through porous media, landfills, centrifuge modeling, geosynthetics.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Associate Professors

Kilduff, J.—P.E., Ph.D. (University of Michigan); physicochemical processes, separations and recovery processes in water and wastewater treatment, effects of adsorption and mass-transfer on pollutant fate and transport in natural systems, membrane processes for water quality control.

Mistur, M.—M.S. (Rensselaer Polytechnic Institute); architecture, building systems.

Nyman, M.C.—Ph.D. (Purdue University); fate and transport of hydrophobic organic contaminants in natural systems, environmental chemistry.

Symans, M.—Ph.D. (University at Buffalo); structural dynamics, earthquake engineering, seismic isolation and energy dissipation systems, structural vibration control.

Zeghal, M.—Ph.D. (Princeton University); soil dynamics and geotechnical earthquake engineering, computational geomechanics, geotechnical system identification and seismic response monitoring, damage diagnosis and nondestructive evaluation, and seismic risk analyses.

Assistant Professors

Ban, X.—Ph.D. (University of Wisconsin); traffic simulation and network modeling.

Wang, X.—P.E., Ph.D. (The University of Texas at Austin); transportation engineering.

Professor of Practice

Reilly, J.—Ph.D. (Rensselaer Polytechnic Institute); transportation systems.

Lecturer

Gadhamshetty, V.—Ph.D. (New Mexico State University); water and wastewater treatment, waste management.

Research Assistant Professors

Bennett, V.—Ph.D. (Rensselaer Polytechnic Institute); geotechnical engineering and instrumentation.

Lombardo, E.—Ph.D. (Texas Tech University); wind engineering, natural hazard modelling, extreme value analysis.

Sasanakul, I.—Ph.D. (Utah State University); geotechnical and geo-environmental engineering.

Adjunct Faculty

Dall, J.—P.E., M.S. (Rensselaer Polytechnic Institute); structural engineering.

Daviero, G.—P.E., Ph.D. (Georgia Institute of Technology); environmental hydraulics and water resources engineering.

Dolmetsch, J.—P.E., B.S. (Rensselaer Polytechnic Institute); wastewater design.

Floess, C.—P.E., Ph.D. (Rensselaer Polytechnic Institute); geotechnical engineering.

Kanonik, M.—P.E., B.S. (The Pennsylvania State University); steel design.

Kenneally, D.—P.E., B.S. (Rensselaer Polytechnic Institute); transportation engineering.

Lesher, C.—P.E., B.S. (The Pennsylvania State University); concrete design.

Suits, L.—M.S. (Clarkson College of Technology); geosynthetics.

Westhuis, T.—P.E., B.S. (Rensselaer Polytechnic Institute); transportation engineering.

Emeritus Faculty

Clesceri, N.L.—Ph.D. (University of Wisconsin); advanced waste treatment, environmentally sound manufacturing, sediment decontamination.

Feeser, L.J.—P.E., Ph.D. (Carnegie Mellon University); structures, computer applications and computer graphics, computer-aided design, structural optimization.
Undergraduate Programs

Civil Engineering

Objectives of the Undergraduate Program in Civil Engineering
The Civil and Environmental Engineering programs are each designed to prepare students for continued learning and successful careers in industry, government, academia, and consulting. Within a few years of graduation our Graduates of the Bachelor of Science program in civil engineering are expected to:

• contribute to the body of knowledge in Civil Engineering as professionals engaged in problem-solving, design, discovery, and responsible application of technology;

• further develop leadership skills by accepting increasing levels of responsibility in engineering practice, communicating in professional and civic forums, and progressing toward professional licensure;

• continue to develop both professionally and personally through graduate study, participation in professional societies, continuing education, and community service.

The Civil Engineering and Environmental Engineering degree programs at Rensselaer are each independently accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

After completing the core engineering sequence, a student enters this curriculum and follows a baccalaureate program leading to the B.S. degree or a professional program leading to the M.Eng. degree as well as the B.S.

Undergraduate concentrations include construction, environmental, geotechnical, structural, and transportation engineering. Following the sample four-year schedule is the recommended collection of courses for each of these concentrations.

Subject to other requirements, students may use core engineering electives to accelerate their entrance into the program. Students also may take courses in related fields. Courses bearing the following codes are suggested for particular consideration in consultation with the student’s adviser: ARCH, ECSE, MANE, ENVE, MATH, CSCI, ERTH, and ISYE.

The following represents a typical four-year civil engineering program. Students who are convinced that they want to become civil engineers are urged to follow this plan of study in lieu of the general core engineering program presented earlier. Required or strongly recommended core engineering electives are shown for optimum scheduling.

**FIRST YEAR**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>CHEM 1100</td>
<td>Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CIVL 1200</td>
<td>Engineering Graphics for Civil Engineers</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ENGR 1100</td>
<td>Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Electives</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>CIVL 1100</td>
<td>Introduction to Civil and Environmental Engineering</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>MATH 1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS 1100</td>
<td>Physics I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Science Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

1 CIVL 1200 may be replaced with ENGR 1200.
2 Choose either ENGR 1600 or CSCI 1100.
3 CIVL 1100 may be replaced with ENGR 1300.
4 If CSCI 1100 was taken as the Spring/First Year Science Elective, replace CSCI 1190 with 1 credit hour of free elective.

SECOND YEAR

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>ENGR 2050</td>
<td>Introduction to Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS 1200</td>
<td>Physics II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>CSCI 1190</td>
<td>Beginning C Programming for Engineers</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ENGR 2090</td>
<td>Engineering Dynamics</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ENGR 2250</td>
<td>Thermal and Fluids Engineering I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ENGR 2530</td>
<td>Strength of Materials</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

1 CIVL 1200 may be replaced with ENGR 1200.
2 Choose either ENGR 1600 or CSCI 1100.
3 CIVL 1100 may be replaced with ENGR 1300.
4 If CSCI 1100 was taken as the Spring/First Year Science Elective, replace CSCI 1190 with 1 credit hour of free elective.
### THIRD YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL 2030</td>
<td></td>
</tr>
<tr>
<td>CIVL 2630</td>
<td></td>
</tr>
<tr>
<td>CIVL 2670</td>
<td></td>
</tr>
<tr>
<td>ENVE 2110</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVE 4310</td>
<td></td>
</tr>
<tr>
<td>ENGR 4760</td>
<td></td>
</tr>
</tbody>
</table>

### FOURTH YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 2600</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL 4920</td>
<td></td>
</tr>
<tr>
<td>ENGR 4010</td>
<td></td>
</tr>
</tbody>
</table>

A minimum of 128 credit hours is required for this curriculum.

**Additional Requirements**

Nonengineering courses graded satisfactory/unsatisfactory are not included within this 128-credit-hour requirement. The Pass/No Credit option can be used only for free electives with something other than a CIVL or ENVE code and the humanities, arts, and social sciences electives. All other courses used to satisfy the degree requirements must be taken on a graded basis.

**Civil Engineering Design Electives and Concentrations**

Six credit hours of civil engineering design electives are required. These must be selected from the following list. Any pair of courses can be selected providing that prerequisites are met, but students most often select a combination focused on a specific area of concentration. The terms in which courses are typically offered are listed in parentheses.

**Structural Engineering**

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL 4070</td>
</tr>
<tr>
<td>CIVL 4080</td>
</tr>
</tbody>
</table>

**Environmental Engineering**

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVE 4200</td>
</tr>
</tbody>
</table>

**Geotechnical Engineering**

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL 4010</td>
</tr>
</tbody>
</table>

**Transportation Engineering**

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL 4620</td>
</tr>
</tbody>
</table>

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5 Text below lists the allowable courses.

6 This course will be fulfilled from a list published at the start of the semester.

7 Can be taken either semester of the senior year.
Any of the design electives listed above can be taken as a CE technical elective, provided the necessary prerequisites are met. The following other civil engineering courses can also be selected:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL 2040</td>
<td>Professional Practice</td>
<td>3</td>
</tr>
<tr>
<td>CIVL 4240</td>
<td>Introduction to Finite Elements</td>
<td>3</td>
</tr>
<tr>
<td>CIVL 4270</td>
<td>Construction Management</td>
<td>3</td>
</tr>
<tr>
<td>CIVL 4440</td>
<td>Advanced Structural Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

**Additional Courses**

With adviser approval, courses from related disciplines can also be taken. These include architecture, environmental engineering, earth and environmental sciences, mechanical engineering, chemical engineering, industrial engineering, and operations research. Graduate level courses (6000-level) are allowable under certain circumstances. A representative list of such courses is as follows:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVE 4110</td>
<td>Aqueous Geochemistry</td>
<td>4</td>
</tr>
<tr>
<td>ENVE 4200</td>
<td>Solid and Hazardous Waste Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ENVE 4310</td>
<td>Applied Hydrology and Hydraulics</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 2120</td>
<td>Structural Geology</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 2330</td>
<td>Earth Materials</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 4710</td>
<td>Groundwater Hydrology</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4800</td>
<td>Numerical Computing</td>
<td>4</td>
</tr>
</tbody>
</table>

**Humanities, Arts, and Social Sciences Electives**

In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities, arts, and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities, Arts, and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

**Environmental Engineering**

**Objectives of the Undergraduate Program in Environmental Engineering**

Graduates of the Bachelor of Science program in Environmental Engineering will be expected to:

- contribute to the body of knowledge in Environmental Engineering as professionals engaged in problem-solving, design, discovery, and responsible application of technology;
- further develop leadership skills by accepting increasing levels of responsibility in engineering practice, communicating in professional and civic forums, and progressing toward professional licensure;
- continue to develop both professionally and personally through graduate study, participation in professional societies, continuing education, and community service.

The Civil Engineering and Environmental Engineering degree programs at Rensselaer are each independently accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

The Rensselaer bachelor’s program in environmental engineering builds upon a broad base of studies in chemistry, life sciences, and engineering sciences culminating in a uniquely structured course sequence. This sequence of courses, as shown below, is designed around the unit operations and transport processes concepts, together with integrated laboratory theory courses. It culminates in senior design courses. This structure presents a unified educational experience in environmental engineering. A minimum of 128 credit hours is required for this curriculum.
# First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1100</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1100</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1200</td>
<td>1</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 1300</td>
<td>1</td>
</tr>
<tr>
<td>MATH 1020</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1100</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Science Elective</td>
<td>4</td>
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</tbody>
</table>

# Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 2250</td>
<td>4</td>
</tr>
<tr>
<td>ENVE 2110</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2400</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1200</td>
<td>4</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 1190</td>
<td>1</td>
</tr>
<tr>
<td>ENGR 2050</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2600</td>
<td>3</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Science Elective</td>
<td>4</td>
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</tbody>
</table>

# Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2250</td>
<td>3</td>
</tr>
<tr>
<td>ENVE 4330</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective I</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Professional Development II</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVE 4310</td>
<td>4</td>
</tr>
<tr>
<td>ENVE 4320</td>
<td>4</td>
</tr>
<tr>
<td>ENVE 4340</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective II</td>
<td>4</td>
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</tbody>
</table>

# Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 4010</td>
<td>1</td>
</tr>
<tr>
<td>ENVE 4350</td>
<td>4</td>
</tr>
<tr>
<td>Technical Elective I &amp; II</td>
<td>3</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVE 4180</td>
<td>3</td>
</tr>
<tr>
<td>ERTH 4180</td>
<td>4</td>
</tr>
<tr>
<td>Technical Elective III</td>
<td>3</td>
</tr>
<tr>
<td>Free Elective III</td>
<td>4</td>
</tr>
</tbody>
</table>

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1. May be taken in any order in the first two semesters. ENGR 1300 may be replaced by ENGR 1310 or CIVL 1100.
2. Choose CHEM 1200 and either BIOC 1010 or another biology course chosen in consultation with adviser. Order does not matter.
3. ENGR 2250 may be replaced by CHME 4010.
4. This course will be fulfilled from a list published at the start of the semester.
5. Multidisciplinary engineering elective: must be an engineering course, chosen in consultation with the adviser (e.g., ENGR 1600, ENGR 4760, CIVL 2030, CIVL 2630, ISYE 4260, ENGR 2530).
6. Technical electives must be selected in consultation with the program adviser (e.g., ENVE 4200, ENVE 4240, ENVE 4210, ENVE 4110). With adviser approval, courses from other disciplines may also be taken. These include Civil Engineering, Chemical Engineering, and Earth and Environmental Sciences (for example, CIVL 2630, CIVL 4150, CHME 4030, ERTH 4710, and others).
Additional Requirements
Nonengineering courses graded satisfactory/unsatisfactory cannot be used toward this 128-credit-hour requirement. The Pass/No Credit option can be used only for free elective courses having a code other than CIVL or ENVE, and for humanities, arts, and social sciences electives subject to Institute-wide HASS core requirements. All other courses used to satisfy the degree requirements must be taken on a graded basis.

Minor Programs

Civil Engineering Minor
Students pursuing this minor must satisfy the prerequisites and/or corequisites for these courses, which may involve other course work.

Program Requirements
Students not majoring in civil engineering may receive a minor in this field by completing five courses selected from the following list (subject to consultation with a civil engineering department program adviser):

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL 2030 Introduction to Transportation Engineering</td>
</tr>
<tr>
<td>CIVL 2630 Introduction to Geotechnical Engineering</td>
</tr>
<tr>
<td>CIVL 2670 Introduction to Structural Engineering</td>
</tr>
<tr>
<td>CIVL 4010 Foundation Engineering</td>
</tr>
<tr>
<td>CIVL 4070 Steel Design</td>
</tr>
<tr>
<td>CIVL 4080 Concrete Design</td>
</tr>
<tr>
<td>CIVL 4150 Experimental Soil Mechanics</td>
</tr>
<tr>
<td>CIVL 4440 Advanced Structural Analysis</td>
</tr>
<tr>
<td>CIVL 4660 Traffic Engineering</td>
</tr>
<tr>
<td>CIVL 4670 Highway Engineering</td>
</tr>
<tr>
<td>ENVE 2110 Introduction to Environmental Engineering</td>
</tr>
</tbody>
</table>

Recommended Courses for Students in Bachelor of Architecture Program
Given the close link between architecture and civil engineering, the following set of courses are recommended for students in the Bachelor of Architecture program who are interested in completing a minor in civil engineering with an emphasis in structural engineering.

Take all of the following:

<table>
<thead>
<tr>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CIVL 2670 Introduction to Structural Engineering</td>
</tr>
<tr>
<td>CIVL 4070 Steel Design</td>
</tr>
<tr>
<td>CIVL 4080 Concrete Design</td>
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</tbody>
</table>

Take two additional courses from the following:

<table>
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<tr>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CIVL 2630 Introduction to Geotechnical Engineering</td>
</tr>
<tr>
<td>CIVL 4010 Foundation Engineering</td>
</tr>
<tr>
<td>CIVL 4150 Experimental Soil Mechanics</td>
</tr>
<tr>
<td>CIVL 4270 Construction Management</td>
</tr>
<tr>
<td>CIVL 4440 Advanced Structural Analysis</td>
</tr>
</tbody>
</table>

Notes:
1) Completion of MATH 1010 is recommended prior to enrolling in Civil Engineering courses. However, MATH 1500 is an acceptable alternative to MATH 1010.

2) The core engineering courses ENGR 1100 and 2530 are prerequisites for many of the civil engineering courses. These core courses are waived for students who have completed ARCH 2330 with a grade of B or higher.

3) Subject to approval of the School of Architecture program adviser, ARCH 4330 will be waived for students who complete CIVL 2670, 4070, and 4080. Since ARCH 4330 is part of the Bachelor of Architecture core program, students will be required to substitute a four-credit elective in its place.

4) Bachelor of Architecture students pursuing this minor should recognize that some of the civil engineering courses may rely on material from some of the core engineering courses (i.e., ENGR 1100, ENGR 2090, MATH 1010, MATH 1020, MATH 2400, and PHYS 1100). Thus, the student should anticipate the possible need for some self-study while taking the civil engineering courses.
Environmental Engineering Minor

Program Requirements
Students not majoring in environmental engineering may receive a minor in this discipline by completing 15-16 credit hours of study beyond the Introduction to Environmental Engineering course. Typically these courses are chosen in consultation with the environmental engineering program adviser but may include:

| Credit Hours |
|-----------------|---------------------|
| ENVE 4260       | Biological Processes in Environmental Engineering |
| ENVE 4310       | Applied Hydrology and Hydraulics ................................. 4 |
| ENVE 4340       | Physicochemical Processes in Environmental Engineering .......................... 4 |

And one or more of:

| Credit Hours |
|-----------------|---------------------|
| ENVE 4200       | Solid and Hazardous Waste Engineering ...................................... 3 |
| ENVE 4320       | Environmental Chemodynamics ............................................ 4 |
| ENVE 4330       | Introduction to Air Quality ................................................ 4 |

Professional Program
This program is intended for undergraduates who wish to continue their education at Rensselaer and obtain a Master’s Degree. Requirements for the co-terminal master’s degree are the same as those for the regular master’s, and both M. Eng. and M.S. options are available.

Co-terminal students receive both their bachelor’s and master’s upon completion of all requirements. As such, co-terminal students are eligible to continue their undergraduate financial aid.

A minimum Grade Point Average of 3.2 is required for entrance into the Civil Engineering or Environmental Engineering co-terminal programs. Applications are preferably due by the end of the student’s junior year.

Graduate Programs
Graduate programs leading to the M.Eng., M.S., and Ph.D. are available in both curricula and Transportation Engineering. The selection of a graduate program and degree is based on student interest, area of graduate concentration, and satisfaction of prerequisites as indicated below. Office of Graduate Education requirements in relation to minimum grades (B average) and maximum number of credits at the 4000 level (15 cr. hrs.) apply.

Master’s Programs

Civil and Environmental Engineering M.Eng.
This is a 30-credit structured program of advanced professional study aimed at preparing students for professional practice. Candidates for this degree in the civil engineering discipline must have an accredited bachelor’s degree in engineering. In environmental engineering, a B.S. in the physical or natural sciences is also acceptable. There is no project or thesis requirement, but students may elect to do one, at either the three- or six-credit level, in consultation with their advisers.

Civil and Environmental Engineering M.S.
This research degree is open to students with undergraduate degrees in engineering or the physical or natural sciences. In addition to the satisfactory completion of an approved set of advanced courses, candidates for this degree must complete a six-credit thesis. This thesis must provide documentation of an independent research-related effort and be approved by the student’s faculty adviser. Listed below are recommended core courses in each of the five civil engineering areas of concentration and in Environmental Engineering. M.S. candidates typically take all the courses listed below in their chosen area of concentration.

Geotechnical Engineering

| Credit Hours |
|-----------------|---------------------|
| CIVL 6450       | Structural Dynamics ................................................................. 3 |
| CIVL 6510       | Advanced Soil Mechanics ............................................................. 3 |
| CIVL 6520       | Advanced Foundations and Earth Structures ...................................... 3 |
| CIVL 6540       | Dynamics of Soil and Soil-Foundation Systems .................................. 3 |
| CIVL 6550       | Advanced Geoenvironmental Engineering ........................................... 3 |

Structural Engineering

| Credit Hours |
|-----------------|---------------------|
| CIVL 4440       | Advanced Structural Analysis .................................................. 3 |
| CIVL 6310       | Advanced Concrete Structures .................................................... 3 |
| CIVL 6320       | Advanced Steel Design ............................................................. 3 |
| CIVL 6450       | Structural Dynamics ................................................................. 3 |
| CIVL 6490       | Earthquake Engineering ............................................................. 3 |
Transportation Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL 6220</td>
<td>Critical Issues in Transportation</td>
<td>3</td>
</tr>
<tr>
<td>CIVL 6230</td>
<td>Transportation Economics</td>
<td>3</td>
</tr>
<tr>
<td>CIVL 6240</td>
<td>Intelligent Transportation Systems</td>
<td>3</td>
</tr>
<tr>
<td>CIVL 6250</td>
<td>Transportation Systems Planning</td>
<td>3</td>
</tr>
<tr>
<td>CIVL 6260</td>
<td>Transportation Network Analysis</td>
<td>3</td>
</tr>
<tr>
<td>CIVL 6270</td>
<td>Traffic Control and Simulation</td>
<td>3</td>
</tr>
<tr>
<td>CIVL 6280</td>
<td>Dynamic Traffic Models</td>
<td>3</td>
</tr>
</tbody>
</table>

Environmental Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL 6550</td>
<td>Advanced Geoenvironmental Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ENVE 4110</td>
<td>Aqueous Geochemistry</td>
<td>4</td>
</tr>
<tr>
<td>ENVE 6110</td>
<td>Advanced Groundwater Hydrology</td>
<td>3</td>
</tr>
<tr>
<td>ENVE 6140</td>
<td>Stream Pollution Control</td>
<td>3</td>
</tr>
<tr>
<td>ENVE 6230</td>
<td>Mathematical Modeling of Environmental Engineering Systems</td>
<td>3</td>
</tr>
</tbody>
</table>

Additional Requirements

M.S. students and Ph.D. students in Civil Engineering are required to take CIVL 6900 Civil Engineering Graduate Seminar once. Course work only M.E. students are not required to take CIVL 6900. M.S. candidates in the environmental engineering discipline are also required to take additional courses in geochemistry and/or separations processes selected in consultation with his/her adviser.

Doctoral Programs

Civil and Environmental Engineering Ph.D.

This is a research-oriented degree focused on the development of new knowledge in the student’s chosen area of study. It includes the preparation of a dissertation that carefully documents the original contribution of the student's research. The Ph.D. program consists of a total of 72 credit hours beyond the bachelor’s degree. This includes a maximum of 30 credit hours for the dissertation and a minimum of 42 course credit hours. If the student holds a master’s degree, 24 course credit hours can be applied towards the 42 course credit hours requirement. In addition to the examination processes required of all Rensselaer doctoral students, civil engineering and environmental engineering students working toward this degree must pass a qualifying examination during the student's second semester if a student has an M.S. degree counting as a degree requirement or at the end of the student’s fourth semester if the student does not have an M.S. degree counting as a degree requirement.

Environmental engineering students must also take a candidacy examination within two semesters after passing the preliminary examination. This is an oral examination based on a thesis proposal submitted by the student at least two weeks prior to the examination. The student's thesis committee will administer the candidacy examination. Environmental engineering candidates are required to submit a draft of a journal article prior to graduation.

Course Descriptions

Courses directly related to all Civil and Environmental Engineering curricula are described in the Course Description section of this catalog under the department codes CIVL and ENVE.
Electrical, Computer, and Systems Engineering

Department Head: Dr. Kim L. Boyer
Graduate Program Director: Dr. Kenneth S. Vastola
Curriculum Chair: Dr. Michael Wozny

Department Home Page: http://www.ecse.rpi.edu/

Engineering can be described as “Science in Service to Society.” Nowhere is that more evident than in Electrical, Computer, and Systems Engineering. Electrical, computer, and systems engineers have long been at the forefront of new discoveries and their integration into advanced design and engineering methodologies. The impact of electrical, computer, and systems engineers on society can be seen in areas as diverse as medicine and medical technology, communications, environmental monitoring, energy sources and systems, entertainment and gaming, advanced transportation systems, and more. Inventions in areas such as integrated electronics and optical devices stimulate innovations in computers, control, and communications. New systems theory and mathematical techniques are then needed for analysis and design.

Addressing perhaps the broadest of scientific disciplines, Electrical, Computer, and Systems Engineering (ECSE) rests on a wide range of scientific fundamentals and therefore offers numerous advantages for undergraduate and graduate study. Among them is the ability to attack the many facets of modern problems of social relevance that cut across disciplinary lines. The flexibility for students to embark on individually tailored programs and for the department to launch new areas of research is a hallmark of ECSE.

The department offers programs of study leading to bachelor’s, master’s, and doctoral degrees in both electrical engineering and in computer and systems engineering. Each curriculum is sufficiently flexible to accommodate a wide range of interests. The curriculum the student selects, and the detailed program within the chosen curriculum, is determined by his or her specific interests.

Research Innovations and Initiatives

The following area descriptions capture activities in research and education across a set of fairly broad technical areas. Individual research groups reside within these broad curricular areas, overlap to sometimes significant degrees, and are highly dynamic and fluid in size and composition as new research initiatives and opportunities arise. These descriptions are therefore best taken as a snapshot of the Department’s research and curricular profile, and the lists of topics and areas are not necessarily exhaustive. Prospective graduate students are encouraged to visit faculty listings and Web pages, and to contact individual faculty with whom they may share technical interests to learn more.

Communications, Information, and Signal Processing

Advanced study and research in this field deals with the encoding, transmission, retrieval, and interpretation of information in many forms. Students may pursue programs of study focusing on mathematical foundations, improved algorithms, and hardware/software implementation. Communications research focuses on the transmission of information over wireless, optical, and wired channels. Telecommunications engineering creates wired and wireless systems that satisfy desirable societal, bandwidth, and hardware constraints. Research in statistical communications aims at reducing adverse effects on signal transmission in such systems through probabilistic modeling. The channels considered range from subminiature networks inside a computer chip, through broadband cable and communications satellites.

Information processing addresses the theory and engineering design associated with interpreting and manipulating received data, primarily in discrete form. Information theory and rate-distortion theory provide the foundation for a quantitative understanding of the nature and meaning of information. These theories treat the fundamental limits and algorithms for saving memory and bandwidth and protecting against transmission errors. Special research emphases at Rensselaer are the applications to image and video compression and transmission. A current exciting application area is network coding.

Signal processing considers the application of digital processing techniques to problems encountered in many areas, including biomedical instrumentation, remote sensing, subsurface sensing and imaging systems, control systems, and audio processing. Special laboratories are available for speech processing, video and image processing, networking, communications, and document image analysis.

There is significant overlap with research activities in computer networking, image processing, geographic information sciences, and computer vision.

Computer Vision, Image Processing, Digital Media, and Computational Geometry

Research in this area covers a range of technologies and applications. Rensselaer has a number of specialized laboratories in which this work is undertaken. These include the Center for Subsurface Sensing and Imaging Systems (CenSSIS), the Center for Image Processing Research (CIPR), the Computational Geometry and Document Analysis Laboratory (DocLab), the Computational Imaging Laboratory, Advanced Imaging Systems Laboratory, and the Intelligent Systems Laboratory.
Research areas include image reconstruction, pattern recognition, computer vision, image and video processing, artificial intelligence, computer graphics, machine learning, computational geometry, geographic information science and computational cartography, probabilistic reasoning and decision making under uncertainty, optical scanning systems, and Internet image analysis services.

Primary application areas include systems biology, computer-assisted surgery, radiation treatment planning, diffuse optical and optical coherence tomography, synthetic aperture imaging, distributed RF imaging, automatic target recognition, camera networks, range data processing, document image analysis, large geometric datasets, image and video processing for human viewers, image analysis aids to neurobiology, and multimodality imaging and analysis. Additional application areas include bioinformatics, human fatigue monitoring, activity monitoring and situational awareness, human computer interaction, eye and gaze tracking, video imagery activity interpretation, robot localization, robotic devices for automated scoring of assays for the biotechnology industry, biotech assay automation, and biological multidimensional microscopy.

Work related to digital media includes such topics as image and video compression for networks, camera networks and video analysis for large performance spaces, advanced image and video compression, image and video transmission, retrieval, and visualization, and methods for indexing video by content. Multimedia work also includes graphics courseware development for the World Wide Web using HTML, java, PHP, my SQL, and VRML.

Computer Engineering, Hardware, Architecture, and Networks
The development of advanced computer systems and their interconnection to facilitate ubiquitous and pervasive computing capabilities is the primary focus of this group. Research topics related to the design, implementation, layout, and testing of hardware systems include the design and testing of digital and mixed-signal chips in CMOS and BiCMOS and the development of computer-aided design tools for such designs. Specific topics include the development of high-speed computer chips using SiGe BiCMOS technology, the design and testing of mixed-signal chips for communications applications, the influence of 3-D integration on computer design, and the development of techniques for the design and reliable operation of digital chips fabricated in deep submicron CMOS.

Other ongoing research activities include error correcting coding system design and VLSI implementation for magnetic and holographic storage, and fiber and wireless communication; algorithm/architecture co-design for wireless multi-antenna signal processing; fault tolerance for semiconductor memories and molecular nanoelectronic memory; signal processing algorithm/architecture co-design for defect/variation tolerance in end-of-the-roadmap CMOS and post-silicon nanoelectronics regimes; silicon-based radio-frequency power amplifiers; multi-Gb/s broadband communications circuits; wafer-level 3-D integration for millimeter-wave smart antenna transceivers; RF-powered wireless communication circuits for bio-implantable microsystems; devices, circuits, systems, algorithms, and methodologies to enable inexpensive portable platforms for environmental and biomedical diagnostics; detection and quantification of low levels of biological signals reliably, conveniently, safely, and quickly.

The computer networking research group works on the development of protocols and architectures for both wired and wireless networks and their modeling for performance evaluation. Emerging technologies for wireless and optical last mile access, wireless sensors networks, network management, traffic management, congestion control, traffic engineering, and quality-of-service (QoS) architectures form the basic areas of current research. The networking group also participates in interdisciplinary research in control theory, economics, scalable simulation technologies, and video compression.

Control, Robotics, and Automation
Current research projects address both control theory and a variety of applications. Faculty interests include advanced control algorithms development in the areas of nonlinear control, adaptive control, multivariable control, robust control, distributed control, and optimal control. These algorithms are applied to robotics, automation systems, robotic multi-vehicle coordination, power generation and transmission systems, power electronics, networked systems, micro and nano-systems, biomedical and biological systems, and discrete-event systems.

Research in robotics and automation is inherently interdisciplinary. ECSE faculty in this area coordinates closely with the Mechanical, Aerospace, and Nuclear Engineering, Computer Science, and Cognitive Science departments for joint research and curriculum development. Current projects include planning and control for advanced manufacturing systems, multi-robot actuator and sensor networks for coordinated monitoring and manipulation, and precision motion and force control with vision guidance in micro and nano assembly manufacturing and distributed robotics for environmental observation and monitoring. Extensive experimental and computational facilities, as well as undergraduate and graduate research opportunities, are available in the New York State Center for Automation and Technology Systems.

Current research topics in nonlinear control include the development of robust and adaptive design tools which systematically account for model uncertainty and unavailable state information. Another area of interest is nonlinear control of large-scale interconnected systems (communication and power networks, vehicle formations, etc.) with limited, local information available to each component of the system. New design techniques are being developed that exploit the input/output properties of these components and achieve the design objectives of stability, decentralization, and robustness.
Discrete-event systems theory is a modeling and control discipline relevant to computer-communication systems, transportation systems, as well as the modeling and control of automated manufacturing systems. These systems are characterized by concurrent and asynchronous operations, resource allocation issues, deadlock detection and avoidance, all in a random environment. Petri nets, multi-agent systems, and holonic control systems techniques are being developed to design, model, analyze, control, and evaluate the performance of such interconnected systems.

**Electric Power, Power Electronics, Plasma Science, and Electromagnetics**

Research in energy sources and systems is becoming critically important to meet the world’s increasing energy needs and demands within the environmental, economic, and national security constraints today. Our faculties are conducting active research programs and projects in electric and magnetic field computation, electrical transients and switching technology, dielectrics and insulation systems, power system analysis and optimization, energy harvesting electromechanical devices, photovoltaic devices and systems, semiconductor power devices and electronics, and fusion plasma diagnostics.

The design of equipment to minimize losses, achieve compaction, or better utilize material frequently requires a sound knowledge of the electric and magnetic field configurations involved. Several projects in the recent past have adapted finite element methods to the solution of current problems in large machines. A new approach to digital field computations is being devised, based on techniques used to solve large network problems. The objective is to develop a more efficient, computationally conservative method. In today’s energy-scarce world, there is a great emphasis on building more efficient electrical equipment.

An electrical insulation system is an essential part of all power equipment. Current research seeks to better understand the fundamental behavior of insulation under a variety of operating conditions and to develop diagnostic instrumentation, particularly for large generators. This involves both experimentation and computer modeling. Much of the effort is currently being directed at the development of nanodielectric structures for use as high-voltage insulation for which substantial enhancements have been demonstrated, in collaboration with the Materials Science and Engineering Department.

In the power system area, ongoing research includes dispatch and control of voltage-sourced converter based flexible AC transmission systems, in conjunction with the operations of actual hardware installations in power transmission companies. A new area of research is the application of high-sampling rate synchronized phasor data to improve the operation of large power grids. The research covers phasor data streaming and database management, off-line disturbance event analysis, and real-time applications in visualization and state estimation.

Optimization theory is used in the design of electric power systems to obtain high efficiency at minimum cost, particularly for systems that involve distributed generation. This has been extended to include the development of intelligent protective relaying for dealing with the problem of islanding and utilizes the department’s hybrid system simulator and Electromagnetic Transient Program (EMTP) studies.

Power electronics and electromechanics play critical roles in ensuring energy security and achieving high energy efficiency. These energy converters provide the foundation for the utilization and integration of renewable energy resources, and enable energy-efficient technologies such as solid-state lighting, variable-speed motor drives, and more-electric transportation systems. Work in these multidisciplinary fields requires an understanding of semiconductor devices, circuit theory, signal analysis, analog and digital control, magnets, and heat transfer. Current interests and research activities include smart power semiconductor (Si, GaAs, SiC, GaN and diamond) devices and ICs; efficient ac-dc and dc-dc power conversion for IT, lighting and other electronics applications; renewable energy systems and smart grids; autonomous and mobile power systems and vibration-based energy harvesting systems enabled by power electronics; as well as multilevel modeling and analysis of complex power electronics and electromechanical systems.

High-temperature plasma research is crucial to the development of a controlled thermonuclear fusion energy source. Rensselaer’s Plasma Dynamics Laboratory has an active research program on the development of particle beam diagnostic systems and sub-system controls for magnetically confined plasma experiments. Specific techniques are developed and tested in the on-campus laboratory and then scaled up and applied on major confinement experiments located at other U.S. universities (e.g., the University of Wisconsin), at U.S. national laboratories (e.g., Oak Ridge National Lab), and foreign institutions (e.g., the Max-Planck Institute in Greifswald, Germany).

The current roadmap for photovoltaic (PV) device and system technology is based on few well established concepts from decades ago. Though theoretical predictions show that one could achieve very high efficiencies in solar to electricity conversion, breakthroughs are required in the device designs and system architectures to enable cheaper materials and manufacturing processes that can deliver the ultra-high efficiency energy converters. Mere industrial scale-up of processes is not enough for reducing the per-watt cost to make PV a sustainable mainstream energy supply source. The scope of our research activities in this area include: design and fabrication of full solar spectrum PV systems with III-V compound semiconductor devices, integrated power switching devices, non-imaging optical solar concentrator systems and nano-rod based passive optical elements.
Electrophysical Devices and Systems

The discovery of new devices and improvement of existing ones led to the modern electronic industry. These new devices are the basic building blocks of many new systems that positively impact our daily lives. Many of our faculty work in developing such new devices using cutting edge technology and then employ them in building state of the art systems. State of the art laboratory facilities exist to carry out advanced study and research in these areas.

A common user facility accessible to all students and faculty is the microfabrication clean room (MCR) housed in the Center for Integrated Electronics (CIE). This MCR is equipped with up to 8” wafer tools for end-to-end device fabrication, characterization, metrology, and testing of silicon-based devices and integrated circuits, and an array of equipments for compound semiconductor device processing. In addition, the nanolithography tools, including nanoimprint, nano ink, and direct e-beam writer enable microelectronic and photonic device fabrication at feature size of 10 nm. This MCR is being used extensively for research in association with the Focus Center-New York (FC-NY), which is part of the national Interconnect Focus Center (IFC), addressing the discovery and invention of new electrical, optical and thermal interconnect solutions. It also enables hyper-integration of heterogeneous components for future terascale systems.

One of the new projects involves investigation of a new regime of transistor operation in the terahertz range using the excitation and rectification of plasma waves in the transistor channel. This work is supported by modeling and parameter extraction based on our circuit simulator, AIM-Spice (with tens of thousands of users world wide) and by materials and device research on multifunctional semiconductors having pyroelectric properties. A variety of commercial design and simulation software, presently including Cadence, Mentor, TMA, and Hewlett-Packard software suites, are available for modeling integrated circuits, devices, processes, and interconnects that enable the discovery of new devices.

Several specialized laboratories are available that are equipped to meet industrial standards for advanced research techniques. The electronic materials laboratory includes several state-of-the-art bulk crystal growth systems, wafer slicing and chemical-mechanical polishing facilities, liquid phase epitaxy system for multilayer hetero-epitaxial growth, and cold wall epitaxial reactors for the growth of single crystal III-V, II-VI semiconductors. This equipment is used to grow and fabricate infrared devices, thermophotovoltaic devices and advanced solar cells. The high-voltage power device laboratory, as part of the Center for Power Electronics Systems (CPES), is used in designing and fabricating high voltage and high power semiconductor devices. Equipment to characterize these devices in wafer and package form up to 20 kV and 25A is available.

The newly established Smart Lighting Engineering Research Center (ERC) ushers in a new era in how humankind harnesses the enormous capabilities of light. The center is funded by the National Science Foundation and has a potential budget of about $50 million over 10 years. The Smart Lighting ERC develops and employs light sources based on semiconductors that exhibit very high efficiency as well as detailed controllability. The controllability, by design or by real-time tunability, includes the emission spectrum, the color temperature, the polarization, the spatial emission pattern, and the temporal modulation. The controllability of semiconductor-based smart lighting sources is a unique feature that is not shared by any other light source.

In contrast to conventional light sources, the efficiency of semiconductor-based solid-state lighting devices is not determined by fundamental limits. Instead the efficiency of solid-state lighting devices is limited only by our own creativity. Overcoming current limitations enables solid-state lighting devices to be up to 20 times more efficient than conventional light bulbs. As a result, gigantic quantities of energy and financial resources could be saved by the global introduction of solid-state lighting. In addition, solid-state lighting technology can dramatically reduce the emission of green-house gases, acid-rain gases and highly toxic mercury.

An equally important aspect of solid-state lighting devices is their ability to be tunable, interactive, responsive, and intelligent, thereby making them truly smart devices. The Smart Lighting ERC will demonstrate revolutionary lighting systems with controllability and tunability in four system testbeds: A bio-imaging testbed based on high-luminance spectrally tunable sources, a high-efficiency display testbed based on polarized sources, and outdoor transportation testbed, and an indoor communications testbed implementing novel modes of communications.

Facilities for conducting Smart Lighting research include the 5,000 square feet ERC Central Laboratories, located in RPI’s George Low building, which include a wide array of semiconductor device fabrication and characterization tools as well as instruments for systems research and testbed implementation.

The above semiconductor devices are the building blocks of many systems, and many of faculty do research in the design, implementation, layout, and testing of hardware systems. Research areas include the design and testing of digital and mixed-signal chips in CMOS and BiCMOS and the development of computer-aided design tools for such designs. Specific topics include the development of high-speed computer chips using SiGe BiCMOS technology, the design and testing of mixed signal chips for communications applications, the influence of wafer-to-wafer bonded 3-D integration on computer design, and the development of techniques for the design and reliable operation of digital chips fabricated in deep submicron CMOS.

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multi-antenna signal processing; fault tolerance for semiconductor memories and molecular nanoelectronic memory; signal processing algorithm/architecture co-design for defect/variation tolerance in end-of-the-roadmap CMOS and exploration of possible post-silicon technology including SiGe, GaAs/GaInAs, InP, GaN, (both FET and HBT) and nanoelectroics; silicon-based radio-frequency power amplifiers; multi-Gb/s broadband communication circuits; millimeter-wave smart antenna transceivers; RF-powered wireless communication circuits for bio-implantable microsystems; devices, circuits, systems, algorithms, and methodologies to enable inexpensive portable platforms for environmental and biomedical diagnostics.

**Faculty**

**Professors**

**Bhat, I.**—Ph.D. (Rensselaer Polytechnic Institute); solid state, electronic materials.

**Boyer, K.L.**—Ph.D. (Purdue University); all aspects of computer vision and medical image analysis.

**Chow, J.H.**—PE., Ph.D. (University of Illinois); large-scale system modeling, multivariable control systems.

**Chow, T.P.**—Ph.D. (Rensselaer Polytechnic Institute); semiconductor device physics and processing technology, integrated circuits.

**Connor, K.A.**—Ph.D. (Polytechnic Institute of New York); electromagnetic theory, wave propagation, plasmas for fusion research and industrial applications, finite element methods.

**Dutta, P.S.**—Ph.D. (Indian Institute of Science); compound semiconductor materials and devices, crystal growth and substrate engineering, semiconductor quantum dots and nano-particles, photovoltaics, optoelectronics and microelectronics technologies.

**Franklin, W.R.**—Ph.D. (Harvard University); computational geometry, graphics and CAD applications, large geometric databases, geographic information systems, terrain visibility and compression.

**Gerhardt, L.A.**—Ph.D. (State University of New York at Buffalo); communication systems, digital voice and image processing, adaptive systems and pattern recognition, integrated manufacturing.

**Ji, Q.**—Ph.D. (University of Washington); computer vision, image processing, pattern recognition, robotics.

**Karlicek, R.F.**—Ph.D. (University of Pittsburgh); compound semiconductor materials and devices, device packaging, lasers and light emitting diodes, solid state lighting.

**McDonald, J.E.**—Ph.D. (Yale University); communication theory, coding and switching theory, computer architecture, integrated circuit design, high frequency packaging, digital signal processing.

**Salon, S.J.**—PE., Ph.D. (University of Pittsburgh); machine design, system component modeling and simulation.

**Sanderson, A.C.**—Ph.D. (Carnegie Mellon University); robotics, knowledge-based systems, computer vision.

**Saulnier, G.J.**—Ph.D. (Rensselaer Polytechnic Institute); circuits and electronics, communication systems, digital signal processing.

**Schubert, E.E.**—Ph.D. (University of Stuttgart); compound semiconductor devices and materials, light emitting diodes, heterobipolar transistors, semiconductor device physics, solid state lighting.

**Shur, M.S.**—D.Sc. (Ioffe Institute); semiconductor materials and devices, integrated circuit simulation, characterization, and design.

**Sun, J.**—Ph.D. (University of Paderborn); power electronics and energy systems.

**Vastola, K.S.**—Ph.D. (University of Illinois); computer and communication networks.

**Wen, J.T.**—Ph.D. (Rensselaer Polytechnic Institute); nonlinear control, robot control, flexible structures control, deformation processes control.

**Woods, J.W.**—Ph.D. (Massachusetts Institute of Technology); digital signal processing, image processing, digital image and video compression.

**Wozny, M.J.**—Ph.D. (University of Arizona); computer graphics, computer-aided design, digital simulation, rapid prototyping systems.

**Yazici, B.**—Ph.D. (Purdue University); inverse problems in biomedical imaging, tomography, diffuse optical tomography, biomedical optics, free space optical communications, ultrasonics, statistical pattern recognition theory and application.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Associate Professors

Abouzeid, A.A.—Ph.D. (University of Washington); packet networks.

Hella, M.—Ph.D. (Ohio State University); RF and mixed signal VLSI circuits for wireless/optical transceivers; analog/RFIC design for biomedical applications.

Huang, Z.R.—Ph.D. (Georgia Institute of Technology); optoelectronic devices, integration and packaging, 3-D integrated microsystems, lightwave circuits, integrated slow wave structures, photodetectors, electro-optic modulators and laser diodes.

Kar, K.—Ph.D. (University of Maryland); routing and traffic management in computer networks, congestion control and fair resource allocation, ad-hoc and sensor networks.

LeCoz, Y.L.—Ph.D. (Massachusetts Institute of Technology); numerical methods, random-walk algorithms for thermal and electromagnetic analysis of IC interconnects, quantum theory of semiconductor heterojunctions.

Lu, J.—Ph.D. (Technical University of Munich); electronic materials.

Parsa, L.—Ph.D. (Texas A&M University); power electronics, energy conversion and motion control.

Radke, R.J.—Ph.D. (Princeton University); image and video processing.

Schoch, P.M.—Ph.D. (Rensselaer Polytechnic Institute); plasma diagnostics, instrumentation, engineering education.

Sikdar, B.—Ph.D. (Rensselaer Polytechnic Institute); computer networks.

Xiang, N.—Ph.D. (Ruhr-University Bochum); signal processing, acoustic sensing, and architectural acoustics.

Zhang, T.—Ph.D. (University of Minnesota); VLSI signal processing, error-correcting coding.

Assistant Professors

Julius, A.A.—Ph.D. (University of Twente); mathematical systems theory and control, systems biology, control of biological systems, hybrid systems.

Sawyer, S.M.—Ph.D. (Rensselaer Polytechnic Institute); optoelectronics, characterization, design, sensor development.

Wang, M.—Ph.D. (Cornell University); computer and communication networks, signal processing.

Research Assistant Professor

Selvaggi, G.P.—Ph.D. (Rensselaer Polytechnic Institute); power systems, electromagnetics.

Professor of Practice

Kanai, J.—Ph.D. (Rensselaer Polytechnic Institute); engineering education, software engineering, systems engineering.

Lecturers

Braunstein, J.—Ph.D. (Rensselaer Polytechnic Institute); microwave heating, antenna theory, and numerical computing.

Kraft, R.P.—Ph.D. (Rensselaer Polytechnic Institute); embedded systems and control education, electronic manufacturing inspection, high-speed digital circuits.

Emeritus Faculty

Borrego, J.M.—P.E., Sc.D. (Massachusetts Institute of Technology); semiconductor device physics and characterization, solar cells, application of microwaves.

Close, C.M.—Ph.D. (Rensselaer Polytechnic Institute); network analysis and synthesis, control systems.

Das, P.K.—Ph.D. (University of Calcutta); microwave acoustics, solid-state devices, integrated circuits.

Degeneff, R.C.—P.E., D.Eng. (Rensselaer Polytechnic Institute); transient voltages in electrical machines and transformers, HVDC system design and electric utility system planning.
Desrochers, A.A.—Ph.D. (Purdue University); discrete event dynamic systems, robotics, automated manufacturing systems control.

DiCesare, E.—Ph.D. (Carnegie Mellon University); discrete event systems, Petri net theory and applications manufacturing automation and integration, traffic control.

Frederick, D.K.—Ph.D. (Stanford University); automatic control, process modeling and control, computer simulation.

Ghandhi, S.K.—Ph.D. (University of Illinois); solid-state materials and devices, integrated circuits, device technology and electronic circuits.

Gutmann, R.J.—Ph.D. (Rensselaer Polytechnic Institute); solid-state devices, microwave techniques, and interconnection technology.

Jennings, W.C.—Ph.D. (Rensselaer Polytechnic Institute); plasma diagnostics, electronics manufacturing, multimedia educational materials.

Kelley, R.B.—Ph.D. (University of California, Los Angeles); methods to give machines smart behaviors, sensor-based automation/robotic systems, teaching methods.

Nagy, G.—Ph.D. (Cornell University); pattern recognition, document-image analysis, optical character recognition, geometric computation, computer-mediated learning, computer vision.

Nelson, J.K.—C.Eng., Ph.D. (University of London); dielectrics and insulation systems, computer-based diagnostics, electrostatic phenomena.

Pearlman, W.A.—Ph.D. (Stanford University); information theory and source coding; image, video, and audio compression; digital image and signal processing.

Rose, K.—Ph.D. (University of Illinois); semiconductor and superconductor materials and processing, VLSI design and testing.

Savic, M.—Eng.Sc.D. (University of Belgrade); signal processing, biomedical electronics, electronics.

Saxena, A.N.—Ph.D. (Stanford University); solid-state materials, devices, integrated circuits, and advanced technologies.

Undergraduate Programs

Objectives of the Undergraduate Curriculum

The Electrical, Computer and Systems Engineering programs are each designed to prepare students for continued learning and successful careers in industry, government, academia, and consulting. Graduates of the programs within Electrical, Computer, and Systems Engineering will be prepared to:

• pursue professional positions and/or graduate study in their areas of interest.

• contribute to the body of knowledge in their professional discipline through problem-solving, discovery, leadership, and responsible application of technology.

• continue to develop both professionally and personally through activities such as participation in professional societies, continuing education, and community service.

The Electrical Engineering and Computer & Systems Engineering degree programs are each independently accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Baccalaureate Programs

Within the department, students may obtain the Bachelor of Science degree in either of two disciplines: electrical engineering or computer and systems engineering. The department also encourages students to consider graduate study in either of these curricula.

Engineering design is introduced and developed throughout the program, setting the stage for a capstone design experience. The capstone design experience is a communications-intensive course and satisfies the Institute writing requirements as it prepares the student for a professional career.

Starting templates are available for students who select either of the ECSE disciplines. However, various arrangements can be made with the help of an adviser. In all cases, adviser approval of individual plans of study is necessary to ensure satisfaction of departmental and accreditation requirements. The adviser must also approve in writing any exceptions to the courses specified in the descriptions below.

The electrical engineering curriculum requires completion of a minimum of 128 credit hours; the computer and systems engineering curriculum requires 129 credit hours. In either case, the Pass/No Credit option may be used only for humanities and social sciences electives (up to a maximum of six credits) or free electives. All other courses used to satisfy the degree requirements must be taken on a graded basis.
Electrical Engineering

Traditionally the largest and most diverse in all of engineering, this curriculum offers courses with various degrees of emphasis on theory, design, experimental work, and computer simulation. Subject matter ranges from semiconductors, electromagnetics, circuits and electronics, and electric power, to control, computer, communication, and information processing systems.

FIRST YEAR

Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CSCI 1100</td>
<td>Computer Science I</td>
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<tr>
<td>ENGR 1100</td>
<td>Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
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<td>HASS Elective</td>
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Spring

<table>
<thead>
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<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>ENGR 1200</td>
<td>Engineering Graphics and CAD</td>
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<tr>
<td>MATH 1020</td>
<td>Calculus II</td>
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<td>PHYS 1100</td>
<td>Physics I</td>
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SECOND YEAR

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<td>Introduction to Differential Equations</td>
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<td>PHYS 1200</td>
<td>Physics II</td>
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<td>HASS Elective</td>
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<tr>
<td></td>
<td>Multidisciplinary Elective</td>
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Spring

<table>
<thead>
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<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ECSE 2010</td>
<td>Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 2610</td>
<td>Computer Components and Operations</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2350</td>
<td>Embedded Control</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2010</td>
<td>Multivariable Calculus and Matrix Algebra</td>
<td>4</td>
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THIRD YEAR

Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ECSE 2050</td>
<td>Introduction to Electronics</td>
<td>4</td>
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<tr>
<td>ECSE 2410</td>
<td>Signals and Systems</td>
<td>3</td>
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<tr>
<td>ECSE 2500</td>
<td>Engineering Probability</td>
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<tr>
<td>ENGR 2050</td>
<td>Introduction to Engineering Design</td>
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<td>Professional Development II</td>
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Spring

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<tr>
<td>ECSE 2100</td>
<td>Fields and Waves I</td>
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<tr>
<td>ECSE 2110</td>
<td>Electrical Energy Systems</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 2210</td>
<td>Microelectronics Technology</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 2900</td>
<td>ECSE Enrichment Seminar</td>
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FOURTH YEAR

Fall

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<td>Professional Development III</td>
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<td>Laboratory Elective</td>
<td>3</td>
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<tr>
<td></td>
<td>Design Elective</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Restricted Electives (2)</td>
<td>6-8</td>
</tr>
<tr>
<td></td>
<td>Free Electives (2 or 3)</td>
<td>8-9</td>
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<tr>
<td></td>
<td>Technical Elective</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>HASS Electives (2)</td>
<td>8</td>
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</tbody>
</table>

1 May be taken either term.
2 The free electives must total at least 12 credits.
3 This course will be fulfilled from a list published at the start of each semester.
4 It is recommended that students use electives to form a concentration. See the ECSE Web page for concentration listings.
5 Students who wish to take ENGR 1600 as their Multidisciplinary Elective must take CHEM 1100.
Humanities, Arts, and Social Sciences Electives
In this area, electives are based on the Institute and School of Engineering requirements. Additionally, at least one course must be selected from the list posted on the ECSE home page. Students are urged to elect humanities, arts, and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities, Arts, and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Science Electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 2120</td>
<td>Introduction to Cell and Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 1100</td>
<td>Chemistry I</td>
<td>4</td>
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</table>

Multidisciplinary Electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ENGR 1600</td>
<td>Materials Science for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2090</td>
<td>Engineering Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2250</td>
<td>Thermal and Fluids Engineering I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2530</td>
<td>Strength of Materials</td>
<td>4</td>
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Laboratory Electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ECSE 4090</td>
<td>Mechatronics</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4130</td>
<td>EPE Laboratory</td>
<td>4</td>
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<tr>
<td>ECSE 4220</td>
<td>VLSI Design</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 4710</td>
<td>Manufacturing Processes and Systems Laboratory I</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4760</td>
<td>Real-Time Applications in Control and Communications</td>
<td>3</td>
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<tr>
<td>ECSE 4770</td>
<td>Computer Hardware Design</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4790</td>
<td>Microprocessor Systems</td>
<td>3</td>
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</table>

Restricted Electives

Any course with the designation ECSE 4xxx or ECSE 6xxx.

Technical Elective

Any course in engineering or science at the 4000 level or higher.

Design Electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 4900</td>
<td>ECSE Design (Fall and spring)</td>
<td>3</td>
</tr>
<tr>
<td>MANE 4220</td>
<td>Inventor’s Studio (Fall and spring)</td>
<td>3</td>
</tr>
</tbody>
</table>

Computer and Systems Engineering

This field is one of the fastest-growing branches of engineering. Strong course sequences in software, hardware, and systems engineering are available. Students consider the computer as a system in itself, as a tool for modeling and design, and as an embedded element within a real-time system. There is the flexibility to study in depth in areas such as automatic control, communications, information processing, computer software, computer hardware, computer networks, robotics, signal processing, and image analysis.

**FIRST YEAR**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
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<tbody>
<tr>
<td>CSCI 1100</td>
<td>Computer Science I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1100</td>
<td>Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1200</td>
<td>Engineering Graphics and CAD</td>
<td>1</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
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<td>MATH 1020</td>
<td>Calculus II, Science Elective, HASS Elective</td>
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Spring

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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<tr>
<td>CSCI 1200</td>
<td>Data Structures</td>
<td>4</td>
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<tr>
<td>MATH 1020</td>
<td>Calculus II, Science Elective, HASS Elective</td>
<td>4</td>
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---

1 May be taken either term
## SECOND YEAR

<table>
<thead>
<tr>
<th>Fall</th>
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<tbody>
<tr>
<td>CSCI 2200</td>
<td>4</td>
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<tr>
<td>Computer Components and Operations</td>
<td>4</td>
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<tr>
<td>ENGR 2350</td>
<td>4</td>
</tr>
<tr>
<td>Embedded Control</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1100</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>Credit Hours</td>
</tr>
<tr>
<td>CSCI 2300</td>
<td>4</td>
</tr>
<tr>
<td>Introduction to Algorithms</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 2610</td>
<td>4</td>
</tr>
<tr>
<td>Computer Components and Operations</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2400</td>
<td>4</td>
</tr>
<tr>
<td>Introduction to Differential Equations</td>
<td>4</td>
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<tr>
<td>PHYS 1100</td>
<td>4</td>
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## THIRD YEAR

<table>
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<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ECSE 2010</td>
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<tr>
<td>Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2050</td>
<td>4</td>
</tr>
<tr>
<td>Introduction to Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2010</td>
<td>4</td>
</tr>
<tr>
<td>Multivariable Calculus and Matrix Algebra</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
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<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>Credit Hours</td>
</tr>
<tr>
<td>ECSE 2050</td>
<td>4</td>
</tr>
<tr>
<td>Introduction to Electronics</td>
<td>4</td>
</tr>
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<td>ECSE 2410</td>
<td>3</td>
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<td>Signals and Systems</td>
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<td>ECSE 2500</td>
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<tr>
<td>Engineering Probability</td>
<td>3</td>
</tr>
<tr>
<td>Free Elective</td>
<td>3-4</td>
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<tr>
<td>HASS Elective</td>
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## Fourth Year

<table>
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<tr>
<td>Professional Development III</td>
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<tr>
<td>Design Elective</td>
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<tr>
<td>Computer Engineering Elective</td>
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<td>Restricted Electives (2)</td>
<td>6-8</td>
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<tr>
<td>Free Electives (2 or 3)</td>
<td>8-9</td>
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<tr>
<td>Technical Elective</td>
<td>3-4</td>
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<td>HASS Elective</td>
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<td>4</td>
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</table>

### Humanities, Arts, and Social Sciences Electives

In this area, electives are based on the Institute and School of Engineering requirements. Additionally, at least one course must be selected from the list posted on the ECSE home page. Students are urged to elect humanities, arts, and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities, Arts, and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

### Science Electives

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1010</td>
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<td>Introduction to Cell and Molecular Biology</td>
</tr>
<tr>
<td>CHEM 1100</td>
</tr>
<tr>
<td>Chemistry I</td>
</tr>
</tbody>
</table>

### Restricted Electives

Any course with the designation ECSE 4xxx, ECSE 6xxx, CSCI 4xxx, or CSCI 6xxx.

### Technical Elective

Any course in science or engineering at the 4000 level or higher.

---

2 The free electives must total at least 12 credits.
3 This course will be fulfilled from a list published at the start of each semester.
4 May be taken in the third year.
5 It is recommended that students use electives to form a concentration. See the ECSE Web page for concentration listings.
Computer Engineering Electives

<table>
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<tr>
<td>CSCI 4440</td>
<td>Software Design and Documentation (Fall or Spring)</td>
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<tr>
<td>ECSE 4670</td>
<td>Computer Communication Networks (Fall)</td>
<td>3</td>
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<tr>
<td>ECSE 4750</td>
<td>Computer Graphics (Fall or Spring)</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4770</td>
<td>Computer Hardware Design (Fall)</td>
<td>3</td>
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<tr>
<td>ECSE 4790</td>
<td>Microprocessor Systems (Fall)</td>
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Design Electives

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ECSE 4900</td>
<td>ECSE Design (Fall or Spring)</td>
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</tr>
<tr>
<td>MANE 4220</td>
<td>Inventor's Studio (Fall or Spring)</td>
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</table>

Minor Programs

Electrical Engineering Minor

Minors in the ECSE curricula are open to undergraduates not majoring in any of these disciplines. The ECSE curriculum chair must approve all minors.

The Minor consists of:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 2010</td>
<td>Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 2410</td>
<td>Signals and Systems</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 2610</td>
<td>Computer Components and Operations</td>
<td>4</td>
</tr>
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<td></td>
<td>Approved ECSE Elective</td>
<td>3–4</td>
</tr>
</tbody>
</table>

Computer and Systems Engineering Minor

The Minor consists of:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 2010</td>
<td>Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 2610</td>
<td>Computer Components and Operations</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 2660</td>
<td>Computer Architecture, Networks, and Operating Systems</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Approved ECSE Elective</td>
<td>3–4</td>
</tr>
</tbody>
</table>

Dual Major Programs

These programs lead to a single baccalaureate degree embracing two fields. Special programs that can be completed in eight terms have been devised for:

- electrical engineering and applied physics
- electrical engineering and computer and systems engineering
- computer and systems engineering and computer science

See the ECSE Web page for detailed information about these programs.

Special Undergraduate Opportunities

ECSE offers a couple of special programs for highly qualified students. These include:

The Undergraduate Honors Program

This program for outstanding undergraduates in electrical engineering or computer and systems engineering introduces research as a professional activity. All participants attend the ECSE Honors Seminar during their sophomore or junior year. Students also participate in at least one research project. An honors faculty adviser is assigned with whom special academic programs are developed that reflect the capabilities and interests of the exceptional student. Applications are accepted during a student’s third semester or thereafter. Forms are available from the department curriculum office.

The Grainger Scholar Program

This program is for well-qualified U.S. students whose individual studies emphasize energy sources and systems. Through this program, the Grainger Foundation supports study in energy and power at Rensselaer.
Graduate Programs
The department offers graduate programs leading to the Master of Engineering, Master of Science, and Doctor of Philosophy in both of the department curricula. In all cases, particular emphasis is placed on developing a coherent individualized Plan of Study with the help of a faculty adviser.

Master’s Programs
Both the M.S. and the M.Eng. require 30 credits beyond the bachelor’s degree.

Master of Science
This program is designed to prepare students for research-oriented careers and eventual pursuit of a doctoral degree. A six-credit thesis or project is usually required, but it may be waived for students who can submit a document of previous individual work that demonstrates equivalency in depth and presentation. Waivers are granted by the director of master’s programs and must be replaced with six credit hours of course work.

The M.S. Plans of Study in electrical engineering and computer and systems engineering must consist of at least 18 credit hours of 6000-level courses and the thesis/project. At least 21 credit hours of ECSE courses must be taken, or up to six of these may be from a related technical area with the approval of the department. Programs that do not include 21 credit hours from ECSE must have prior approval from the director of master’s programs. Students who do not have adequate preparation for their chosen area of specialization may need to take background courses in addition to the 30-credit-hour requirement. An information sheet giving the requirements for several areas of specialization is available for all accepted students.

In the electric power engineering curricula, most study and research is of an applied nature, which is recognized in the awarding of the M.Eng. degree. However, courses and research directed more toward basic understanding of physical phenomena, such as the fundamental processes of electrical breakdown in dielectrics, can be pursued. This type of research would lead to the M.S. degree. This avenue also allows students with accredited degrees—not in engineering but perhaps in science—to obtain advanced degrees in the electric power area.

Master of Engineering
This one-year program is designed to prepare graduates for professional careers. Students entering the program typically hold accredited bachelor’s degrees in appropriate branches of engineering. A master’s thesis or project is not required.

The M.Eng. Plans of Study in electrical engineering and computer and systems engineering consist of at least 18 credit hours in 6000-level courses. In addition, they must include at least 21 credit hours in ECSE courses, or up to six of these may be from a related technical area with the approval of the department. Programs that do not include 21 credit hours from ECSE must have prior approval from the director of master’s programs. Students who do not have adequate preparation for their chosen area of specialization may need to take background courses in addition to the 30-credit-hour requirement. An information sheet giving the requirements for several areas of specialization is available for all accepted students.

The electric power engineering M.Eng. degree is a structured program of advanced professional study for the student holding an accredited bachelor’s degree in the field or its equivalent in electrical engineering.

Course listings do not represent requirements except where indicated (see the fifth year requirements listed earlier); they are intended only to guide the student, who is encouraged to develop an individual program in consultation with his or her graduate adviser.

Doctoral Programs
Advanced study and research for a Ph.D. degree is conducted under the guidance of a thesis adviser representing the department. The student formulates an individual Plan of Study in consultation with the adviser. The doctoral qualifying examination should be taken prior to completing 15 credit hours beyond the master’s degree. A minimum of 60 credit hours beyond the master’s degree, including a dissertation, is required. The department expects the Institute requirements for candidacy and residency to be satisfied.

Special Graduate Opportunities
In collaboration with the various campus centers and other departments, ECSE sponsors master’s and doctoral program options in manufacturing systems and semiconductor technology. Descriptions of these programs are available upon request.

Course Descriptions
Courses directly related to all Electrical, Computer, and Systems Engineering curricula are described in the Course Description section of this catalog under the department codes CSCI, ECSE, ENVE, ISYE, ITEC, MATH, MATP, MTLE, and PHYS.
Industrial and Systems Engineering

Department Head: Charles J. Malmborg
Director, Doctoral Program: David Mendonca
Director, Master’s Program: William J. Foley
Director, Undergraduate Program: Charles J. Malmborg

Department Home Page: http://www.ise.rpi.edu

The Department of Industrial and Systems Engineering offers degree programs at the bachelor’s, master’s, and doctoral levels including the bachelor’s and master’s degree in Industrial and Management Engineering, and the doctoral degree in Decision Sciences and Engineering Systems. The common theme throughout the department’s academic programs is the use of mathematical, statistical, and computational/simulation models to better understand, predict, and optimize complex engineering, managerial, operational, and physical systems.

Research Innovations and Initiatives

The department’s research is focused on core disciplinary strengths in Industrial and Systems Engineering (ISE). ISE involves the application of mathematical, computational, statistical, and information science methods to model, analyze, and solve complex decision problems in engineering, business, and social systems. ISE employs methods of mathematical programming, queuing theory, computational optimization, decision analysis, applied statistics, database systems, soft computing, and discrete event simulation for solving problems related to the design, planning, and operation of complex systems where intelligent coordination is necessary to achieve optimal performance. It is distinctive from management and economics in the use of an engineering approach to design and analyze enterprise processes to optimize performance. It is distinctive from computer science in its focus on the design of data and knowledge systems as the organizational nerve center where operations and enterprise systems are integrated.

The department’s faculty research aligns directly with these core strengths to exploit dynamically evolving opportunities of high relevance in such areas as Adaptive Supply Chains, Social and Cognitive Networks, Homeland Security, Service Systems Engineering, Energy and Environmental Systems, and Biotechnology.

Cognitive and Social Networks

The department’s research thrust in cognitive and social networks relates to the development of computational technologies focused on the application of artificial intelligence, soft computing, data fusion, information systems, and data mining. Key applications include threat detection in social network communications, issues of trust and ethics in online communities, visualization in media and design, emergent and improvisational organizational responses to natural and unnatural disasters, and group and individual behavior in dynamic social systems. This research lies at the intersection of operations research, systems engineering, and psychology. The unifying thread is the use of cyber-infrastructure to enhance the information value chain from data, to information, to knowledge to decision making. The research has yielded practical techniques and algorithms for such tasks as automated mining of media files and social network communications, modeling organizational responses to unplanned events, and the impact of interdependencies among infrastructural sub-systems in urban areas.

An excellent example of the department’s research in this area is in systems for disaster response and recovery. Recent events remind us of the global importance of natural, technological, and willful disasters. Such critical events precipitate a wide range of impacts on the interconnected, complex systems that constitute our infrastructure for food, transportation, power, housing, and medical supplies. These technological systems are more vulnerable because they are interdependent; disruptions in one can spread to others, causing cascading and potentially catastrophic failures. This vulnerability is exacerbated by advances in communications and computing technologies that are now integral to the operations of our infrastructure systems. For example, efficient and effective global supply chains could not function without both the logistical infrastructure to collect, store, and move goods and the information infrastructure to monitor and control the flow of those goods over the network.

Adaptive Supply Chain

The department’s research in adaptive supply chains deals with the logistics of efficiently deploying finite resources to assemble, transport, sustain, and distribute people and goods, thereby facilitating the fulfillment of demand associated with economic commerce, national defense, disaster response, and/or humanitarian aid. The focus is on efficient and integrated coupling of supply with distribution network resources from a total integrated systems perspective. The functional scope of Adaptive Supply Chains spans production/procurement, materials management, storage, transport, routing, warehousing, dispatching, delivery, and service. Its contextual scope spans production, transportation, military, health, maritime, and communications systems. All of these systems are characterized by complex interdependencies where the methodologies of Industrial and Systems Engineering can address major challenges in both the ability of supply chains to adapt to evolutionary change and respond to planned and unplanned disruptive events. The current body of design and modeling research in this area focuses on life-cycle cost minimization under steady state conditions, sequential supply and demand management, and predictable asset and material values. This traditional approach is clearly insufficient to deal with the challenges facing supply chains in the 21st
century where criteria related to resiliency and sustainability will rival cost as a dominant driver in decision making. The department’s research in adaptive supply chains is expanding the theoretical frameworks for understanding, modeling, and simulating interdependent supply chains under short-term disruptive conditions as well as their adaptability over the system life cycle.

**Other Important Research Themes**
ISE research in Energy and the Environment models self-reconfigurable power grids with cyber-infrastructure and distributed sensors using agent-based methodologies. Related research in this application area involves load forecasting, advanced simulation models to assess the impact of climate change, and proton exchange membrane fuel cell manufacturing. ISE research in Service Systems Engineering builds on the complementarity of services and manufacturing in applying cyber-infrastructure to produce and provide on-demand, mass-customized services. The key characteristics of these services include scalability, asynchronous co-production, and human-centered assistance through cyber-infrastructure. ISE research in Biotechnology uses computational intelligence for computer-aided drug design, simulation tools for modeling the spread of infectious diseases, and the development of text-mining techniques in bioinformatics.

**Faculty *\**

**Professors**

Hsu, C.—Ph.D. (Ohio State University); electronic commerce, metadatabase and information systems, enterprise integration and modeling, Internet enterprises planning, computerized manufacturing, information visualization, economic evaluation of cyberspace-augmented enterprises.

Malmborg, C.J.—Ph.D. (Georgia Institute of Technology); modeling and analysis of problems in facility design, materials handling, material flow, storage systems, simulation-based optimization methods, manufacturing systems, decision analysis.

Wallace, W.A.—Ph.D. (Rensselaer Polytechnic Institute); decision support systems, environmental management modeling process, disaster management.

Willemain, T.R.—Ph.D. (Massachusetts Institute of Technology); probabilistic modeling, data analysis, forecasting.

**Associate Professors**

Chan, W.K.—Ph.D. (University of California at Berkeley); discrete event simulation, design and analysis of manufacturing and service systems, mathematical statistics, queuing theory.

Embrechts, M.J.—Ph.D. (Virginia Polytechnic Institute); application of neutral networks and fuzzy logic for manufacturing and process control; image recognition and classification with the aid of neural networks; neural networks, fractals, chaos, and wavelets for time-series analysis; data mining and computational intelligence.

Mendonca, D.—Ph.D. (Rensselaer Polytechnic Institute); decision analysis, decision making in emergent environments, group decision making, human performance, infrastructure systems.

Ryan, J.—Ph.D. (Northwestern University); Bayesian methods for decision support systems, stochastic optimization methods for logistical systems, stochastic models for inventory control and supply chain management, analysis of make-to-stock production/inventory systems, service parts logistics, decision models for large-scale condition monitoring.

**Assistant Professor**

Sharkey, T.—Ph.D. (University of Florida); mathematical programming, network algorithms, combinatorial and computational optimization, supply chain logistics, demand allocation based supply chain optimization models, nonlinear network design problems.

**Research Professor**

Grabowski, M.—Ph.D. (Rensselaer Polytechnic Institute); management information systems, knowledge-based systems, human and organizational error in large-scale systems, impact of information technology on systems and organizations.

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* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Lecturers

Aboul-Seoud, M.—Ph.D. (University of Louisville); reliability engineering, quality control, operations research.

Foley, W.J.—PE., Ph.D. (Rensselaer Polytechnic Institute); engineering design, computer simulation modeling, health applications of operations research, health case policy analysis.

Emeritus Faculty

Berg, D.—NAE, Ph.D. (Yale University); Institute Professor of Science and Technology (joint in Lally School of Management and Information Technology); management of technological organizations, innovation, policy, robotics, policy issues of research and development in the service sector.

Graves, R.J.—Ph.D. (State University of New York at Buffalo); manufacturing systems modeling and analysis, facilities planning and material handling system design, scheduling systems, concurrent engineering and design for manufacture, continuous flow manufacturing systems design, distributed manufacturing concepts, information infrastructure.

Raghavachari, M.—Ph.D. (University of California at Berkeley); statistical inference, quality control, multivariate methods, scheduling problems.

Sullo, P.—Ph.D. (Florida State University); reliability, life testing, statistical quality control, quality management, biostatistics, industrial statistics.

Tien, J.—NAE, Ph.D. (Massachusetts Institute of Technology); systems modeling, queuing theory, public policy and decision analysis, computer performance evaluation, and information and decision support systems, expert systems, computational cybernetics.

Wilkinson, J.—Ph.D. (University of North Carolina); regression modeling, statistical analysis.

Undergraduate Programs

Objectives of the Undergraduate Curriculum

While certain objectives of an undergraduate education in engineering are common to all disciplines, there are subtle but important differences ensuring that all graduates have specialized technical knowledge in their chosen field. Three to five years after graduation, graduates of Rensselaer’s bachelor’s program in Industrial and Management Engineering will:

• pursue professional positions in industry and/or graduate study programs in their areas of interest.
• contribute to the body of knowledge in their professional discipline through problem-solving, discovery, leadership, and responsible application of technology.
• continue to develop both professionally and personally through activities such as participation in professional societies, continuing education, and community service.

The Industrial and Management Engineering degree program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.
Baccalaureate Program

The ISE department offers an undergraduate curriculum in Industrial and Management Engineering (IME). The first two years of this curriculum provide a strong foundation in basic science, engineering science, mathematics, and the humanities, arts, and social sciences. These two years are oriented toward the quantitative (mathematical) approach. Computer-based technology, including simulation, computational modeling, and systems design, is emphasized. In the last two years of the program, students concentrate on building expertise in statistics, operations research, manufacturing and services engineering, and industrial engineering methods and models. Through the appropriate choice of electives, students can focus on their selected areas of interest. Design projects include problems in manufacturing, services, and public systems. It is advisable to develop a Plan of Study leading to the desired degree and concentration by the beginning of the third year. The department recommends that students declare their intent to major in Industrial and Management Engineering as early as possible in their academic career. Students are also urged to work closely with their assigned faculty advisers to ensure that all degree requirements are satisfied.

This curriculum requires a minimum of 128 credit hours and completion of the course requirements shown in the typical four-year program presented in the Programs section of this catalog.

FIRST YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1100 Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1100 Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1300 Engineering Processes1</td>
<td>1</td>
</tr>
<tr>
<td>MATH 1010 Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
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</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 1200 Engineering Graphics and CAD1</td>
<td>1</td>
</tr>
<tr>
<td>MATH 1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1100 Physics I</td>
<td>4</td>
</tr>
<tr>
<td>Computer Science Elective2</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
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SECOND YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ENGR 2050 Introduction to Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2400 Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1200 Physics II</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 2600 Modeling and Analysis of Uncertainty</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 2210 Production and Operations Management and Cost Accounting</td>
<td>4</td>
</tr>
<tr>
<td>Technical Elective3</td>
<td>3-4</td>
</tr>
<tr>
<td>Management Elective4</td>
<td>4</td>
</tr>
</tbody>
</table>

1 For these two courses, order does not matter. ENGR 1300 may be replaced with ISYE 1100-Introduction to Industrial and Systems Engineering. ENGR 1200 may be replaced with ENGR 1400-Engineering Communications.

2 IME majors must take CSCI 1010 Introduction to Computer Programming or CSCI 1100 Computer Science I for the Computer Science Elective.

3 IME majors must select six courses from the following list of technical electives. The selected courses must include a minimum of four ISYE numbered courses and at least two courses from among: ISYE 4200, ISYE 4230, ISYE 4240, ISYE 4250 and ISYE 4280:

- ENGR 1600 Materials Science for Engineers
- ENGR 2090 Engineering Dynamics
- ENGR 2250 Thermal and Fluids Engineering I
- ENGR 2350 Embedded Control
- ENGR 2530 Strength of Materials
- ENGR 2710 General Manufacturing Processes
- ENGR 4270 Electronics Instrumentation
- ENGR 4710 Advanced Manufacturing Laboratory I
- ENGR 4720 Advanced Manufacturing Laboratory II
- ISYE 4200 Design and Analysis of Work Systems
- ISYE 4230 Quality Control
- ISYE 4240 Engineering Project Management
- ISYE 4250 Facilities Design & Industrial Logistics
- ISYE 4280 Decision Focused Systems Engineering
- Other approved technical elective options:
- ISYE 4220 Optimization Algorithms and Applications
- ISYE 4260 Human Performance Modeling and Support
- ISYE 4760 Mathematical Statistics
- ISYE 4940 Computational Intelligence
- ISYE 4950 Complex Systems Modeling for Industrial and Systems Engineering

Special undergraduate sections or regular graduate sections of 6000 level ISYE courses can also serve as technical electives except for ISYE 6600, ISYE 6610 and ISYE 6620.

4 IME majors may select any one of the following courses to satisfy the management elective requirement:

- ECON 2010 Managerial Economics
- ECON 4270 Cost Benefit Analysis
- MGMT 1100 Introduction to Management
- MGMT 2320 Managerial Finance
- MGMT 4510 Invention, Innovation, & Entrepreneurship
- MGMT 4520 Technological Entrepreneurship
- MGMT 4530 Starting Up a New Venture
- MGMT 4850 Managing the High Perf. Org I
- MGMT 4860 Managing the High Perf. Org II

- ISYE 4930 Ethics of Modeling for Industrial and Systems Engineering
- ISYE 4931 Ethics of Modeling for Industrial and Systems Engineering

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### THIRD YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISYE 4140 Statistical Analysis</td>
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<tr>
<td>ISYE 4600 Operations Research</td>
<td>4</td>
</tr>
<tr>
<td>Technical Elective&lt;sup&gt;3&lt;/sup&gt;</td>
<td>3</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Professional Development II</td>
<td>2</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISYE 4290 Discrete Event Simulation Modeling and Analysis</td>
<td>4</td>
</tr>
<tr>
<td>Technical Elective&lt;sup&gt;3&lt;/sup&gt;</td>
<td>3</td>
</tr>
<tr>
<td>Technical Elective&lt;sup&gt;3&lt;/sup&gt;</td>
<td>3</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
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</table>

### FOURTH YEAR

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>ENGR 4760 Engineering Economics</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4530 Information Systems</td>
<td>4</td>
</tr>
<tr>
<td>Technical Elective&lt;sup&gt;3&lt;/sup&gt;</td>
<td>3</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 4010 Professional Development III&lt;sup&gt;6&lt;/sup&gt;</td>
<td>1</td>
</tr>
<tr>
<td>ISYE 4210 Design and Analysis of Supply Chains</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4270 Industrial and Management Engineering Design&lt;sup&gt;6&lt;/sup&gt;</td>
<td>3</td>
</tr>
<tr>
<td>Free Elective Credit</td>
<td>4</td>
</tr>
<tr>
<td>Technical Elective&lt;sup&gt;3&lt;/sup&gt;</td>
<td>3</td>
</tr>
</tbody>
</table>

**Electives**

The free electives indicated above may be chosen from any academic discipline to broaden the student’s educational background and/or develop greater depth in a selected discipline.

**Humanities, Arts, and Social Sciences Electives**

The electives in this area are based on the Institute and School of Engineering requirements. Students are urged to elect humanities, arts, and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities, Arts, and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

**Industrial and Management Engineering Senior Portfolio**

A recommended practice for engineers and others who use creativity and inventiveness to solve problems or create a design or artifact is maintaining a portfolio of their work. Students enrolled in Rensselaer’s bachelor of science program in Industrial and Management Engineering are required to submit a professional portfolio prior to graduation. The portfolio is a collection of the student’s work representing examples of the professional skills and corroborating achievement of specific educational outcomes gained through the undergraduate program. Upon declaring Industrial and Management Engineering as the undergraduate major, students should contact the Undergraduate Program Director to obtain materials and instructions for assembling the senior portfolio.

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<sup>3</sup> IME majors must select six courses from the following list of technical electives. The selected courses must include a minimum of four ISYE numbered courses and at least two courses from among: ISYE 4200, ISYE 4230, ISYE 4240, ISYE 4250 and ISYE 4280:

- ENGR 1600 Materials Science for Engineers
- ENGR 2090 Engineering Dynamics
- ENGR 2250 Thermal and Fluids Engineering I
- ENGR 2350 Embedded Control
- ENGR 2530 Strength of Materials
- ENGR 2710 General Manufacturing Processes
- ENGR 2820 Electronic Instrumentation
- ENGR 4210 Design and Analysis of Work Systems
- ISYE 4200 Design and Analysis of Work Systems
- ISYE 4230 Quality Control
- ISYE 4240 Engineering Project Management
- ISYE 4250 Facilities Design & Industrial Logistics
- ISYE 4710 Advanced Manufacturing Laboratory I
- ISYE 4720 Advanced Manufacturing Laboratory II
- ISYE 4750 Mathematical Statistics
- ISYE 4810 Computational Intelligence
- ISYE 4930 Complex Systems Modeling for Industrial and Systems Engineering
- ISYE 4931 Ethics of Modeling for Industrial and Systems Engineering
- ISYE 4933 Systems Engineering

**Other approved technical elective options:**

- ISYE 4220 Optimization Algorithms and Applications
- ISYE 4260 Human Performance Modeling and Support
- ISYE 4760 Mathematical Statistics
- ISYE 4880 Computational Intelligence
- ISYE 4930 Complex Systems Modeling for Industrial and Systems Engineering
- ISYE 4931 Ethics of Modeling for Industrial and Systems Engineering

<sup>5</sup> This course can be fulfilled by taking a two-credit course from a list of courses published at the start of each semester.

<sup>6</sup> May be taken in either fall or spring semester.
Special Undergraduate Opportunities

Cooperative Education Program
The department encourages this option, which allows students to gain professional experience as part of the educational program. Additional information on co-op opportunities is included in the Educational Programs and Resources section of this catalog, as well as through the faculty adviser or the Center for Career and Professional Development.

Graduate Programs

Master’s Programs
The Industrial and Systems Engineering Department offers the Master of Science and Master of Engineering degrees in Industrial and Management Engineering. Both degrees require a minimum of 30 credit hours. The Master of Science degree requires a thesis. The Master of Engineering degree is a non-thesis option. All applicants to the IME master’s programs must take the Graduate Record Exam (GRE).

Industrial and Management Engineering M.S./M.Eng.
The department offers the Master of Science and Master of Engineering degrees in Industrial and Management Engineering. Both degrees require a minimum of 30 credit hours. The Master of Science degree requires a thesis. The Master of Engineering degree is a non-thesis option. In general, all applicants to the IME master’s programs must take the Graduate Record Exam (GRE).

To complete the Master’s degree requirements, students must include a minimum of 24 credits from the list of approved Industrial and Management Engineering courses for the master’s program. The courses selected may include the two required prerequisite courses listed below but must simultaneously define a adviser-approved, application-focused concentration area, (e.g., manufacturing logistics, optimization, complex systems modeling, etc.). A minimum of 50% of credit hours in the plan of study must be at the 6000 level or higher.

Program Requirements
Prerequisite requirements for the master’s programs include the following courses or their equivalents:

<table>
<thead>
<tr>
<th>Credit Hours</th>
<th>ISYE 4140 Statistical Analysis</th>
<th>ISYE 6610 Systems Modeling in Decision Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Approved Industrial and Information Systems Engineering Courses
The following courses may be included among the 24 credits of restricted electives:

|--------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
Doctoral Programs

The Industrial and Systems Engineering Department offers the Ph.D. in Decision Sciences and Engineering Systems. All applicants to the Ph.D. program must take the Graduate Record Exam (GRE). During the first year of residency, doctoral students are required to elect courses from the restricted list of approved doctoral courses which are subject to adviser and Doctoral Program Director approval. The approved list of courses can be found under the Ph.D. in Decision Sciences and Engineering program information.

Ph.D. Decision Sciences and Engineering Systems

The Industrial and Systems Engineering Department offers the Ph.D. in Decision Sciences and Engineering Systems. All applicants to the Ph.D. program must take the Graduate Record Exam (GRE). During the first year of residency, doctoral students are required to elect courses from the restricted list of approved doctoral courses shown below subject to adviser and Doctoral Program Director approval:

Approved Industrial and Information Systems Engineering Courses for the Doctoral Program:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISYE 4210</td>
<td>Design and Analysis of Supply Chains</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4220</td>
<td>Optimization Algorithms and Applications</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4230</td>
<td>Quality Control</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4250</td>
<td>Facilities Design and Industrial Logistics</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4260</td>
<td>Human Performance Modeling and Support</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4290</td>
<td>Discrete Event Simulation Modeling and Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 4300</td>
<td>Complex Systems Models for Industrial and Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4310</td>
<td>Ethics of Modeling for Industrial and System Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4760</td>
<td>Mathematical Statistics</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 4810</td>
<td>Computational Intelligence</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6010</td>
<td>Applied Regression Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6020</td>
<td>Design of Experiments</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6100</td>
<td>Time Series Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6140</td>
<td>Exploratory Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6180</td>
<td>Knowledge Discovery with Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6210</td>
<td>Theory of Production Scheduling</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6330</td>
<td>Decision Support and Expert Systems</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6760</td>
<td>Combinatorial Optimization and Integer Programming</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 6770</td>
<td>Linear Programming</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 6780</td>
<td>Nonlinear Programming</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 6820</td>
<td>Queuing Systems and Applications</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6870</td>
<td>Introduction to Neural Networks</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6960</td>
<td>Topics in ISYE</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6965</td>
<td>Agent Based Simulation Methods</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 696x</td>
<td>Stochastic Models of Supply Chain</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 696x</td>
<td>Group Decision Making and Cognition</td>
<td>3</td>
</tr>
</tbody>
</table>

Additional Information

First year doctoral students must also take the three-credit course, ISYE 6900 Seminar in Industrial and Systems Engineering Research, through which they are introduced to the research environment, identify the prospective research adviser, and prepare a proposal for dissertation research. These proposals are reviewed by the faculty as part of the doctoral qualifying requirements. Additional doctoral program requirements include:

- Doctoral candidacy examination: Each student must take an oral candidacy examination after meeting doctoral qualifying requirements but before completing 45 credit hours of graduate work beyond the master’s degree. This examination tests the candidate’s background for the proposed research, appropriateness of the thesis research, and the ability of the candidate to successfully complete the research. The thesis research proposal must contain at least one result that meets journal publishing standards.

- Doctoral dissertation and defense: Each student must write a doctoral thesis and give a formal oral public defense.

Apart from the seminar in ISYE research and the first year course requirements, there are no additional course requirements for the doctoral degree. However, the student is expected to develop in-depth knowledge in his/her dissertation area through appropriate coursework, as well as supervised research. A Plan of Study is required, which must be approved by the thesis adviser and the ISYE doctoral program director.

Course Descriptions

Courses directly related to all Industrial and Systems Engineering curricula are described in the Course Description section of this catalog under the department code ISYE.
Materials Science and Engineering

Department Head: Robert Hull
Undergraduate Advising: Daniel Gall
Graduate Recruiting: Pawel Keblinski
Graduate Advising: Minoru Tomozawa
Department Home Page: http://mse.rpi.edu/

Progress in modern technology is often limited by the availability of suitable solid materials. The materials engineer must produce materials to meet the demands of the designers of jet engines and rocket boosters, microelectronic devices, optical components, medical prostheses, and many other products.

The principles that govern the processing and structure of materials to produce optimum mechanical and physical properties and performance are embodied in the materials engineering curriculum. The program is designed to produce engineers and scientists whose degrees represent useful specialization coupled with a broad background in all classes of materials.

Undergraduate students wishing to extend their education can undertake specialized study in a range of fields. These include ceramics, polymers, composites, nanostructured materials, high-temperature alloys, solidification, corrosion, deformation processing, welding, high-strength high-modulus materials, biomaterials, electronic materials, surface and molecular kinetics, glass science, and the origin of mechanical and physical properties in many different types of materials. Graduate students, in addition to pursuing classroom courses, conduct research in a variety of areas described below and write their theses based on this research. Extensive laboratories containing modern and sophisticated equipment are available.

For the student who likes to innovate and who wants to apply knowledge to the real problems of a modern technological society, materials science and engineering provides a broad range of exciting opportunities.

Research and Innovation Initiatives

Materials Processing
Major research programs include fundamental studies of the solidification process and the effect of solidification under reduced gravity on the formation of dendritic structures, and practically oriented programs in the extrusion processing of aluminum alloys. In the latter program, studies of the complex interactions among stress, strain rate, and temperature during forming processes have made it possible to apply advanced software models to the control of metalworking operations. Studies of powder processing have made possible the extrusion processing of composite materials, while research on joining processes has led to synergistic coupling of adhesive bonding and spot welding technology in automotive sheet metal fabrication. Broad efforts focused on the synthesis, processing, and properties of nanostructured materials are expanding the capabilities of materials engineering and nanotechnology into additional areas including ceramics, metals, polymers, composites, and biomaterials. Novel applications of carbon nanotubes for device and chemical applications are under investigation, along with chemical, electrical, and mechanical isolation engineering using nanocomposites.

Materials for Microelectronic Systems
This research spans multiple fields including the development of epitaxial semiconductor materials for new electronic applications, exploration of new semiconductor nanostructural architectures for new nanoelectronic device concepts, development of new methods for material characterization and fabrication at the nanoscale, and materials problems associated with the interconnections between integrated circuit elements. Included are the growth of thin films of metals, semiconductors, polymeric and ceramic materials, advances in the patterning and etching processes necessary for the fabrication of multilayer devices, and the application of state-of-the-art ion and electron beam lithography and microscopy methods.

Glasses and Ceramics
Research efforts focus on factors influencing the useful lifetime of glass components and the effect of environments, especially aqueous environments, on glass failure. In addition to the conventional applications such as windows and bottles, glasses are used as optical components such as optical communication fibers. Specifically, variation of the glass surface structure with time and its influence on glass properties are under investigation. Another emphasis is the development of nonoxide glasses, primarily those based on fluorides, as the transmitting medium in optical fibers for communications purposes.

Nanocomposite Materials
Composite materials are made up of at least two distinct materials that when combined yield superior properties compared to the starting materials. Traditional examples of composite materials are carbon fiber reinforced polymers, glass fiber reinforced polymers, metal matrix composites, engineered woods, etc. Nanocomposite materials are those in which one of the components has nanoscale dimensions. For
example, carbon nanotubes, organoclay sheets (organically modified clay), silica nanoparticles, graphene (individual graphite layers), etc. When nanoscale materials are combined with, for example, polymers, the resulting material provides improvements and control over multiple properties such as electrical, optical, thermal, thermo-mechanical, mechanical, environmental, etc. Research at Rensselaer spans all types of nanoscale materials and their nanocomposites mainly with polymeric materials. Examples include silica, alumina, titania, zinc oxide, organoclay, graphene, single and multi walled carbon nanotube filled polymers.

**Computational Materials Science**

A number of MSE faculty focus on computational materials science and have expertise ranging from electronic structure calculation via classical molecular dynamics methods and mesoscale-level techniques, to continuum-level analysis and calculations. The main goal of the computational and theoretical research is to provide a framework for understanding the detailed role of individual parameters such as microstructural size, surface structure and chemistry, nature of defects and their distribution in material synthesis, processing and properties. Specific research areas include mass and heat transport, phase diagram and phase change modeling, chemical and thermal processes in energy materials, and ceramic and metallic glasses.

**Nanomaterials**

Nanostructured materials are being widely studied by faculty, postdoctoral, and student researchers in the Materials Science and Engineering Department at Rensselaer. For example, polymer nanocomposites containing inorganic nanoparticles or carbon nanotubes are being made that have potential applications that combine novel electrical, optical, or mechanical responses. Rensselaer’s Materials Science and Engineering investigators have put significant research effort into exploring the design of polymer nanocomposites with controlled dispersions of nanoparticle fillers and how these alter the various material properties of the host polymer. NSEC researchers in the department also investigate the conformation and activity of biopolymers (such as proteins) near (or adsorbed onto) highly curved nanoparticle surfaces and their effects on biological function as well as the ability to create new materials.

**Biomaterials**

The field of biomaterials focuses on understanding the interactions of materials with biological systems, particularly within the human body, and applying this understanding to advancing human health.

**Faculty *\**

**Professors**

**Duquette, D.J.**—Ph.D. (Massachusetts Institute of Technology); environmental and surface effects on the mechanical behavior of metals, corrosion, stress corrosion fatigue (John Tod Horton Distinguished Professor in Materials Engineering).

**Gall, D.**—Ph.D. (University of Illinois, Urbana-Champaign); thin film and nanostructure growth, electronic properties of materials, protective coatings, energy materials, electronic materials, single crystal layer deposition.

**Hull, R.**—Ph.D. (Oxford University); Nanoscaled materials, electronic materials, semiconductors, interfaces, crystalline defects, nanofabrication, materials characterization, electron microscopy, and focused ion beams (Henry Burlage Jr. Professor of Engineering and Department Head).

**Keblinski, P.**—Ph.D. (Pennsylvania State University); atomic-level computational modeling of interfacial processes; structure-property correlations; heat flow at nanoscale, polymer nanocomposites.

**Ramanath, G.**—Ph.D. (University of Illinois); thin film electronic materials; interconnects, diffusion barriers, low-k dielectrics; characterization of interfacial reactions, kinetics, and mechanisms of microstructure and phase evolution during deposition and annealing; processing self-organized structures for microelectronics applications.

**Schadler, L.S.**—Ph.D. (University of Pennsylvania); mechanical, electrical, and optical properties of polymer nanocomposites with an emphasis on designed interfaces to control macroscopic properties (Russell Sage Professor).

**Siegel, R.W.**—Ph.D. (University of Illinois); synthesis, processing, structure, and properties of functional nanostructured materials including metals, ceramics, and composites; biomaterials; atomic-scale defects and diffusion in materials (Robert W. Hunt Professor).

**Tomozawa, M.**—Ph.D. (University of Pennsylvania); electrical properties of glasses, X-ray and light scattering, phase separation, mechanical properties of glasses.

**Wright, R.N.**—Sc.D. (Massachusetts Institute of Technology); metal forming and fabrication, mechanical behavior of metals.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Associate Professors

Lewis, D.J.—Ph.D. (Lehigh University); solidification and diffusion in multicomponent solids, modeling of phase transformations, understanding long term degradation in fuel cells.

Ozisik, R.—Ph.D. (The University of Akron, Ohio); multiscale simulations of polymers and polymer nanocomposites, role of interface and confinement on the properties of nanocomposites, supercritical carbon dioxide assisted processing of polymers and polymer nanocomposites, polymeric foams.

Assistant Professors

Chen, Y.—Ph.D. (Massachusetts Institute of Technology); shape memory alloys, microstructure design, metallurgy, mesoscale modeling, mechanical properties, continuum simulations.

Huang, L.—Ph.D. (University of Illinois, Urbana-Champaign); computational and experimental techniques, oxide glasses and ceramics with superior properties, nanostructured materials for energy, environment and biology-related applications.

Shi, Y.—Ph.D. (University of Michigan, Ann Arbor); computational material science, molecular motors, nanoporous materials, energetic materials, metallic glasses, and metal-semiconductor interfaces.

Emeritus Faculty

Chung, C.I.—Ph.D. (Rutgers University); polymer processing, polymer melt theology, relaxation behavior in polymer solids.

Ficalora, P.J.—Ph.D. (Pennsylvania State University); kinetics and thermodynamics of heterogeneous reactions, chemisorption effects on electronic materials.

Hudson, J.B.—Ph.D. (Rensselaer Polytechnic Institute); adsorption on solid surfaces, structure and reactivity of solids, physics and chemistry of surfaces, nanocrystal growth.

MacCrone, R.J.—D.Phil. (University of Oxford); electric properties of polymers and oxides, polarons, electron paramagnetic resonance and magnetic behavior of glasses, phase transformations, nucleation, electrical properties of thin oxide and nitride films, one-dimensional conductivity.

Messler, R.W., Jr.—Ph.D. (Rensselaer Polytechnic Institute); materials in manufacturing, welding.

Moynihan, C.T.—Ph.D. (Princeton University); ionic transport in glass, infrared transmission in glasses and glass ceramics, thermodynamic properties of glasses.

Murarka, S.P.—Ph.D. (University of Minnesota); metallization for deep submicron silicon integrated circuits, low temperature and localized processes, thin dielectric films, diffusion and defects (Elaine S. and Jack S. Parker Chair in Engineering).

Steinbruchel, C.—Ph.D. (University of Minnesota); thin films, electronic materials, plasma processing, ion beam and ultra-high vacuum techniques.

Sternstein, S.S.—Ph.D. (Rensselaer Polytechnic Institute); high-performance composites; physical properties of polymers; rubber elasticity theory; fracture, yielding, and craze formation in glassy polymers and composites, viscoelastic properties; swelling in filled elastomers (William Weightman Walker Professor of Polymer Engineering).

Manager of Electron Microscopy Laboratories

Dove, R.

Manager of Materials Analysis Laboratories

Planty, R.

Technical Director

van Steele, D.
Undergraduate Programs

Objectives of the Undergraduate Curriculum

While certain objectives of an undergraduate education in engineering are common to all programs, there are subtle but important differences that require some subset of objectives specific to ensuring that all graduates have specialized technical knowledge in their chosen field.

Graduates of the materials engineering baccalaureate program who remain in their field, as graduate students or as professionals, will have, within a few years of their graduation:

- used their broad knowledge of all classes of materials, and their background in mathematics and science, to contribute effectively to the solution of engineering problems, including problems involving design.
- demonstrated expertise in understanding the interdependence of the structure, properties, processing, and performance of materials and have utilized the interdependence in their professional activities.
- demonstrated themselves capable of dealing with emerging engineering problems and their societal consequences.
- demonstrated themselves effective in working with multi-disciplinary teams and in communicating clearly and convincingly in a variety of contexts.
- demonstrated the capacity for continued future learning and have a desire to engage in such learning.


Baccalaureate Program

The sample curriculum shown below, which results in the B.S. degree in Materials Engineering, requires a minimum of 129 credit hours and completion of the required elective courses that follow.

**FIRST YEAR**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1100</td>
<td>Chemistry I .......................................................... 4</td>
</tr>
<tr>
<td>ENGR 1100</td>
<td>Introduction to Engineering Analysis ......................................... 4</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I ........................................................... 4</td>
</tr>
<tr>
<td>HASS Elective ........................................................ 4</td>
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</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 1300</td>
<td>Engineering Processes3, 4 ........................................... 4</td>
</tr>
<tr>
<td>ENGR 1600</td>
<td>Materials Science for Engineers3 ........................................... 4</td>
</tr>
<tr>
<td>MATH 1020</td>
<td>Calculus II........................................................... 4</td>
</tr>
<tr>
<td>PHYS 1100</td>
<td>Physics I ............................................................ 4</td>
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<tr>
<td>HASS Elective ........................................................ 4</td>
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</table>

**SECOND YEAR**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 1200</td>
<td>Engineering Graphics and CAD5 ........................................... 4</td>
</tr>
<tr>
<td>ENGR 2250</td>
<td>Thermal and Fluids Engineering I ........................................... 4</td>
</tr>
<tr>
<td>MATH 2400</td>
<td>Introduction to Differential Equations ........................................ 4</td>
</tr>
<tr>
<td>PHYS 1200</td>
<td>Physics II ........................................................... 4</td>
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<td>HASS Elective ........................................................ 4</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 1190</td>
<td>Beginning C Programming for Engineers ........................................... 4</td>
</tr>
<tr>
<td>ENGR 2050</td>
<td>Introduction to Engineering Design ........................................... 4</td>
</tr>
<tr>
<td>MTLE 2100</td>
<td>Structure of Engineering Materials ........................................... 4</td>
</tr>
<tr>
<td>Science Elective ...................................................... 4</td>
<td></td>
</tr>
<tr>
<td>HASS Elective ........................................................ 4</td>
<td></td>
</tr>
</tbody>
</table>

1 Students are encouraged to select a life science course, such as BIOL 1010.
2 This course can be taken in either semester.
3 May be replaced by MTLE 1200.
4 May be replaced by ENGR 1400.
### THIRD YEAR

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 2600</td>
<td>Modeling and Analysis of Uncertainty</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4100</td>
<td>Thermodynamics of Materials</td>
<td>4</td>
</tr>
<tr>
<td>MTLE 4200</td>
<td>Properties of Engineering Materials I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Professional Dev. II</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Spring

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTLE 4150</td>
<td>Kinetics in Materials Systems</td>
<td>4</td>
</tr>
<tr>
<td>MTLE 4250</td>
<td>Properties of Engineering Materials II</td>
<td>4</td>
</tr>
<tr>
<td>MTLE 4910</td>
<td>Materials Selection</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Restricted Elective</td>
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</table>

### FOURTH YEAR

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ENGR 4010</td>
<td>Professional Development III</td>
<td>1</td>
</tr>
<tr>
<td>MTLE 4400</td>
<td>Materials Synthesis and Processing I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Materials Selective I</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Free Elective I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Free Elective II</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Spring

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTLE 4450</td>
<td>Materials Synthesis and Processing II</td>
<td>4</td>
</tr>
<tr>
<td>MTLE 4920</td>
<td>Design and Applications of Materials</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Materials Selective II</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Free Elective II</td>
<td>4</td>
</tr>
</tbody>
</table>

**Electives**

The following is a list of courses from which the electives indicated above may be selected. The courses in the Materials Electives list may be substituted with any MTLE 4000- or 6000-level course. In order to take a 6000-level course, students may be required to obtain formal approval from the Office of Graduate Education, as specified in the course catalog. The free electives must total at least 12 credits.

**Restricted Elective Options**

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 2010</td>
<td>Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2090</td>
<td>Engineering Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2300</td>
<td>Electronic Instrumentation</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2350</td>
<td>Embedded Control</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2530</td>
<td>Strength of Materials</td>
<td>4</td>
</tr>
</tbody>
</table>

**Materials Electives**

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTLE 4030</td>
<td>Glass Science</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4050</td>
<td>Introduction to Polymers</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4160</td>
<td>Semiconducting Materials</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4310</td>
<td>Corrosion</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4420</td>
<td>Joining of Advanced Materials</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4960</td>
<td>Topics in Materials Engineering</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4961</td>
<td>Materials for Energy</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4961</td>
<td>Thin Films</td>
<td>3</td>
</tr>
</tbody>
</table>

**Materials Science and Engineering Minor**

Students not majoring in materials science and engineering may receive a minor in this discipline by completing 15 credit hours of department courses with a MTLE designation. As general preparation for these courses, students should have taken ENGR 1600 Materials Science for Engineers.

A list of suggested courses is given below. These are only suggestions, and courses can be chosen according to interest and scheduling. It is possible to take some courses out of sequence if the student is willing to put in the appropriate effort. Note, however, that some courses in the Department of Materials Science and Engineering are offered once a year, whereas others are offered only every other year.

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2 This course will be fulfilled from a list published at the start of each semester.

3 This course can be taken in either semester.
An excellent program for a Minor in Materials Science and Engineering, giving students a solid foundation, would be to take Structure of Engineering Materials (MTLE 2100), plus any two of the four-credit courses: Thermodynamics of Materials (MTLE 4100), Kinetics in Materials Science (MTLE 4150), Properties of Engineering Materials I (MTLE 4200), Properties of Engineering Materials II (MTLE 4250), plus one four-credit materials elective.

**Graduate Programs**
The Department of Materials Science and Engineering offers programs leading to the M.S., M.Eng., and Ph.D. degrees.

**Master's Programs**
Both the M.S. and M. Eng. degrees require completion of a minimum of 30 credit hours. The M.S. degree requires a written thesis as well as an oral presentation to the scientific community. A three-credit capstone independent study project is required for the M. Eng. degree.

**Master of Science**
For the M.S. degree, students must complete at least 24 credits of course work and six credits of research work leading to an M.S. thesis.

The program must include 18 credits from the five core graduate courses Advanced Mechanical Properties (4 credits), Advanced Thermodynamics (4 credits), Advanced Electronic Properties (3 credits), Advanced Structure of Materials (4 credits), and Advanced Kinetics of Materials Reactions (3 credits). The program must also include two three-credit elective, graduate-level (6000-level) courses in the School of Engineering or the School of Science, and six M.S. thesis research credits.

Before graduating, the student is required to complete a written thesis as well as an oral presentation to the scientific community conveying important aspect of the thesis. Examples of such a presentation include an oral talk at a workshop or conference or a seminar at RPI.

**Master of Engineering**
For the M.Eng. degree, students must complete at least 27 credits of course work and three credits for an independent study capstone project.

The program must include 18 credits from the five core graduate courses Advanced Electronic Properties (3 credits), Advanced Mechanical Properties (4 credits), Advanced Thermodynamics (4 credits), Advanced Structure of Materials (4 credits), and Advanced Kinetics of Materials Reactions (3 credits). The program must also include at least six additional credits from two graduate level (6000-level) courses in the School of Engineering or the School of Science.

**Doctoral Program**
The Ph.D. degree requires completion of 72 credit hours. Students must complete at least 27 credits of course work, the remainder being credits for research work leading to a Ph.D. thesis. The program must include 18 credits from the five core graduate courses (Advanced Mechanical Properties (4 credits), Advanced Thermodynamics (4 credits), Advanced Electronic Properties (3 credits), Advanced Structure of Materials (4 credits), and Advanced Kinetics of Materials Reactions (3 credits)). The first three courses are offered each fall semester, and the latter two courses each spring semester. The program must also include at least nine additional credits from three graduate level (6000-level) courses in the School of Engineering or the School of Science. The student must pass an oral preliminary examination covering the five core subjects, an oral candidacy examination, as well as the final examination on the Ph.D. thesis.

**Course Descriptions**
Courses directly related to the Materials Engineering curricula are described in the Course Descriptions section of this catalog primarily under the department code MTLE.
Mechanical, Aerospace, and Nuclear Engineering

**Department Head:** Suvarnu De

**Department Home Page:** [http://mane.rpi.edu/](http://mane.rpi.edu/)

Mechanical engineers are engaged in a wide range of activities. At one end of the spectrum, they are concerned with fundamental engineering science, especially energetics and mechanics. At the other end, they are involved with the hardware of various technologies—the design and manufacture of mechanical components and systems. Aerospace engineering is concerned with disciplines and technologies that pertain not only to aircraft and spacecraft, but to other vehicular systems such as submarines and hydrofoils as well. Nuclear engineering focuses on the methods, devices, and systems required for the peaceful use of nuclear technology.

**Research and Innovation Initiatives**

Opportunities for research and innovation are delineated below. Opportunities may be theoretical, computational, and/or experimental. The Flexible Manufacturing Center, the Center for Multiphase Research, the Multiscale Science and Engineering Center, the New York State Center for Automation Technologies, the Scientific Computation Research Center, and the Center for Integrated Electronics offer additional research opportunities for the department’s undergraduate and graduate students and their faculty advisers.

**Aeronautics**

Research is conducted into the performance of fixed wing aircraft, rotorcraft, and space vehicles, as well as micro-vehicles. The research is supported by fundamental studies in aerodynamics, advanced propulsion concepts, vehicle dynamics, and design optimization. Facilities include the fluid dynamics laboratory and the structures and controls laboratory.

**Applied Mechanics/Mechanics of Materials**

Applied Mechanics refers to the theoretical foundations of mechanical engineering. Basic research is being performed on diverse topics such as acoustics, fatigue and fracture processes, nonlinear vibrations, and plasticity. Materials of the latest technologies such as composites, microelectronic materials, and carbon nanotubes are studied from the mechanical perspective. The finite element method is a computational approach in modeling material behavior.

Facilities include the mechanics of materials laboratory, the laboratory for noise control research, and the mechanical systems laboratory.

**Energy Systems/Multiphase Phenomena and Heat Transfer**

Studies are related to energy conversion and the development of mechanical power, convective heat transfer and freezing, electronic cooling, fouling, heat transfer augmentation, mass transfer, computational fluid dynamics and multidimensional effects in multiphase flow, and heat transfer with applications in nuclear, mechanical, thermal, chemical, biomedical and pharmaceutical systems, development of mechanistic models, and computer simulation capabilities.

Mechanical and Nuclear Engineering are both concerned with energy conversion and the development of mechanical power. Issues of heat transfer are important, from a range of large-scale industrial processes, down to the cooling of electronic micro-components with extreme power density. Thermal and fluid flow properties are studied by theoretical and computational means (computational fluid dynamics). Multiphase processes are important in problems from drug delivery optimization to nuclear power cooling systems.

Facilities include the gas turbine laboratory; the energy systems laboratory; subsonic and transonic wind tunnels; the heat transfer laboratory; and the laboratory for fouling research. Additional equipment includes various two-phase flow loops and associated instrumentation, particle image velocimetry, optical void probes, and the resources of the Center for Multiphase Research.

**Environmental Health Physics and Radiation Dosimetry**

Research in this area has diverse applications: the assessment of environmental radioactivity for the nuclear industry; investigations of health physics practices in hospitals; analysis of worker effective doses from external and internal exposures; and optimization of radiation therapy doses in biomedical applications. These problems are studied theoretically by Monte Carlo methods, among several techniques. Facilities include a versatile health physics laboratory and modern nuclear radiation detection and characterization systems.

**Manufacturing/Design**

Studies revolve around design methodology in general and mechanical engineering design techniques in particular. There are applications in machinery and mechanical systems design, the development of new manufacturing techniques, and operation of manufacturing facilities. Areas of concentration include CAD/CAM, diagnostics and controls, tribology, metrology rapid prototyping, robotics and flexible manufacturing, and system integration. Facilities include the advanced manufacturing laboratory, the design optimization laboratory, and the mechanisms laboratory.
Nuclear Science and Technology
Research involves a wide spectrum of issues crucial to the nuclear industries. Investigations are ongoing into the interaction of neutrons and other radiation with materials used in nuclear reactors; nuclear data analysis and evaluation; radiation transport studies; conceptual designs of fusion power systems and their engineering, safety, and environmental implications; plasma wall interactions; analysis of reactor accidents and safety studies. Facilities include a versatile 100-Mev electron linear accelerator, time-of-flight and associated instrumentation, a critical reactor facility, a three-dimensional laser Doppler anemometer, and miscellaneous nuclear radiation equipment and computational aids.

Space Technology
Research areas include analysis, design, development, and operations required for space exploration and utilization. Research is ongoing in advanced energetics (laser propulsion), structural dynamics and optimization, and crystal growth in space. Facilities include various wind tunnels and crystal growth laboratories.

Faculty *

Professors

Amitay, M.—D.Sc. (Technion-Israel Institute of Technology); aerodynamic flow control, mini- and micro-aerial vehicles, wind turbine performance enhancement, two-phase flows.

Anderson, K.S.—Ph.D. (Stanford University); multibody dynamics, advanced algorithm development, parallel computing, molecular dynamics (Associate Dean, Undergraduate Studies).

Blanchet, T.A.—Ph.D. (Dartmouth College); tribology, solid lubrication, surface science, contact mechanics.

Danon, Y.—Ph.D. (Rensselaer Polytechnic Institute); nuclear data and instrumentation, accelerator technology and radiation applications, nondestructive testing, novel radiation source and detectors.

De, S.—Sc.D. (Massachusetts Institute of Technology); numerical methods in engineering, haptics and virtual reality, multiscale modeling, computational biomechanics, soft tissue biomechanics (Department Head).

Drew, D.A.—Ph.D. (Rensselaer Polytechnic Institute); applied mathematics, fluid mechanics (joint appointment, Mathematics home department).

Gandhi, F.—Ph.D. (University of Maryland at College Park); helicopter dynamics and aeroelasticity, advanced configuration design, rotor active control and rotor morphing, smart materials and structures for structural vibration reduction and damping augmentation, cellular and variable stiffness structures; (Rosalind and John J. Redfern Jr. ’33 Professor of Engineering).

Hirsa, A.—Ph.D. (University of Michigan); fluid mechanics, experimental gas dynamics (jointly with the Chemical and Biological Engineering Department).

Hajela, P.—Ph.D. (Stanford University); optimum design, structural dynamics, aeroelasticity (Vice Provost for Administration, Dean of Undergraduate Education; Provost).

Jensen, M.K.—PE., Ph.D. (Iowa State University); heat transfer, fluid mechanics, heat exchangers, boiling and two-phase flows, enhanced heat transfer, fuel cells, solar energy, sustainability.

Koratkar, N.A.—Ph.D. (University of Maryland at College Park); smart materials and structures, rotorcraft, unsteady aerodynamics.

Malaviya, B.K.—Ph.D. (Harvard University); fission and fusion reactor physics and technology, biomedical applications, radioactive waste management, pedagogic technology (jointly with Engineering Science).

Maniatty, A.M.—Ph.D. (Cornell University); mechanics of materials, computational mechanics, continuum mechanics, polycrystalline materials.

Oberai, A.—Ph.D. (Stanford University); multiscale modeling, turbulence modeling and simulation, computational biomechanics, inverse problems, biomedical imaging.

Peles, Y.—Ph.D. (Technion-Israel Institute of Technology); MEMS fabrication, design and device testing, design and manufacturing of electronic packaging (Associate Head for Graduate Studies).

Picu, C.R.—Ph.D. (Dartmouth College); mechanics of solids, micro- and nano-mechanics of crystalline defects, atomistic simulations.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Podowski, M.Z.—Ph.D. (Warsaw University of Technology); two-phase flow and heat transfer, reactor dynamics and safety, system stability, applied mathematics.

Rusak, Z.—D.Sc. (Technion-Israel Institute of Technology); theoretical and computational fluid dynamics, aerodynamics, and combustion dynamics; vortex stability and breakdown, compressible flows, viscous flows, and reacting flows.

Smith, R.N.—Ph.D. (University of California, Berkeley); thermal-fluid and energy systems.

Shephard, M.S.—Ph.D. (Cornell University); finite element analysis, computer graphics, computer-aided design (jointly with the Civil Engineering Department; Samuel A. Johnson’37 and Elizabeth C. Johnson Professor of Engineering).

Tichy, J.A.—Ph.D. (University of Michigan); tribology, non-Newtonian fluid mechanics, rheology.

Walczyk, D.F.—PE., Ph.D. (Massachusetts Institute of Technology); rapid tooling, environmentally conscious design, machine design.

Wen, J.T.—Ph.D. (Rensselaer Polytechnic Institute); modeling and control of dynamical systems with applications to precision motion, robot manipulation, adaptive optics, distributed coordination and control, and thermal management (joint appointment, home department Electrical, Computer and Systems Engineering).

Xu, G.X.—Ph.D. (Texas A&M University); environmental health physics, health and medical physics, Monte Carlo simulations, anatomical modeling, biomedical use of radiation (jointly with the Biomedical Engineering Department, Program Head, Nuclear Engineering).

Professors of Practice

Sreepada, S.—Ph.D. (Columbia University); nuclear thermal-hydraulics, nuclear fuel design, reactor safety, energy conversion.

Steiner, M.W.—Ph.D. (Rensselaer Polytechnic Institute); multidisciplinary design, product architecture, advanced design methods.

Associate Professors

Borca-Tasciuc, D.—Ph.D. (University of California, Los Angeles); MEMS, NEMS, microfluidics, heat transfer in nanosystems.

Borca-Tasciuc, T.—Ph.D. (University of California, Los Angeles); heat transfer and energy conversion, nanotechnology, MEMS.

Embrechts, M.J.—Ph.D. (Virginia Polytechnic Institute); fusion engineering, applied chaos theory, neural networks (joint appointment, Decision Sciences and Engineering Systems home department).

Lian, J.—Ph.D. (University of Michigan); radiation effects, advanced nuclear materials, ion beam technique, nano-scale characterization and nanofabrication.

Oehlschlaeger, M.—Ph.D. (Stanford University); combustion, propulsion and energy systems, optical diagnostics.

Scarton, H.A.—Ph.D. (Carnegie Mellon University); biomechanics, acoustics, non-destructive testing, dynamics, vibrations, ultrasonic communication, fluid and solid mechanics, sensors, noise control, wave phenomena, MEMS devices, acoustic emission, fluid-solid interaction, experimental methods, dynamic hardness, laser propulsion, design and invention.

Zhang, L.—Ph.D. (Northwestern University); numerical modeling, computational fluid dynamics, fluid-structure interactions, biomechanics.

Assistant Professors

Bevilacqua, R.—Ph.D. (University Sapienza, Rome, Italy); guidance, navigation, and control of space systems and multi-spacecraft systems, rendezvous, docking, autonomous assembly, responsive space, optimization of spacecraft relative trajectories, differential drag control, on-the-ground hardware-in-the-loop testbeds, real-time systems.

Chung, A.—Ph.D. (Cornell University); fluid mechanics, optofluidics, inertial microfluidics, biomicrofluidics, nanobiotechnology, miniaturized systems for basic biology, medical diagnostics, and cellular engineering.

Hicken, J.—Ph.D. (University of Toronto); simulation-based design, optimization, aerodynamics, computational fluid dynamics, shape optimization.

Ji, W.—Ph.D (University of Michigan); nuclear reactor core analysis, computational methodology development in radiation transport, Monte Carlo modeling, simulation in stochastic media.
Liu, L.—Ph.D. (Massachusetts Institute of Technology); neutron scattering, dynamics of water, structure and dynamics of nano-materials and macro-molecules, radiation damage.

Mishra, S.—Ph.D. (University of California, Berkeley); Dynamic Systems and Control, Modeling and Control of Micro/Nano-scale Manufacturing Processes, Data-driven Control System Design, Smart Building Systems.

Sahni, O.—Ph.D. (Rensselaer Polytechnic Institute); fluid mechanics, computational fluid dynamics, turbulence simulations, computational mechanics, high-performance and parallel computing.

Samuel, J.—Ph.D. (University of Illinois at Urbana Champaign); micro/nano-scale manufacturing, design of advanced materials for manufacturing, bio-medical manufacturing and green manufacturing.

Sotoudeh, Z.—Ph.D. (Georgia Tech); Aeroelasticity, Vibration, Dynamics, Helicopter Dynamics, Computational Structural Dynamics (CSD).

Senior Lecturer
Swersey, B.L.—B.S. (Cornell University); creativity in design, design methodology.

Lecturers
Caracappa, P.—Ph.D. (Rensselaer Polytechnic Institute); operational health physics, internal and external dosimetry, radiation detection.

Haley, T.—Ph.D. (Rensselaer Polytechnic Institute); nuclear fuel management, mathematical modeling, reactor design.

Hurst, J. L.—Ph.D. (Rensselaer Polytechnic Institute); control, dynamics, optimization, mechatronics.

Leong, C. M.—Ph.D. (Rensselaer Polytechnic Institute); experimental fluid mechanics, biofluid mechanics, active flow control, wind energy, fluid-structure interactions, experimental techniques.

Morris, W. III—Ph.D. (Rensselaer Polytechnic Institute); aerodynamics, fluid dynamics, stall prediction, flow control, transitioning flow, CFD, computational fluid dynamics, aircraft design, stability and control, flight dynamics.

Zhou, W.—Ph.D. (University of California at Berkeley); nuclear waste management (risk and safety assessment), reservoir simulation, environmental system analysis, coupled processes in porous media.

Research Assistant Professors
Antal, S.—Ph.D. (Rensselaer Polytechnic Institute); computational fluid dynamics, numerical methods in multiphase flows, heat transfer.

Sankaranarayanan, G.—Ph.D. (University of Washington); haptics and virtual reality, telerobotics, surgical robotics, mechatronics, networked control systems.

Adjunct Faculty
Borton, D.N.—Ph.D. (Rensselaer Polytechnic Institute); solar energy.

Trumbull, T.H.—Ph.D. (Rensselaer Polytechnic Institute); research reactor experimental operations.

Emeritus Faculty
Bergles, A.E.—P.E., NAE, Ph.D. (Massachusetts Institute of Technology); heat transfer, two-phase flow.

Block, R.C.—Ph.D. (Duke University); nuclear structure and data, radiation effects in electronics, accelerator technology neutron reactions, real-time radiography, industrial applications of radiation, nondestructive testing.

Crespo da Silva, M.R.M.—Ph.D. (Stanford University); dynamics, nonlinear vibrations, perturbation methods, computerized symbolic manipulation.

Derby, S.J.—Ph.D. (Rensselaer Polytechnic Institute); automation, mechanisms, robotics, design.

Dvorak, G.J.—NAE, Ph.D. (Brown University); mechanics of solids, composite materials and structures, fracture and fatigue.
Ettles, C.M.—Ph.D. (Imperial College), D.Sc. (University of London); mechanical design, machine dynamics, tribology.

Hagerup, H.J.—Ph.D. (Princeton University); viscous flow.

Harris, D.R.—Ph.D. (Rensselaer Polytechnic Institute); reactor physics, fusion technology, shielding, reactor noise analysis.


Lahey, R.T., Jr.—NAE, Ph.D., (Stanford University); multiphase flow and boiling heat transfer, reactor safety analysis, reactor thermal-hydraulics, applications of chaos theory, sonofusion technology.

Lee, D.—Sc.D. (Massachusetts Institute of Technology); mechanics of materials, computer-aided manufacturing.

Sneck, H.J., Jr.—PE, Ph.D. (Rensselaer Polytechnic Institute); viscous-fluid mechanics, bearing lubrication and design.

Somerscales, E.F.C.—Ph.D. (Cornell University); heat transfer.

Steiner, D.—Ph.D. (Massachusetts Institute of Technology); nuclear fusion systems, plasma engineering, radiation effects on materials (Institute Professor of Nuclear Engineering).

Technical Support Staff

Brand, P. Kerdoun, A. Sikora, C.
DiGiulio, D. McDougall, R. Strock, M.
Gray, M. Mielke, W.R., Jr. Trumbull, T.

Undergraduate Programs

MANE Program Educational Objectives

The Mechanical, Aerospace, and Nuclear Engineering programs are each designed to prepare students for continued learning and successful careers in industry, government, academia, and consulting. While certain objectives of an undergraduate education in engineering are common to all programs, there are subtle but important differences that require some subset of objectives specific to ensuring that all graduates have specialized technical knowledge in their chosen field. Graduates of the programs within Mechanical, Aerospace, and Nuclear Engineering will be expected to:

• engage in professional practice at or beyond the entry level or enroll in high-quality graduate programs, applying their engineering knowledge, critical thinking, and problem solving skills.

• become leaders in engineering, science, academia, business, and public service.

• continue their intellectual development through participation in continuing education, professional development, and/or community service.

The Mechanical Engineering, Aeronautical Engineering, and Nuclear Engineering degree programs are each independently accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Baccalaureate Programs

Freshmen or sophomores who have identified mechanical, aerospace, or nuclear engineering as their major may follow the baccalaureate program below in lieu of the general core engineering program. Dual major programs which lead to a single baccalaureate degree embracing two fields are also available and are described in more detail in the department.
# Mechanical Engineering Curriculum

## First Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td>CHEM 1100</td>
<td>Chemistry I</td>
<td>4</td>
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<td></td>
<td>ENGR 1100</td>
<td>Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ENGR 1200</td>
<td>Engineering Graphics and CAD</td>
<td>1</td>
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<tr>
<td></td>
<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
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<td></td>
<td>HASS Elective</td>
<td></td>
<td>4</td>
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<tr>
<td><strong>Spring</strong></td>
<td>ENGR 1300</td>
<td>Engineering Processes</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ENGR 1600</td>
<td>Materials Science for Engineers</td>
<td>4</td>
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<tr>
<td></td>
<td>MATH 1100</td>
<td>Calculus II</td>
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<td></td>
<td>PHYS 1100</td>
<td>Physics I</td>
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<td></td>
<td>HASS Elective</td>
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## Second Year

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<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td><strong>Fall</strong></td>
<td>ENGR 2530</td>
<td>Strength of Materials</td>
<td>4</td>
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<tr>
<td></td>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
<td>4</td>
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<tr>
<td></td>
<td>PHYS 1200</td>
<td>Physics II</td>
<td>4</td>
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<td>HASS Elective</td>
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<td>4</td>
</tr>
<tr>
<td><strong>Spring</strong></td>
<td>CSCI 1190</td>
<td>Beginning C Programming for Engineers</td>
<td>1</td>
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<tr>
<td></td>
<td>ENGR 2050</td>
<td>Introduction to Engineering Design</td>
<td>4</td>
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<tr>
<td></td>
<td>ENGR 2090</td>
<td>Engineering Dynamics</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ENGR 2250</td>
<td>Thermal and Fluids Engineering I</td>
<td>4</td>
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<tr>
<td></td>
<td>MATH 2100</td>
<td>Multivariable Calculus and Matrix Algebra</td>
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## Third Year

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<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tr>
<td></td>
<td>ENGR 2300</td>
<td>Electronic Instrumentation</td>
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<td>ENGR 2350</td>
<td>Embedded Control</td>
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<tr>
<td></td>
<td>ENGR 2600</td>
<td>Modeling and Analysis of Uncertainty</td>
<td>3</td>
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<tr>
<td></td>
<td>MANE 4050</td>
<td>Modeling and Control of Dynamic Systems</td>
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<td></td>
<td>MANE 4030</td>
<td>Mechanical Design Core Module</td>
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<td>MANE 4040</td>
<td>Thermal and Fluids Core Module</td>
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<td></td>
<td>Professional Development II</td>
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## Fourth Year

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<th>Course Code</th>
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<tr>
<td></td>
<td>ENGR 4010</td>
<td>Professional Development III</td>
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<td></td>
<td>MANE 4260</td>
<td>Design of Mechanical Systems</td>
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<td>Technical Elective (Restricted)</td>
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<td>HASS Elective</td>
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<td>Free Elective</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Free Elective</td>
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</tbody>
</table>

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1. These required courses may be taken in any order.
2a. The Mechanical Design Core Module consists of MANE 4030, taken either before or concurrently with MANE 4040.
2b. The Thermal and Fluids Core Module consists of MANE 4010, taken either before or concurrently with MANE 4020.
3. This course will be fulfilled from a list published at the start of the semester. It must be completed before MANE 4260.
4. Course may be taken either semester.
5. Can be taken either semester senior year.
6. MATH 2100 and MATH 2400 may be taken in either semester of the second year.
Technical Electives

- The Technical Electives shall be comprised of three courses.
- Two of the three Technical Electives must be taken from any upper-level (4000 or above) MANE course.
- The third course may be selected from any upper-level (4000 or above) course in the School of Engineering or the School of Science. An independent study course, such as a design project or an undergraduate research project in the School of Engineering or the School of Science may also be used to satisfy this requirement.
- Technical Electives may not be taken on a Pass/No Credit basis.

Humanities, Arts, and Social Sciences Electives

In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities, arts, and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities, Arts, and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Dual Major Programs

Dual majors lead to a single baccalaureate degree embracing two fields. Special programs which can be completed in eight semesters have been developed. Examples include dual majors in Mechanical Engineering and Aerospace Engineering, Mechanical Engineering and Biomedical Engineering, Mechanical Engineering and Nuclear Engineering, Mechanical Engineering and Design, Innovation, and Society (STS), and others. Further information is available in the departmental office. Degree templates for Dual Majors offered by the MANE department may be found here: http://www.eng.rpi.edu/mane/undergraduate.cfm

AEROSPACE ENGINEERING CURRICULUM

FIRST YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CHEM 1100 Chemistry I</td>
<td>4</td>
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<tr>
<td>ENGR 1100 Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1200 Engineering Graphics and CAD¹</td>
<td>1</td>
</tr>
<tr>
<td>MATH 1010 Calculus I</td>
<td>4</td>
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<td>HASS Elective</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ENGR 1300 Engineering Processes¹</td>
<td>1</td>
</tr>
<tr>
<td>MANE 2060 Fundamentals of Flight</td>
<td>3</td>
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<tr>
<td>MATH 1020 Calculus II</td>
<td>4</td>
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<tr>
<td>PHYS 1100 Physics I</td>
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<td>HASS Elective</td>
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SECOND YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ENGR 2530 Strength of Materials</td>
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<tr>
<td>MATH 2400 Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1200 Physics II</td>
<td>4</td>
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<td>HASS Elective</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>CSCI 1190 Beginning C Programming for Engineers</td>
<td>1</td>
</tr>
<tr>
<td>ENGR 2050 Introduction to Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2090 Engineering Dynamics</td>
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<tr>
<td>ENGR 2250 Thermal and Fluids Engineering I</td>
<td>4</td>
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<tr>
<td>MATH 2010 Multivariable Calculus and Matrix Algebra</td>
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¹ These required courses may be taken in any order.
### THIRD YEAR

#### Fall
<table>
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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>MANE 4060</td>
<td>Aerospace Structures and Materials</td>
</tr>
<tr>
<td>MANE 4070</td>
<td>Aerodynamics I</td>
</tr>
<tr>
<td>MATH 4800</td>
<td>Numerical Computing, HASS Elective</td>
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</table>

#### Spring
<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ENGR 2600</td>
<td>Modeling and Analysis of Uncertainty</td>
</tr>
<tr>
<td>MANE 4050</td>
<td>Modeling and Control of Dynamic Systems</td>
</tr>
<tr>
<td>MANE 4900</td>
<td>Aeroelasticity and Structural Vibrations</td>
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<tr>
<td>MANE 4920</td>
<td>Aerospace Structures and Control Laboratory</td>
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<td>HASS Elective</td>
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### FOURTH YEAR

#### Fall
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 4010</td>
<td>Professional Development III</td>
</tr>
<tr>
<td>MANE 4080</td>
<td>Propulsion Systems</td>
</tr>
<tr>
<td>MANE 4800</td>
<td>Boundary Layers and Heat Transfer</td>
</tr>
<tr>
<td>MANE 4910</td>
<td>Flight Mechanics Elective, Professional Development II</td>
</tr>
</tbody>
</table>

#### Spring
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capstone Design Elective</td>
<td>3</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

Humanities, Arts, and Social Sciences Electives

In this area, the electives are based on the Institute and School of Engineering requirements for these electives. Students are urged to elect humanities, arts, and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities, Arts, and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Dual Major Programs

A dual major in Aerospace Engineering and Mechanical Engineering is available to students who follow a prescribed program that can be completed in eight semesters. General requirements and procedures for dual degrees are described within the Academic Information and Regulations section of this catalog. Degree templates for Dual Majors offered by the MANE department may be found here: [http://www.eng.rpi.edu/mane/undergraduate.cfm](http://www.eng.rpi.edu/mane/undergraduate.cfm).

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2 This course will be fulfilled from a list published at the start of each semester.
3 Can be taken either semester.
4 Choice of MANE 4090, MANE 4100, or MANE 4200.
5 Choice of MANE 4230, MANE 4850, or MANE 4860.
### Nuclear Engineering Curriculum

#### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHEM 1100</strong> Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td><strong>ENGR 1100</strong> Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td><strong>MATH 1010</strong> Calculus I</td>
<td>4</td>
</tr>
<tr>
<td><strong>MANE 1961</strong> Intro to Nuclear Engineering$^2$</td>
<td>1</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENGR 1200</strong> Engineering Graphics and CAD</td>
<td>1</td>
</tr>
<tr>
<td><strong>ENGR 1600</strong> Materials Science for Engineers</td>
<td>4</td>
</tr>
<tr>
<td><strong>MATH 1100</strong> Calculus II</td>
<td>4</td>
</tr>
<tr>
<td><strong>PHYS 1100</strong> Physics I</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MATH 2400</strong> Introduction to Differential Equations$^6$</td>
<td>4</td>
</tr>
<tr>
<td><strong>PHYS 1200</strong> Physics II</td>
<td>4</td>
</tr>
<tr>
<td><strong>Free Elective I</strong></td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CSCI 1190</strong> Beginning C Programming for Engineers</td>
<td>1</td>
</tr>
<tr>
<td><strong>ENGR 2050</strong> Introduction to Engineering Design$^1$</td>
<td>4</td>
</tr>
<tr>
<td><strong>MANE 2830</strong> Nuclear Phenomena for Engineering Applications</td>
<td>4</td>
</tr>
<tr>
<td><strong>MATH 2010</strong> Multivariable Calculus and Matrix Algebra$^a$</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENGR 2250</strong> Thermal and Fluids Engineering I</td>
<td>4</td>
</tr>
<tr>
<td><strong>MANE 2400</strong> Fundamentals of Nuclear Engineering</td>
<td>4</td>
</tr>
<tr>
<td><strong>MANE 4350</strong> Nuclear Instrumentation and Measurement</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENGR 2600</strong> Modeling and Analysis of Uncertainty</td>
<td>3</td>
</tr>
<tr>
<td><strong>MANE 4400</strong> Nuclear Power Systems Engineering</td>
<td>4</td>
</tr>
<tr>
<td><strong>MANE 4470</strong> Radiological Engineering</td>
<td>3</td>
</tr>
<tr>
<td><strong>MANE 4480</strong> Physics of Nuclear Reactors</td>
<td>4</td>
</tr>
<tr>
<td>Professional Development II$^5$</td>
<td>2</td>
</tr>
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</table>

#### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENGR 4010</strong> Professional Development III$^3$</td>
<td>1</td>
</tr>
<tr>
<td><strong>MANE 4050</strong> Modeling and Control of Dynamic Systems</td>
<td>4</td>
</tr>
<tr>
<td><strong>MANE 4370</strong> Nuclear Engineering Laboratory</td>
<td>4</td>
</tr>
<tr>
<td><strong>MANE 4380</strong> NEEP Senior Design Project I</td>
<td>1</td>
</tr>
<tr>
<td>Restricted (NE) Elective I</td>
<td>3</td>
</tr>
<tr>
<td>Free Elective II</td>
<td>4</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MANE 4390</strong> NEEP Senior Design Project II</td>
<td>2</td>
</tr>
<tr>
<td><strong>MANE 4440</strong> Critical Reactor Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>Technical Elective$^d$</td>
<td>3</td>
</tr>
<tr>
<td>Restricted (NE) Elective II</td>
<td>3</td>
</tr>
<tr>
<td>Free Elective III</td>
<td>4</td>
</tr>
</tbody>
</table>

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1. Includes Professional Development I.
2. Other 1-credit Engineering Exploration courses, such as ENGR 1300 may be substituted.
3. May be taken either semester senior year.
4. Any course in engineering or science at 2000 level or higher.
5. Students choose either PSYC 4170 or STSS 4840 to fulfill this requirement.
6. MATH 2010 and MATH 2400 may be taken in either semester of the second year.
Humanities, Arts, and Social Sciences Electives
In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities, arts, and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities, Arts, and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Dual Major Programs
Dual major programs in Nuclear Engineering and Mechanical Engineering are available to students who follow prescribed programs that can be completed in eight semesters. Degree templates for Dual Majors offered by the MANE department may be found here: http://www.eng.rpi.edu/mane/undergraduate.cfm.

Nuclear Engineering Minor
Students not majoring in nuclear engineering may receive a minor in this discipline by completing 15–16 credit hours of study selected in consultation with their program adviser.

Graduate Programs
The department offers graduate programs in mechanical engineering, aeronautical engineering, mechanics, nuclear engineering, and engineering physics. To accommodate a student’s career plans and interests, the graduate programs are structured to allow great flexibility in choosing appropriate courses, while ensuring sufficient depth and breadth. The professor assigned to or chosen by a student as the adviser has the knowledge to make suggestions of specific courses to further the student’s educational goals.

Among the available degrees are the M.Eng., which is perceived to be more practically oriented and consists of course work; the M.S., which is considered more scholarly or fundamental and must include a thesis; and Ph.D. Listed below are many of the requirements for these degrees. For all degrees, full-time students must register each semester for the zero credit course MANE 6900, Graduate Seminar. Complete requirement information is available on the MANE department Web page, http://www.rpi.edu/dept/mane/deptweb/index.html.

Master’s Programs

Master of Science
Students work on a research project in conjunction with a professor who serves as the academic adviser. The topic is chosen based on mutual interests and needs. Course work typically focuses on subjects related to the research project. In addition to the Institute requirements and those listed above, the M.S. requires a total of 30 credits, six of which come from the thesis. Of the 24 credits of course work, a minimum of 12 must be at the 6000 level with a minimum of nine of these 6000-level credits from MANE courses (or courses that are cross-listed with MANE courses), and a minimum of 15 credits overall must be from MANE courses (or courses that are cross-listed with MANE courses). No more than six credits can be from outside of Engineering or Science.

Master of Engineering
M.Eng. students will primarily take courses to deepen and broaden their knowledge, usually in a focused area of study. If a project is included in the degree program, the student will have to involve a professor as an adviser. In addition to the Institute requirements and those listed above, the M.Eng. requires a total of 30 credits. If a project is taken, a minimum of 12 credits of coursework must be taken at the 6000 level with a minimum of nine of these taken within MANE (or courses cross-listed with MANE courses). If no project is undertaken, a minimum of 18 credits must be at the 6000 level, with a minimum of 12 of these taken within MANE (or courses that are cross-listed with MANE courses).

Students must also take part in a culminating experience consisting of:
• an approved sequence of three integrated or related courses with at least two courses in MANE, only one of which may be at the 4000 level. One of these courses must involve a project or design experience which integrates or synthesizes knowledge from other courses taken in the master’s program, or
• a six-credit project, or
• an internship/practicum involving a minimum of one summer and one semester full-time work in an approved setting.
Doctoral Programs

For the doctoral degree, 72 credits in addition to the bachelor’s or 48 credits in addition to the master’s degree are required. In addition to residence and thesis requirements, students must successfully complete 12 or more courses beyond the bachelor’s degree. These courses will be specified by the adviser and the doctoral committee. Under the guidance of a thesis adviser, the student conducts advanced study and research. If a student chooses to do a thesis with a thesis adviser from another department, a Mechanical, Aerospace, and Nuclear Engineering Department faculty member must be appointed co-chair and the doctoral committee must contain at least two department faculty members. After approximately one year of full-time study, the student should have a research adviser and be advanced to doctoral student status. To attain this milestone, a qualifying examination is required. When thesis research has begun and after approximately two years of full-time study, the candidacy examination is taken. At the completion of the research project and after the dissertation has been written, the student must defend the thesis in an open presentation to his or her committee. The degree awarded is the Doctor of Philosophy.

This degree is awarded under the auspices of the Office of Graduate Education when the thesis is directed toward making an original contribution to fundamental knowledge in a particular field or in an interdisciplinary field. A dissertation that is scholarly, creative, original, and publishable may deal also with the relation of a discipline to educational problems and objectives within the field.

Course Descriptions

Courses directly related to all Mechanical, Aerospace, Nuclear Engineering and Engineering Physics curricula are described in the Course Description section of this catalog under the department code MANE.

Engineering at Hartford

Rensselaer at Hartford offers an engineering curriculum designed to accommodate the evolving needs of the practicing engineer. Each curriculum helps students establish and build on a solid theoretical base while allowing them to practice their skills. This blend of academic excellence and industrial experience creates a unique learning environment for engineering students at Rensselaer at Hartford. Degree programs are offered in Mechanical Engineering, Electrical Engineering, Computer and Systems Engineering, and Engineering Science together with Graduate Certificate Programs in Control Systems and High-Temperature Materials.

Engineering Degrees

Master of Engineering and Master of Science degrees are offered in selected engineering disciplines. The Master of Engineering degrees require completion of a three-credit project as a culminating experience while Master of Science degree candidates must carry out research leading to a six-credit thesis. Apart from that, the curricula for both degrees are identical. The Master of Engineering degree is designed to fulfill the needs of practicing engineers in industry while the Master of Science degree is for those focused on a research career. The following engineering degrees are awarded:

- M.Eng. in Electrical Engineering
- M.S. in Electrical Engineering
- M.Eng. in Computer and Systems Engineering
- M.S. in Engineering Science
- M.Eng. in Mechanical Engineering
- M.S. in Mechanical Engineering

A candidate for the master’s degree in Hartford must complete an adviser-approved Plan of Study consisting of:

- at least 30 credit hours beyond the bachelor’s degree with cumulative GPA of 3.0/4.0 or higher.
- at least 18 of the total credit hours presented toward the degree must have the suffix numbers 6000-6990 or 7000-7990.
- at least 21 of the total credit hours presented towards the degree must be from courses taken within the discipline.

A student may transfer credits for two graduate-level (equivalent to 6000 or 7000 level in the Rensselaer at Hartford Catalog) courses (total of six credit hours) taken at an accredited graduate school with the grade(s) of B or better. The transfer/waiver process must be approved by the faculty adviser and the Assistant Dean for Academic Programs. Transfer courses must be relevant to the program of study being pursued by the student at Rensselaer.
Students must prepare their Plans of Study together with their adviser and have it reviewed and approved by the adviser and the Assistant Dean for Academic Programs before completion of their fourth course. All the above requirements must be completed within three years of admission.

**Culminating Experience (Engineering Project/Engineering Thesis)**

The culminating experience is a requirement for the master’s degree as stipulated by the Board of Governors for Higher Education of the State of Connecticut. It may be fulfilled by either of the following:

- Completing a three-credit-hour master’s project along with 27 credit hours of appropriate course work thus leading to the Master of Engineering degree.
- Completing a six-credit-hour master’s thesis along with 24 credit hours of appropriate course work thus leading to the Master of Science degree.

**Electrical Engineering M.Eng. (Hartford)**

The Rensselaer at Hartford master’s program in Electrical Engineering allows students to increase their competence in a number of Electrical Engineering subjects, particularly in Digital Communications and Signal Processing, Control Systems, and Communication Networks.

**Admission Requirements**

1. Students who have received a B.S. degree in Electrical Engineering or Computer Engineering from an accredited institution, a GPA in the upper quartile, and some work experience in a high-technology environment

2. Students with a B.S. degree in another engineering discipline, mathematics, or physics may be admitted subject to fulfillment of the following Electrical Engineering Background Requirements.

**Electrical Engineering Background Requirements**

- Advanced Mathematics (i.e. Complex Variables, Laplace Transforms, Fourier Analysis, Probability) (one term)
- Electric Circuits (one term)
- Electronic Circuits (two terms)
- Signals and Systems (one term)
- Digital Logic (one term)
- Technical Design Elective (e.g., Communications Systems, Control Systems Engineering, Computer Networks) (one term)

Students lacking any of the above courses must consult with their adviser to devise a plan for corrective action.

**Areas of Specialization**

Students must include in their Plan of Study a sequence of three 6000- (or 7000-) level courses in at least one of the following areas of specialization:

- Digital Communications and Signal Processing
- Control Systems
- Communication Networks

**M.Eng. in Electrical Engineering Program Requirements**

The Master’s of Engineering degree is awarded on successful completion of the following:

<table>
<thead>
<tr>
<th>Required Core (15 credits)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 6400 Systems Analysis Techniques</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6560 Digital Communications</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6620 Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6980 Master’s Project</td>
<td>3 to 9</td>
</tr>
</tbody>
</table>
Electives (15 credits) | Credit Hours
---|---
ECSE 6960 | Topics in Electrical Engineering, LANS, MANS, and Internetworking
ECSE 6960 | Topics in Electrical Engineering, Embedded Digital Control Systems
ECSE 6960 | Topics in Electrical Engineering, Mechatronics
ECSE 4440 | Control Systems Engineering
ECSE 4490 | Robotics II
ECSE 4670 | Computer Communication Networks
ECSE 4770 | Computer Hardware Design
ECSE 6050 | Advanced Electronic Circuits
ECSE 6420 | Nonlinear Control Systems
ECSE 6440 | Optimal Control Theory
ECSE 6460 | Multivariable Control Systems
ECSE 6590 | Principles of Wireless Communications
ECSE 6630 | Digital Image and Video Processing
ECSE 6660 | Broadband & Optical Networking
ECSE 7010 | Optical Fiber Communications
ECSE 7100 | Real-Time Programming and Applications

Example Curricula for Three Areas of Specialization

**Digital Communications and Signal Processing**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 4670</td>
<td>Computer Communication Networks</td>
</tr>
<tr>
<td>ECSE 6400</td>
<td>Systems Analysis Techniques</td>
</tr>
<tr>
<td>ECSE 6560</td>
<td>Digital Communications</td>
</tr>
<tr>
<td>ECSE 6590</td>
<td>Principles of Wireless Communications</td>
</tr>
<tr>
<td>ECSE 6620</td>
<td>Digital Signal Processing</td>
</tr>
<tr>
<td>ECSE 6630</td>
<td>Digital Image and Video Processing</td>
</tr>
<tr>
<td>ECSE 6660</td>
<td>Broadband &amp; Optical Networking</td>
</tr>
<tr>
<td>ECSE 6960</td>
<td>Topics in Electrical, Computer, and Systems Engineering</td>
</tr>
<tr>
<td>ECSE 6980</td>
<td>Master's Project</td>
</tr>
<tr>
<td>ECSE 7010</td>
<td>Optical Fiber Communications</td>
</tr>
</tbody>
</table>

**Control Systems**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 4440</td>
<td>Control Systems Engineering</td>
</tr>
<tr>
<td>ECSE 4490</td>
<td>Robotics II</td>
</tr>
<tr>
<td>ECSE 6420</td>
<td>Nonlinear Control Systems</td>
</tr>
<tr>
<td>ECSE 6440</td>
<td>Optimal Control Theory</td>
</tr>
<tr>
<td>ECSE 6460</td>
<td>Multivariable Control Systems</td>
</tr>
<tr>
<td>ECSE 6560</td>
<td>Digital Communications</td>
</tr>
<tr>
<td>ECSE 6980</td>
<td>Master's Project</td>
</tr>
</tbody>
</table>

**Communication Networks**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 6090</td>
<td>Topics in Electrical Engineering, LANS, MANS and Internetworking</td>
</tr>
<tr>
<td>ECSE 6960</td>
<td>Topics in Electrical Engineering, Cryptography, and Network Security</td>
</tr>
<tr>
<td>CISH 6230</td>
<td>Network Management</td>
</tr>
<tr>
<td>ECSE 4670</td>
<td>Computer Communication Networks</td>
</tr>
<tr>
<td>ECSE 6400</td>
<td>Systems Analysis Techniques</td>
</tr>
<tr>
<td>ECSE 6560</td>
<td>Digital Communications</td>
</tr>
<tr>
<td>ECSE 6590</td>
<td>Principles of Wireless Communications</td>
</tr>
<tr>
<td>ECSE 6620</td>
<td>Digital Signal Processing</td>
</tr>
<tr>
<td>ECSE 6660</td>
<td>Broadband &amp; Optical Networking</td>
</tr>
<tr>
<td>ECSE 6980</td>
<td>Master's Project</td>
</tr>
<tr>
<td>ECSE 7010</td>
<td>Optical Fiber Communications</td>
</tr>
</tbody>
</table>

**Electrical Engineering M.S. (Hartford)**

The Master of Science in Electrical Engineering requirements are the same as those for the Master of Engineering in Electrical Engineering, except for the substitution of a six-credit-hour thesis in place of one elective and the three-credit-hour project.

Please contact Professor Farooque Mesiya at mesiyf@rpi.edu if you have any questions about the Rensselaer at Hartford Electrical Engineering program.
Computer and Systems Engineering M.Eng. (Hartford)

The Master of Engineering in Computer and Systems Engineering provides the student with the appropriate hardware and software tools needed in such critical areas as digital communications and signal processing, robotics and automation systems, computer communication networks, and software engineering.

Please contact Professor Farooque Mesiya at mesiyf@rpi.edu if you have any questions about the Computer and Systems Engineering program information provided below.

Admission Requirements
1. Students who have received a B.S. degree in Electrical Engineering, Computer Engineering, or Computer Science.

2. Students with a B.S. degree in another engineering discipline, mathematics, or physics, subject to the condition that the following essential prerequisites for their chosen area of specialization have been completed:

Program Requirements
Preparatory courses do not apply toward the minimum 30 credit hours required for the Master of Engineering degree.

Digital Communications and Signal Processing

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 2010</td>
<td>Electric Circuits</td>
<td></td>
</tr>
<tr>
<td>ECSE 2410</td>
<td>Signals and Systems</td>
<td></td>
</tr>
<tr>
<td>ECSE 2610</td>
<td>Computer Components and Operations</td>
<td></td>
</tr>
</tbody>
</table>

Computer Communications Networks

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 2010</td>
<td>Electric Circuits</td>
<td></td>
</tr>
<tr>
<td>ECSE 2410</td>
<td>Signals and Systems</td>
<td></td>
</tr>
<tr>
<td>ECSE 2610</td>
<td>Computer Components and Operations</td>
<td></td>
</tr>
</tbody>
</table>

Robotics and Automation Systems

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 2010</td>
<td>Electric Circuits</td>
<td></td>
</tr>
<tr>
<td>ECSE 2410</td>
<td>Signals and Systems</td>
<td></td>
</tr>
<tr>
<td>ECSE 2610</td>
<td>Computer Components and Operations</td>
<td></td>
</tr>
</tbody>
</table>

Software Engineering

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 2010</td>
<td>Electric Circuits</td>
<td></td>
</tr>
<tr>
<td>ECSE 2410</td>
<td>Signals and Systems</td>
<td></td>
</tr>
<tr>
<td>ECSE 2610</td>
<td>Computer Components and Operations</td>
<td></td>
</tr>
</tbody>
</table>

Required Core (15 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 4210</td>
<td>Operating Systems</td>
<td></td>
</tr>
<tr>
<td>ECSE 4670</td>
<td>Computer Communication Networks</td>
<td></td>
</tr>
<tr>
<td>ECSE 6620</td>
<td>Digital Signal Processing</td>
<td></td>
</tr>
<tr>
<td>ECSE 6980</td>
<td>Master’s Project</td>
<td></td>
</tr>
</tbody>
</table>

Electives (15 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 6960</td>
<td>Topics in Electrical Engineering, LANS, MANS, and Internetworking</td>
<td></td>
</tr>
<tr>
<td>ECSE 6960</td>
<td>Topics in Electrical Engineering, Embedded Digital Control Systems</td>
<td></td>
</tr>
<tr>
<td>ECSE 6960</td>
<td>Topics in Electrical Engineering, Applied Digital Signal Processing</td>
<td></td>
</tr>
<tr>
<td>CISH 6010</td>
<td>Object Oriented Programming and Design</td>
<td></td>
</tr>
<tr>
<td>CISH 6050</td>
<td>Software Engineering Management</td>
<td></td>
</tr>
<tr>
<td>CISH 6510</td>
<td>Web Application Design and Development</td>
<td></td>
</tr>
<tr>
<td>COMM 6420</td>
<td>Foundations of Human-Computer Interaction Usability</td>
<td></td>
</tr>
<tr>
<td>ECSE 4490</td>
<td>Robotics II</td>
<td></td>
</tr>
<tr>
<td>ECSE 4770</td>
<td>Computer Hardware Design</td>
<td></td>
</tr>
<tr>
<td>ECSE 6050</td>
<td>Advanced Electronic Circuits</td>
<td></td>
</tr>
<tr>
<td>ECSE 6420</td>
<td>Nonlinear Control Systems</td>
<td></td>
</tr>
<tr>
<td>ECSE 6440</td>
<td>Optimal Control Theory</td>
<td></td>
</tr>
<tr>
<td>ECSE 6460</td>
<td>Multivariable Control Systems</td>
<td></td>
</tr>
<tr>
<td>ECSE 6560</td>
<td>Digital Communications</td>
<td></td>
</tr>
<tr>
<td>ECSE 6590</td>
<td>Principles of Wireless Communications</td>
<td></td>
</tr>
<tr>
<td>ECSE 6630</td>
<td>Digital Image and Video Processing</td>
<td></td>
</tr>
<tr>
<td>ECSE 6660</td>
<td>Broadband &amp; Optical Networking</td>
<td></td>
</tr>
<tr>
<td>ECSE 6770</td>
<td>Software Engineering I</td>
<td></td>
</tr>
<tr>
<td>ECSE 6780</td>
<td>Software Engineering II</td>
<td></td>
</tr>
<tr>
<td>ECSE 7010</td>
<td>Optical Fiber Communications</td>
<td></td>
</tr>
<tr>
<td>ECSE 7100</td>
<td>Real-Time Programming and Applications</td>
<td></td>
</tr>
</tbody>
</table>
Sample Curricula for Four Areas of Specialization

### Digital Communications and Signal Processing

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 4440</td>
<td>Control Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4670</td>
<td>Computer Communication Networks</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6400</td>
<td>Systems Analysis Techniques</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6560</td>
<td>Digital Communications</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6620</td>
<td>Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6630</td>
<td>Digital Image and Video Processing</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6960</td>
<td>Topics in Electrical, Computer, and Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Applied Digital Signal Processing</td>
<td></td>
</tr>
<tr>
<td>ECSE 6980</td>
<td>Master's Project</td>
<td>3 to 9</td>
</tr>
<tr>
<td>ECSE 7010</td>
<td>Optical Fiber Communications</td>
<td>3</td>
</tr>
</tbody>
</table>

### Robotics and Automation Systems

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 4440</td>
<td>Control Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4490</td>
<td>Robotics II</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4670</td>
<td>Computer Communication Networks</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6400</td>
<td>Systems Analysis Techniques</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6420</td>
<td>Nonlinear Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6440</td>
<td>Optimal Control Theory</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6460</td>
<td>Multivariable Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6620</td>
<td>Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6960</td>
<td>Topics in Electrical, Computer, and Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Mechatronics</td>
<td></td>
</tr>
<tr>
<td>ECSE 6980</td>
<td>Master's Project</td>
<td>3 to 9</td>
</tr>
</tbody>
</table>

### Computer Communication Networks

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 6960</td>
<td>Topics in Electrical Engineering, LANS, MANS, and Internetworking</td>
<td></td>
</tr>
<tr>
<td>ECSE 6960</td>
<td>Topics in Electrical Engineering, Cryptography and Network Security</td>
<td>3</td>
</tr>
<tr>
<td>CISH 6230</td>
<td>Network Management</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>or Cryptography and Network Security</td>
<td></td>
</tr>
<tr>
<td>ECSE 4670</td>
<td>Computer Communication Networks</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6560</td>
<td>Digital Communications</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6620</td>
<td>Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6660</td>
<td>Broadband &amp; Optical Networking</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6980</td>
<td>Master's Project</td>
<td>3 to 9</td>
</tr>
<tr>
<td>ECSE 7010</td>
<td>Optical Fiber Communications</td>
<td>3</td>
</tr>
</tbody>
</table>

### Software Engineering

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 4210</td>
<td>Operating Systems</td>
<td>3</td>
</tr>
<tr>
<td>CISH 6010</td>
<td>Object Oriented Programming and Design</td>
<td>3</td>
</tr>
<tr>
<td>CISH 6050</td>
<td>Software Engineering Management</td>
<td>3</td>
</tr>
<tr>
<td>CISH 6510</td>
<td>Web Application Design and Development</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>or Foundations of Human-Computer Interaction Usability</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4670</td>
<td>Computer Communication Networks</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6620</td>
<td>Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6770</td>
<td>Software Engineering I</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6780</td>
<td>Software Engineering II</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6980</td>
<td>Master's Project</td>
<td>3 to 9</td>
</tr>
</tbody>
</table>

### Engineering Science

The Master of Science in Engineering Science degree serves students whose educational needs do not correspond to the standard professional engineering curricula. It allows students to tailor a Plan of Study to their particular requirements. Each student’s course of study is developed in close consultation with the adviser to allow meaningful and strongly directed interdisciplinary approach. The degree awarded in this area is not, nor is it intended to be, accredited for practice. Students entering the Engineering Science program are expected to hold a Bachelor of Science degree in one of the traditional engineering disciplines. Applicants not holding such a degree must have evidence of coursework in at least:

- Mathematics, through Ordinary Differential Equations (three terms or 12 credits)
- Physics (two terms)
- Chemistry and/or Engineering Materials (one term)
- Mechanics (one term)
- Electronics/Circuits (one term)
- Probability and Statistics (one term)
Students lacking one or more of these courses are expected to take corrective action before entering the Engineering Science program. Please contact Professor Ernesto Gutierrez-Miravete at gutiee@rpi.edu if you have any questions about the Master of Science in Engineering Science program.

**Mechanical Engineering**

The Master of Engineering in Mechanical Engineering and Master of Science in Mechanical Engineering degrees allow the student to increase his or her competence in a number of mechanical engineering subjects, or to specialize in depth in the areas of fluid mechanics, heat transfer, mechanical design, solid mechanics, or thermodynamics.

**Admission Requirements**

1. Students who have received a B.S. degree in Mechanical Engineering from an accredited institution, a GPA in the upper quartile, and some work experience in a high-technology environment.

2. Students with a B.S. degree in another engineering discipline, mathematics, or physics may be admitted subject to fulfillment of the following background requirements.

**Mechanical Engineering Background Requirements**

- Chemistry (one additional term)
- Dynamics (one term)
- Fluid Mechanics (one term)
- Machine Design (one term)
- Mechanisms (one term)
- Statics (one term)
- Strength of Materials (one term)
- Heat Transfer (one term)
- Thermodynamics (one term)

Students lacking any of the above courses must work closely with their adviser to devise a plan for corrective action.

Please contact Professor Ernesto Gutierrez-Miravete at gutiee@rpi.edu if you have any questions about the Mechanical Engineering program.

**Master of Engineering**

The Master of Engineering in Mechanical Engineering degree is awarded on successful completion of the following:

**Mechanical Engineering Program Requirements**

<table>
<thead>
<tr>
<th>Required Core (15 credits)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANE 5000</td>
<td>Advanced Engineering Mathematics I</td>
</tr>
<tr>
<td>MANE 5100</td>
<td>Mechanical Engineering Foundations I</td>
</tr>
<tr>
<td>MANE 6980</td>
<td>Master’s Project (Culminating Experience)</td>
</tr>
<tr>
<td>MANE 7000</td>
<td>Advanced Engineering Mathematics II</td>
</tr>
<tr>
<td>MANE 7100</td>
<td>Mechanical Engineering Foundations II</td>
</tr>
</tbody>
</table>

**Electives (15 credits)**

In consultation with adviser, select five courses from a single or several specialty area(s).

<table>
<thead>
<tr>
<th>Specialty Area: Solids</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANE 4240</td>
<td>Introduction to Finite Elements</td>
</tr>
<tr>
<td>MANE 4610</td>
<td>Vibrations</td>
</tr>
<tr>
<td>MANE 6180</td>
<td>Mechanics of Composite Materials</td>
</tr>
<tr>
<td>MANE 6200</td>
<td>Plates and Shells</td>
</tr>
<tr>
<td>MANE 6960</td>
<td>Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics</td>
</tr>
<tr>
<td></td>
<td>Advanced Topics in Finite Element Analysis</td>
</tr>
</tbody>
</table>
### Advanced Topics in Finite Element Analysis

#### Specialty Area: Fluids

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANE 4800</td>
<td>Boundary Layers and Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>MANE 5060</td>
<td>Introduction to Compressible Flow</td>
<td>3</td>
</tr>
<tr>
<td>MANE 5080</td>
<td>Turbomachinery</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6530</td>
<td>Turbulence</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6550</td>
<td>Theory of Compressible Flow</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6720</td>
<td>Computational Fluid Dynamics</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Specialty Area: Thermal Systems

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANE 6540</td>
<td>Advanced Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6630</td>
<td>Conduction Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6640</td>
<td>Radiation Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6650</td>
<td>Convective Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6830</td>
<td>Combustion</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6840</td>
<td>An Introduction to Multiphase Flow and Heat Transfer I</td>
<td>3</td>
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</tbody>
</table>

#### Specialty Area: Manufacturing and Materials

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTLE 7061</td>
<td>Casting and Joining Process</td>
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</tr>
<tr>
<td>MTLE 4260</td>
<td>High Temperature Alloys</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 6960</td>
<td>Topics in Materials Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 6960</td>
<td>High Temperature Coatings Engineering</td>
<td></td>
</tr>
</tbody>
</table>

### Additional Information

Students must work closely with their adviser to decide whether to focus on one of the above concentration areas or take electives from all of them. A limited number of elective courses outside the area of mechanical engineering are permitted. However, the student's adviser must approve these courses prior to them being taken.

Please contact Professor Ernesto Gutierrez-Miravete at gutie@rpi.edu if you have any questions about the mechanical engineering program.

### Sample Curricula for Master of Engineering in Mechanical Engineering

#### Solid Mechanics Focus

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANE 5000</td>
<td>Advanced Engineering Mathematics I</td>
<td>3</td>
</tr>
<tr>
<td>MANE 5100</td>
<td>Mechanical Engineering Foundations I</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6180</td>
<td>Mechanics of Composite Materials</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6200</td>
<td>Plates and Shells</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6960</td>
<td>Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6980</td>
<td>Master's Project</td>
<td>1 to 9</td>
</tr>
<tr>
<td>MANE 7000</td>
<td>Advanced Engineering Mathematics II</td>
<td>3</td>
</tr>
<tr>
<td>MANE 7100</td>
<td>Mechanical Engineering Foundations II</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Thermofluids Focus

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANE 4800</td>
<td>Boundary Layers and Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>MANE 5000</td>
<td>Advanced Engineering Mathematics I</td>
<td>3</td>
</tr>
<tr>
<td>MANE 5100</td>
<td>Mechanical Engineering Foundations I</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6630</td>
<td>Conduction Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6650</td>
<td>Convective Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6720</td>
<td>Computational Fluid Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6980</td>
<td>Master's Project</td>
<td>1 to 9</td>
</tr>
<tr>
<td>MANE 7000</td>
<td>Advanced Engineering Mathematics II (6000 level)</td>
<td>3</td>
</tr>
<tr>
<td>MANE 7100</td>
<td>Mechanical Engineering Foundations II (6000 level)</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Computational Focus

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>MANE 4240</td>
<td>Introduction to Finite Elements</td>
<td>3</td>
</tr>
<tr>
<td>MANE 5000</td>
<td>Advanced Engineering Mathematics I (4000 level)</td>
<td>3</td>
</tr>
<tr>
<td>MANE 5100</td>
<td>Mechanical Engineering Foundations I (4000 level)</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6530</td>
<td>Turbulence</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6720</td>
<td>Computational Fluid Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6960</td>
<td>Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6980</td>
<td>Master's Project</td>
<td>1 to 9</td>
</tr>
<tr>
<td>MANE 7000</td>
<td>Advanced Engineering Mathematics II (6000 level)</td>
<td>3</td>
</tr>
<tr>
<td>MANE 7100</td>
<td>Mechanical Engineering Foundations II (6000 level)</td>
<td>3</td>
</tr>
</tbody>
</table>
Master of Science in Mechanical Engineering Program Requirements

The Master of Science in Mechanical Engineering requirements are the same as those for the Master of Engineering in Mechanical Engineering, except for the substitution of a six-credit-hour thesis in place of one elective and the three-credit-hour project.

Engineering Graduate Certificate Programs

For working professionals not seeking a complete master's degree, Rensselaer at Hartford’s Graduate Certificate Programs are tailored to enhance or update skills in a shorter period of time. They have a selective focus and require that a student successfully complete three or four graduate courses in a specific area of engineering. With an adviser’s approval, credits earned may be subsequently applied as electives toward a master's degree.

Graduate Certificate in Control Systems (Hartford)

Control systems are widely used in engineering to monitor the values of process variables by measurement so as to make rational decisions about required corrective actions. Analysis and design of control systems requires consideration of sensors, controllers, transmitters as well as auxiliary control and hardware elements.

Rensselaer at Hartford offers a Graduate Certificate in Control Systems designed to provide an understanding of control systems engineering, including the fundamental principles of control systems and their application to real-life engineering problems.

Academic credit earned from these courses may then be applied towards a master’s degree.

Please contact Professor Farooque Mesiy at mesiyf@rpi.edu if you have any questions about the Control Systems Certificate Program described below.

Program Requirements

The Certificate of Advanced Graduate Studies in Control Systems is awarded upon successful completion of the following courses:

<table>
<thead>
<tr>
<th>Core Courses (6 credits):</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 4440 Control Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6400 Systems Analysis Techniques</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elective Courses (Any two, 6 credits):</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 6420 Nonlinear Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6440 Optimal Control Theory</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6460 Multivariable Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6480 Adaptive Systems</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6960 Topics in Electrical, Computer, and Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>MANE 6960 Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Sensors and Actuators in Mechatronics</td>
</tr>
</tbody>
</table>
Graduate Certificate in High Temperature Materials

Materials used in the “hot zones” of propulsion and power generation systems must satisfy stringent demands for integrity and performance. Materials exposed to these extreme environments exhibit continuously evolving microstructures and this must be accounted for during the component design stage of production.

Rensselaer at Hartford offers a Graduate Certificate in High Temperature Materials designed to provide an understanding of the properties of high temperature alloys as well as skills in improving those properties by manipulating the material microstructure through processing.

Academic credit earned from these courses can then be applied towards a master’s degree.

Please contact Professor Ernesto Gutierrez-Miravete at gutiee@rpi.edu if you have any questions about the Graduate Certificate in High Temperature Materials program.

Program Requirements
The Graduate Certificate in High Temperature Materials is awarded upon successful completion of the following courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTLE 7061</td>
<td>Casting and Joining Processes for Superalloys</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4260</td>
<td>High Temperature Alloys</td>
<td></td>
</tr>
<tr>
<td>MTLE 6960</td>
<td>Topics in Materials Engineering</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>High Temperature Coatings Engineering</td>
<td></td>
</tr>
</tbody>
</table>

Faculty

Professors of Practice

Gutierrez-Miravete, E.—Ph.D. (Massachusetts Institute of Technology); modeling and simulation metal processing; Assistant Dean for Academic Programs.

Mesiya, M.—Ph.D. (Queen's University); communications, networks.

Younessi, H.—Ph.D. (Swinburne University of Technology); systems engineering; Assistant Dean for Academic Programs.

Lecturer

Brown, R.—M.S.E.E. (University of Illinois); networks, security.

Adjunct Faculty

Ahmed, A.—M.S., Ph.D. (BUET, Dhaka, Bangladesh; Worcester Polytechnic Institute).

Annigeri, B.—M.M.E., Sc.D. (Illinois Institute of Technology; Massachusetts Institute of Technology).

Bak, M.—M.S., Ph.D. (University of California, Berkley; University of Connecticut).

Bell, D.—M.S. (Rensselaer Polytechnic Institute).

Bengta, S.—Ph.D. (Purdue University).

Bortoff, S.—M.S., Ph.D. (Syracuse University; University of Illinois).

Brown, K.—M.S., Ph.D. (Rensselaer Polytechnic Institute).

Cousins, W.—M.S., Ph.D. (Virginia Polytechnic Institute and State University).

Dennis, A.—Ph.D (University of Connecticut).

Donachie, M.—M.S., Ph.D. (Massachusetts Institute of Technology).

Gerlach, D.—M.S., Ph.D. (University of Illinois at Urbana).

Ghosh, A.—Ph.D (University of Washington, Seattle).

Ghoshal, A.—M.S., Ph.D. (University of Connecticut).

Huffner, D.—M.S., Ph.D. (Rensselaer Polytechnic Institute; University of Connecticut).

Kling, C.—M.S., Ph.D. (University of Michigan).


Marcin, J.—M.S. (Rensselaer Polytechnic Institute).


Naik, R.—M.S., Ph.D. (University of Maine; Old Dominion University).


Oggianu, S.—M.S., Ph.D. (Massachusetts Institute of Technology).

Quinn, J.—M.S. (Trinity College).

Ragini, A.—M.S., Ph.D. (Pennsylvania State University).

Scholte, E.—Msc., Ph.D. (University of Twente, Enschede, The Netherlands; Cornell University).

Seetharaman, V.—M.Sc., Ph.D. (University of Bombay; Institute of Technology, Bombay).

Schemenski, R.—MBA (University of Connecticut).

Slimon, S.—M.S., Ph.D. (Rensselaer Polytechnic Institute; University of Connecticut).

Staroselsky, A.—Ph.D. (Massachusetts Institute of Technology).

Tew, D.—Ph.D. (Massachusetts Institute of Technology).

Torrani, S.—M.S. (Polytechnic Institute of Brooklyn).

Vasko, T.—M.S., Ph.D. (Rensselaer Polytechnic Institute; University of Connecticut).

Wagner, C.—M.S.E.M. (Western New England College).

Wagner, T.—M.S., Ph.D. (Virginia Polytechnic Institute and State University).

Webster, C.—M.S., Ph.D. (University of Connecticut).
Interdisciplinary Degree Programs

Rensselaer has long understood that neither student career interests nor modern industry needs are easily pigeonholed into a single discipline. In fact, the discovery of new and more advanced technologies more often than not results from combining the knowledge of a variety of disciplines. Rensselaer is, therefore, resolved to become a leader in providing numerous opportunities for interdisciplinary study.

In keeping with this commitment, the School of Engineering has developed a variety of special programs that bridge one or more departments or even Institute schools. These include both degree and research programs that allow students to develop a breadth and depth of knowledge in more than one discipline. By their nature, these programs are highly flexible and often involve working in teams with faculty and students representing multiple disciplines.

In addition to opportunities in the School of Engineering described within the School of Engineering section of this catalog, other interdisciplinary programs available at Rensselaer are listed in the Interdisciplinary Studies Index of this catalog and are described fully in the section pertaining to the associated Institute school or division.

Programs

- Center for Flow Physics and Control (CeFPaC)
- Center for Modeling, Simulation, and Imaging in Medicine (CeMSIM)
- Engineering Core Curriculum
- Engineering Science
- M.S., Ph.D. Engineering Science
- Master of Engineering Program in Systems Engineering and Technology Management

Design, Innovation, and Society

**Chair:** Mark W. Steiner (Interim)

**Chair:** Sharon Anderson-Gold (Interim)

The School of Humanities, Arts, and Social Sciences offers this dual major program called Design, Innovation, and Society (DIS). The program offers a B.S. degree in DIS as well as the opportunity to dual major in Mechanical Engineering or Management as well as other curricula.

DIS prepares students to become innovative designers capable of developing and designing the advanced products and technologies for the 21st century. Built around a design studio during seven of eight semesters, DIS combines the technical sophistication of Rensselaer’s engineering or management curricula with the aesthetic and cultural insights and vision of the humanities and social sciences disciplines in the DIS curriculum.

Through the DIS core of design studios, students obtain a hands-on opportunity that brings together the major curricula. The accredited mechanical engineering curriculum can also provide a fundamental education in mechanical engineering with a focus on design methodology in general and mechanical design techniques in particular (see sample template below). The management curriculum provides a fundamental education in management with course offerings in product design, marketing, and entrepreneurship if combined with DIS. The DIS curriculum provides a fundamental education in the historical, ethical, cultural, and policy dimensions of product development and innovation, including numerous case studies of successes and failures through which students learn what it takes to be effective leaders of design teams. On this basis, the design studios help students explore and develop their creativity while building a portfolio of design experiences continuously throughout all four years.

The design experiences range over a breadth of problems, from larger systemic problems to smaller focused problems, so that students have broad exposure to all the different applications of design practice. Collectively the studios are taught as an integrated sequence that give students experiences with the design process that extend from problem identification to project implementation. The studios also develop students’ skills in using computers and other advanced tools and techniques, as well as in drawing, visualizing, communicating, and working together. In short, the program’s design aspects provide the elements necessary to put students’ creativity to work as leaders of design and innovation, whether it is in a multinational business at the cutting edge of the global marketplace or in a smaller business venture that creates a unique solution to an important problem.
### DESIGN, INNOVATION, AND SOCIETY CURRICULUM (INTERDISCIPLINARY, ENGINEERING)

#### FIRST YEAR

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS 1962</td>
<td>Design, Innovation, and Society</td>
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</tr>
<tr>
<td>CHEM 1100</td>
<td>Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1200</td>
<td>Engineering Graphics and CAD&lt;sup&gt;1&lt;/sup&gt;</td>
<td>1</td>
</tr>
<tr>
<td>IHSS 1610</td>
<td>Product Design and Innovation Design Studio I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
</tbody>
</table>

**Spring - Credits: 17**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ENGR 1100</td>
<td>Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1300</td>
<td>Engineering Processes&lt;sup&gt;1&lt;/sup&gt;</td>
<td>1</td>
</tr>
<tr>
<td>ENGR 2020</td>
<td>Product Design and Innovation Design Studio II</td>
<td>4</td>
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<tr>
<td>MATH 1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>STSS 2200</td>
<td>Engineering, Design, and Society</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>STSS 2210 Design, Culture, and Society</td>
<td>4</td>
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</table>

#### SECOND YEAR

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<thead>
<tr>
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<tbody>
<tr>
<td>CSCI 1190</td>
<td>Beginning C Programming for Engineers</td>
<td>1</td>
</tr>
<tr>
<td>ENGR 1600</td>
<td>Materials Science for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>IHSS 2610</td>
<td>Product Design and Innovation Studio III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1100</td>
<td>Physics I</td>
<td>4</td>
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**Spring - Credits: 16**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ENGR 2050</td>
<td>Introduction to Engineering Design (PDI Studio IV)</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2090</td>
<td>Engineering Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2530</td>
<td>Strength of Materials</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1200</td>
<td>Physics II</td>
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</table>

#### THIRD YEAR

<table>
<thead>
<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>ENGR 2350</td>
<td>Embedded Control</td>
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<td>ENGR 2600</td>
<td>Modeling and Analysis of Uncertainty</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 2710</td>
<td>General Manufacturing Processes&lt;sup&gt;2&lt;/sup&gt;</td>
<td>3</td>
</tr>
<tr>
<td>MATH 2010</td>
<td>Multivariable Calculus and Matrix Algebra</td>
<td>4</td>
</tr>
<tr>
<td>STSH 4610</td>
<td>Product Design and Innovation Studio V</td>
<td>4</td>
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**Spring - Credits: 16**

<table>
<thead>
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<th>Course Code</th>
<th>Course Title</th>
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<td>Design Studio VI&lt;sup&gt;2&lt;/sup&gt;</td>
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<tr>
<td>STSH 4xxx</td>
<td>STS Advanced Option&lt;sup&gt;3&lt;/sup&gt;</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2250</td>
<td>Thermal and Fluids Engineering I</td>
<td>4</td>
</tr>
<tr>
<td>MANE 4050</td>
<td>Modeling and Control of Dynamic Systems</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4170</td>
<td>Professional Development II: Leadership Theories</td>
<td>2</td>
</tr>
<tr>
<td>or</td>
<td>STSS 4840 Professional Development II</td>
<td>2</td>
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</table>

#### FOURTH YEAR

<table>
<thead>
<tr>
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<th>Course Title</th>
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<tbody>
<tr>
<td>STSS 4xxx</td>
<td>STS Advanced Option&lt;sup&gt;3&lt;/sup&gt;</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 4010</td>
<td>Professional Development III</td>
<td>1</td>
</tr>
<tr>
<td>MANE 4030</td>
<td>Elements of Mechanical Design</td>
<td>4</td>
</tr>
<tr>
<td>MANE 4040</td>
<td>Mechanical Systems Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>MANE 4260</td>
<td>Design of Mechanical Systems</td>
<td>3</td>
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</table>

**Spring - Credits: 14**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>ENGR 2300</td>
<td>Electronic Instrumentation</td>
<td>4</td>
</tr>
<tr>
<td>MANE 4010</td>
<td>Thermal and Fluids Engineering II</td>
<td>4</td>
</tr>
<tr>
<td>MANE 4020</td>
<td>Thermal and Fluids Engineering Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>STSS 4980</td>
<td>Senior Project&lt;sup&gt;4&lt;/sup&gt;</td>
<td>4</td>
</tr>
</tbody>
</table>

---

1 These courses may be taken in any order.
2 PDI Studio II and VI and General Manufacturing Processes satisfy the ME requirements for concentration electives.
3 Candidate courses include STSS 4350, STSS 4250, STSS 4310, STSS 4560, STSS 4650, and STSS 4960.
4 The STS Senior Project can be combined with the PDI Capstone Design Studio VII to make a seven-credit capstone project. Coordination should be done with the DIS adviser.
Engineering Science

Program Office: School of Engineering, Office of Undergraduate Education

The goal of the BSES degree is to provide a program of study with a strong engineering foundation, but enough flexibility in the curriculum for students to focus on specific broader interests such as: pre-medicine, pre-law, management, energy, and the environment, where accreditation is not necessary. This program is not recommended for students interested in obtaining licensure as a Professional Engineer (PE).

Accreditation—This program does not meet the requirement of the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) for Professional Engineering Certification. It is a NYS approved degree.

Faculty—The program is suited best for those students who have clearly defined career goals better served by a more general degree in engineering and for whom professional licensure (or even practicing as an engineer) is not a goal (e.g. business administration, law, medicine, etc.). Because the degree is non-departmental, the program does not prepare the students for the conventional career opportunities available to students in departmental programs.

Degree Program Candidates—The program is suited best for those students who have clearly defined career goals better served by a more general degree in engineering and for whom professional licensure (or even practicing as an engineer) is not a goal (e.g. business administration, law, medicine, etc.). Because the degree is non-departmental, the program does not prepare the students for the conventional career opportunities available to students in departmental programs.

BS Engineering Science Requirements

The Bachelor’s Degree of Science in Engineering Science has six components: 1) core engineering and science courses that all engineering students currently take, 2) electives in core engineering to provide foundational knowledge in engineering, 3) humanities, arts, and social science courses that complement the students’ engineering interests, 4) science and engineering electives that broaden the degree, 5) free electives, and 6) a culminating design or research experience.

Students can be admitted to the BSES degree at the end of the freshmen year, and no later than the end of their sophomore year. Students must submit a plan of study and a short essay outlining their career goals. The plan of study must be approved before entering the program by a committee consisting of the Associate Dean of Academic Affairs, the Associate Dean of Undergraduate Studies, and two faculty members from different departments appointed by the Associate Dean Academic Affairs, who serve three-year terms on the BSES curriculum committee.

Core Requirements (42 credits) Credit Hours

These courses must be taken by all BSES students and a GPA of 3.0 or higher must be achieved.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 2120</td>
<td>Introduction to Cell and Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 1100</td>
<td>Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1100</td>
<td>Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2050</td>
<td>Introduction to Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2600</td>
<td>Modeling and Analysis of Uncertainty</td>
<td>3</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1100</td>
<td>Physics I</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1200</td>
<td>Physics II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Professional Development I</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Professional Development III</td>
<td></td>
</tr>
</tbody>
</table>

Foundation Electives (eight credits) - Choose two Credit Hours

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 2010</td>
<td>Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1600</td>
<td>Materials Science for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2090</td>
<td>Engineering Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2250</td>
<td>Thermal and Fluids Engineering I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2300</td>
<td>Electronic Instrumentation</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2350</td>
<td>Embedded Control</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2530</td>
<td>Strength of Materials</td>
<td>4</td>
</tr>
</tbody>
</table>

HASS Credits (22 credits) - Follow Institute requirements

These courses are chosen to complement the student’s interests. For example, if the interest is in energy, there are several energy related STSS courses that should be taken.
Science, Engineering, Management, STS, or Economics Electives (40 credits) — 4000-level electives
Students can choose from a long list of courses, taking at least 24 credits from the School of Science and/or the School of Engineering. However, no more than 24 credits can be taken from the School of Engineering toward meeting this requirement. The following courses are examples of those which can be used to meet this requirement.

- Two courses at the 2000 level from the School of Engineering or School of Science
- Any 4000-level course in the School of Engineering or School of Science
- Any 4000-level course in the Lally School
- Any 4000-level course in ECON or STSS

Free Electives (12 credits)
These can be courses from any school in the Institute.

Culminating Design or Research Experience (4 credits)
Students must take either a Senior Capstone Design Course, Inventors Studio, or complete a faculty directed research experience of at least 4 credits that is evaluated based on a final written report of the research results.

M.S., Ph.D. Engineering Science
School of Engineering Associate Dean for Academic Affairs: Linda S. Schadler
Rensselaer’s graduate Engineering Science program serves students whose educational desires do not correspond to the standard professional engineering curricula. M.S. and Ph.D. degrees are awarded to students whose programs of study are truly multidisciplinary. The M.S. degree in Engineering Science is reserved for students pursuing their program of study through Rensselaer at Hartford. The requirements for this program may be found in this Catalog in the School of Engineering section under the heading Engineering at Hartford. The Doctor of Philosophy (Ph.D.) degree in Engineering Science is awarded by the School of Engineering for genuine multidisciplinary research. The degree is earned once the student’s dissertation adviser and doctoral committee agree that the student has demonstrated independent thought and research, has made original contributions to the fundamental knowledge in a given interdisciplinary field, and has produced a substantial body of information in the form of a dissertation, aspects of which are publishable in a refereed journal. Since each student develops an individual program in consultation with a faculty adviser, the program provides the opportunity to tailor programs of study to specific needs. Studies may be based on the sciences. For example, programs may concentrate on the application of engineering and scientific techniques to areas between technology and the humanities, arts, and social sciences. The general requirements for the Ph.D. in Engineering Science may be found in the Catalog section on Academic Information and Regulations under the heading Doctoral Degree. Specific information pertaining to the Engineering Science doctoral program is available from the Office of Academic and Student Affairs in the School of Engineering (JEC 3018).

Master of Engineering Program in Systems Engineering and Technology Management
The School of Engineering and the Lally School of Management jointly offer a unique Master of Engineering program in Systems Engineering and Technology Management (SETM). Although the program is open to qualified undergraduates from other institutions, it is primarily intended as a co-terminal degree option for Rensselaer engineering undergraduates. It is a 30-credit-hour program leading to the Master of Engineering degree. The program is designed to provide engineering students with an opportunity to extend their understanding of emerging technologies within their disciplines while providing fundamental background in technical decision making methods and technology management. The program provides essential background in the financial metrics of business performance, the analytical modeling tools for applying these metrics in organizational and technical decision making systems, and the critical challenges associated with new models of value creation and business growth across different industries. Students will be prepared for technical management roles as they simultaneously extend their expertise in their undergraduate engineering disciplines beyond the bachelor’s level. Graduates of the program will be prepared to assume management responsibilities sooner upon entering the professional workforce.
Program Features
The unique feature of this program is the fusion of a management/industrial and systems engineering core with the student's undergraduate engineering discipline. The curriculum culminates in a four-to-five course concentration in the student's technical focus area. The technical concentration courses can be at the 6000 or 4000 levels. In addition to the bachelor's degree in engineering, (including an introductory course in engineering statistics such as ENGR 2600 Modeling and Analysis of Uncertainty), the program requires five 6000-level courses that provide the management and decision sciences foundation of the program including:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ISYE 6610</td>
<td>Systems Modeling in Decision Sciences</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6620</td>
<td>Discrete-Event Simulation</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6020</td>
<td>Financial Management I</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6080</td>
<td>Networks, Innovation, and Value Creation</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 7740</td>
<td>Accounting for Reporting and Control</td>
<td>3</td>
</tr>
</tbody>
</table>

Culminating Technical Concentration
The culminating technical concentration requires four-to-five adviser approved concentration courses in the student's engineering discipline.

As one example for illustration purposes only, consider an industrial engineering student seeking a career in a manufacturing industry. A student with this interest could elect technical concentration courses that could include the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ISYE 6020</td>
<td>Design of Experiments</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6180</td>
<td>Knowledge Discovery with Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6210</td>
<td>Theory of Production Scheduling</td>
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<tr>
<td>ISYE 6600</td>
<td>Design of Manufacturing System Supply Chains</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6820</td>
<td>Queueing Systems and Applications</td>
<td>3</td>
</tr>
</tbody>
</table>

Example Plan of Study with the Master's Project
As an alternative to the four-to-five course culminating technical concentration, students can elect a three-to-four course technical concentration plus an engineering Master's project for three credit hours. To complete this requirement, students must register for three credit hours under the 6980 Master's project course in their engineering discipline and complete a project directly related to the technical concentration.

Again for illustration purposes only, the corresponding Plan of Study for the degree option described above could be:

<table>
<thead>
<tr>
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<th>Credit Hours</th>
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<tbody>
<tr>
<td>Fall</td>
<td>ISYE 4220</td>
<td>Optimization Algorithms and Applications</td>
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<tr>
<td></td>
<td>ISYE 6610</td>
<td>Systems Modeling in Decision Sciences</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ISYE 6620</td>
<td>Discrete-Event Simulation</td>
<td>3</td>
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<tr>
<td></td>
<td>MGMT 6020</td>
<td>Financial Management I</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>MGMT 7740</td>
<td>Accounting for Reporting and Control</td>
<td>3</td>
</tr>
<tr>
<td>Spring</td>
<td>ISYE 6020</td>
<td>Design of Experiments</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ISYE 6210</td>
<td>Theory of Production Scheduling</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ISYE 6980</td>
<td>Master's Project</td>
<td>1 to 9</td>
</tr>
<tr>
<td></td>
<td>MGMT 6080</td>
<td>Networks, Innovation, and Value Creation</td>
<td>3</td>
</tr>
</tbody>
</table>

Examples of Potential Other Technical Concentrations
This program is open to all engineering majors. Other examples of representative technical concentrations available through this program are summarized below:

- A civil engineering student seeking a career in the construction field might combine a technical concentration in construction engineering with a complementary elective course in technical project management.

- An industrial engineering student seeking a career as a technical analyst in a Wall Street brokerage firm might combine a technical concentration in optimization with a complementary elective course in risk analysis.

- An electrical engineering student seeking a career as a microelectronics engineer might combine a technical concentration in microelectronics with a complementary elective course in statistical quality control.

- A computer systems engineering student seeking a career as a systems developer might combine a technical concentration in software engineering with a complementary elective course in the area of human-computer interaction.
• An aeronautical engineering student seeking a career in aircraft design might combine a technical concentration in structures and control with a complementary elective course in the area of research and development management.

• A mechanical engineering student seeking a career in the automotive industry might combine a technical concentration in manufacturing processes with a complementary elective course in production operations management.

For information about the Master of Engineering program in Systems Engineering and Technology Management, contact Associate Dean Linda Schadler in the School of Engineering or Professor Charles J. Malmborg in the Department of Industrial and Systems Engineering.

Interdisciplinary Research Centers

Center for Earthquake Engineering Simulation

Director: Ricardo Dobry
Associate Director: Tarek Abdoun
Associate Director for Training and Outreach: Thomas Zimmie

The Center for Earthquake Engineering Simulation (CEES) is part of NEES (Network for Earthquake Engineering Simulation) and NSF initiative aimed at revolutionizing earthquake engineering research in the United States. NEES has merged experimental laboratory and field research with analytical simulations at a number of university facilities, electronically linking them into a national Collaboratory. Today, it includes 14 experimental sites or “nodes” plus the NEEScomm that is located at Purdue University. NEES provides open access to the 14 sites by allocating research time at the facilities while leading training, education, and outreach activities and establishing ties with U.S. and international partners. Rensselaer is a node in NEES and provides access to the campus-based 150-g ton geotechnical centrifuge facility. CEES is a multi-disciplinary research center committed to providing researchers a state-of-the-art facility to conduct analytical, experimental, analytical-experimental, and multi-disciplinary research. The facility is a multi-hazard mitigation site with a capability to support research for mitigation of other natural hazards. The facility is now a home to tele-participation tools, including state-of-the-art telecontrol and teleconference rooms. The CEES center is also home to a 2-directional earthquake simulator, 2-degrees of freedom and 4-degrees of freedom in-flight robots and state-of-the-art Data Acquisition (DAQ) software.

As part of a 10-year initiative that started in October of 2004, NEES facilities will be used in innovative earthquake research, including use of CEES by Rensselaer faculty and outside researchers working on campus, or via tele-participation tools. Since 2004, NEES@RPI has participated in over 24 major research projects for both NEES and industrial users, which focus on:

• The seismic response of pile foundations to liquefaction,
• The effect of blasting on tunnels and earth embankments,
• The centrifuge modeling of levees, retaining walls, tailings dams, slopes, and offshore structures,
• The development of advanced sensors and tools for centrifuge and existing in-flight robots,
• The numerical modeling and analysis of buildings subjected to seismic loads, and
• Field monitoring and assessing of levee and flood-control infrastructure system.

Affiliated Faculty

T. Abdoun, R. Dobry, M. O'Rourke, I. Sasanakul, M. Symans, B. Yazici, M. Zeghal, T. Zimmie, V. Bennett
Center for Flow Physics and Control (CeFPaC)

**Director:** Michael Amitay

The mission of the Center for Flow Physics and Control (CeFPaC) is to conduct research in flow physics, prediction, modeling, and control. The center focuses on a combination of basic research aimed at verifying or developing theories for fluid dynamic behavior and the application of these theories towards controlling flows. The research involves a large variety of macro and micro flow fields including laminar and turbulent boundary layers, jets, shear layers, wakes, airfoils, finite wings/Blades, inlets and UAVs.

The center’s main two thrusts are: Aerodynamics (aerial and underwater vehicles), and Wind Energy (smart wind turbine blades, and the building of integrated wind).

The research in Aerodynamics has four main objectives: (1) understand the flow mechanisms associated with the interaction between the flow and the actuators, (2) explore, experimentally and numerically, the feasibility of using active flow control for flight control, (3) develop low order models of the flow, and (4) develop closed loop control schemes.

Wind energy focuses on topics such as smart wind turbine blades and building integrated wind. As the desire to harvest energy from the wind increases, industrial manufactures seek to implement techniques that improve wind turbine efficiency and longevity. The use of variable-speed rotors (used in most modern large-scale turbines) offers an efficiency increase by allowing turbine to operate closer from the wind. The development of larger, more efficient turbines mandates a fundamental study of the interaction between the wind and the blade so that these effects can be considered and exploited in the design of larger turbines.

CeFPaC is poised to make an important impact in the rapidly emerging field of active flow control. The Center focuses on the important fields of both aerospace engineering and energy systems. In our center, we work to advance the state-of-the-art in wind turbine blades, green airplanes, smart buildings, and more.

**Affiliated Faculty**

**Research Engineer**
I. Salvador

**Administrative Associate**
K. Rusello

Center for Infrastructure, Transportation, and the Environment

**Director:** Jose Holguin-Veras

**CITE Home Page:** [http://transp.rpi.edu/~CITE](http://transp.rpi.edu/~CITE)

The Center for Infrastructure, Transportation, and the Environment (CITE) is a national and international leader in research, education, outreach, and technology transfer in the areas of infrastructure, transportation, and their links to the environment. CITE was formerly the Center for Infrastructure and Transportation Studies (CITS), which was originally established in 1993 as a collaborative environment in which interdisciplinary transportation and infrastructure-related research could be conducted. A member of the Council for University Transportation Centers (CUTC), CITE is known for research in freight transportation, humanitarian logistics, intelligent transportation systems, transportation systems planning, network modeling, traffic simulation, advanced econometrics, and traffic signal system control.

The mission of the Center is to investigate complex transportation and infrastructure problems and to assist in developing solutions or approaches for dealing with these problems. The Center either directly provides solutions to the owners, operators, or users of civil infrastructure systems or delivers educational technologies that allow the owners, operators, or users to develop and implement their own solutions. CITE focuses on the following roles:

- Providing a forum for complex transportation issues, identifying the parameters of the issues and cooperatively develop solutions or approaches for dealing with the issues.
- Conducting studies in systems operation and facilities management.
- Developing policies and methodologies to increase the sustainability of transportation activity.
- Developing analytical techniques that help identify and prioritize investments in transportation infrastructure.
CITE provides an administrative umbrella for the new Center of Excellence on Sustainable Urban Freight Systems (CoE-SUFS), funded by the Volvo Research and Educational Foundations (VREF). This $4 million, five-year international research venture seeks to jumpstart the creation of a framework that engages and fosters collaboration between cities, the private sector, and academia. Through collaboration between its core research partners, core industry partners and associate research centers across six continents, CoE-SUFS will develop a holistic, integrated suite of technologies, regulations, and incentives to help shape a new paradigm of freight transportation systems that are more cost efficient, more energy efficient, and less disruptive to commuter traffic in urban centers.

During its early years, the main funding for CITS was derived from the New York State Thruway Authority, the New York State Energy Research and Development Authority (NYSERDA), and the New York State Department of Transportation (NYSDOT). More recently, continued funding from the United States Department of Transportation (USDOT) and the National Science Foundation (NSF) has replaced local and state funding as the main source of research revenues for CITE. This reflects the national stature and leadership role played by the faculty associated with the center. Work on pavement management systems, bridge management systems, hazardous materials logistics, and traffic signal systems has given way to projects focused on freight transportation modeling, economics, sustainable systems, and traffic control.

Civil and environmental engineers (CEE) have a crucial role to play in the solution of mankind’s challenges, both current and future. The nature of this role is being shaped by a conjunction of emerging challenges and societal/technological trends. Among them, it is important to highlight:

• The important role played by CEE towards achieving energy and environmental goals.
• The CEE research needs associated with unmanaged urbanization and the rise of megacities.
• The anticipated increase in natural and man-made disasters and the need to develop new paradigms of resilient and sustainable CEE systems.
• The pervasive role of information technology, sensors, and wireless technologies that can enhance CEE decision making.
• The deplorable state of the nation’s infrastructure and the need to create new paradigms of design and operation that lead to sustainable and resilient CEE systems.
• Climate change and its impacts on coastal areas where the share of the world population is increasing.

Projects recently completed or presently underway include:

• Humanitarian logistics (NSF)
• Dynamic urban goods modeling (NSF)
• Integrated urban freight demand management (USDOT)
• Advanced Wireless Traveler Information Systems (USDOT/NYSDOT)
• Assessment of Impacts of Value Pricing Projects (FHWA/NJDOT)
• Freight-related network enhancements (USDOT/NYSDOT)
• Traffic simulation modeling of planned special events (NYSDOT)

Current research funding within CITE/CITS stands at between $1.5-$2 million/year. Total research funding at Rensselaer is $80 million, a significant portion of which comes from industry, well above the national average, and testimony to the importance of Rensselaer research to the private sector.

Affiliated Faculty
J. Ban, J. Chow, G. de Angelo, R. Dobry, F. Duchin, M. Embrechts, K. Fortun, J. Holguin-Viras (Director), M. Kalsher, M. O’Rourke, W. Wallace, C. Wang

Participating Faculty
J. Ban, G. de Angelo, F. Duchin, K. Fortun, M. Goldberg, J. Holguin-Veras (Director), M. Magdon-Ismail, J. Mitchell, S. W. Wallace, C. Wang

Research Engineering Staff
J. Wojtowicz

Administrative Staff
J. Perttierra
Center for Modeling, Simulation, and Imaging in Medicine (CeMSIM)

**Director:** Suvranu De

The goal of the Center for Modeling, Simulation, and Imaging in Medicine (CeMSIM) is to actively develop advanced modeling, simulation, and imaging (MSI) technology for healthcare through interdisciplinary collaborations with the aim of transitioning the technology to clinical practice.

Situated at the intersection of medicine and engineering, the CeMSIM develops novel MSI solutions for a variety of challenges in the healthcare enterprise. To accomplish its objectives, the CeMSIM engages in fundamental research related to computational science and engineering, imaging science and engineering, biomedical science and engineering, biorobotics, medical visualization, haptics, networking science and technology, virtual reality and cognitive science. Application projects encompass all aspects of clinical medicine including image-based diagnostic tools (e.g., radiology, ultrasound, CT, MRI and X-ray), image analysis methods, elastographic techniques, noninvasive clinical therapy as well as surgical planning and training, tele-medicine, and robotic surgery. The CeMSIM partners with premier medical schools, hospitals, industries and academic institutions across the country as well as many of the research platforms within Rensselaer. Research at the CeMSIM is aimed at rapid translation of technology from the bench to the bedside and to the greater community.

**Affiliated Faculty**

**Postdoctoral Research Associates**
J. Pan, Q. Peng, Rahul

Center for Subsurface Sensing and Imaging Systems

**Interim Director:** Richard Radke

**CenSSIS Home Page:** [http://www.ecse.rpi.edu/censsis](http://www.ecse.rpi.edu/censsis)

The Center for Subsurface Sensing and Imaging Systems (CenSSIS) is a National Science Foundation Engineering Research Center (NSF-ERC) that conducts multidisciplinary research on common solutions to diverse problems for sensing and imaging objects that are hidden under a surface. This is part of a larger center involving Northeastern University, Boston University, University of Puerto Rico at Mayagüez, and several affiliate institutions including The Woods Hole Oceanographic Institute, Memorial Sloan-Kettering Cancer Center, Massachusetts General Hospital, Idaho National Engineering and Environmental Laboratory, and Lawrence Livermore National Laboratory. Examples of applications include deep confocal laser-scanning microscopy of minute subcellular objects, electrical impedance tomography of the human body and underground waste sites, retinal imaging, surgical planning for radiation treatment, and inspection of hidden defects in roads and bridges. These diverse applications are addressed using advanced computer algorithms for tomographic image reconstruction, image analysis, and computer vision. Some projects involve design and fabrication of working prototypes using advanced electronics, processors, and embedded algorithms. Graduate and undergraduate students participate on various projects at the center. Opportunities also exist for qualified K-12 students to participate in selected projects.

**Affiliated Faculty**
School of Humanities, Arts, and Social Sciences

Dean: Mary H. Simoni

Associate Dean of Undergraduate Programs and Curriculum Initiatives: C.L. Odell
Associate Dean of Graduate Programs and Research Initiatives: Nancy D. Campbell

School of Humanities, Arts, and Social Sciences Home Page: http://www.hass.rpi.edu

In an historic technological institution, the Rensselaer School of Humanities, Arts, and Social Sciences (HASS) offers exciting new Institute research areas as well as broad university educational opportunities. The School’s five departments offer innovative and interdisciplinary programs of study at both the undergraduate and graduate levels. The undergraduate programs include: majors in humanities, social science, and arts disciplines; collaborations and dual majors for students of all schools; and a core curriculum that is a common element in the course of study for all Rensselaer students. The graduate programs in HASS offer unique opportunities for study of the technological world, its impact on society, and its potential contributions to social, cultural, and artistic goals. All HASS students have a broad choice of electives representing Rensselaer’s global vision and commitment to personal excellence though new studies in arts, communications, and culture studies as well as to the traditional areas of liberal arts and social sciences.

HASS programs at Rensselaer give every student close contact with outstanding faculty members. Those faculty—scholars and practitioners themselves—create programs that are distinctive for research applications at both the undergraduate and graduate levels. Students also have access to field work and studio experiences, internships and professional co-op opportunities, outstanding electronic laboratories and computer facilities, and, above all, opportunities to cross boundaries and to develop new interdisciplinary projects. These programs integrate the intellectual depth and the practical experience needed for leadership careers in business, non-profit corporations, government and government-related organizations, higher education, and arts. Our students do not only participate in the technological world: they create it, and they shape it.

Undergraduate and graduate degree programs are offered in five degree granting departments, including Arts; Cognitive Science; Economics; Language, Literature, and Communication; and Science and Technology Studies. In addition, students can major in interdisciplinary programs that integrate scientific and technical tools with the arts, social sciences, communication, and humanities. These include Electronic Media, Arts, and Communication (EMAC), Design, Innovation and Society (DIS), and Games and Simulation Arts and Sciences (GSAS) at the undergraduate level; and Ecological Economics, Values, and Policy (EEVP) at the graduate level.

Degrees Offered and Associated Departments

| Cognitive Science | Cognitive Science |
| Communication | Communication and Media |
| Communication and Rhetoric | Communication and Media |
| Design, Innovation and Society | Interdisciplinary |
| Ecological Economics | Economics |
| Ecological Economics, Values, and Policy | Interdisciplinary |
| Economics | Economics |
| Electronic Arts | Arts |
| Electronic Media, Arts, and Communication | Interdisciplinary |
| Games and Simulation Arts and Sciences | Interdisciplinary |
| Philosophy | Cognitive Science |
| Psychology | Cognitive Science |
| Science, Technology, and Society | Science and Technology Studies |
| Science and Technology Studies | Science and Technology Studies |
| Sustainability Studies | Science and Technology Studies |
| Technical Communication | Language, Literature, and Communication |
Overview of Undergraduate Programs

Individual departments in the School of Humanities, Arts, and Social Sciences offer Bachelor of Science degree programs in each of the following curricula: Communication, Economics, Electronic Arts, Philosophy, Psychology, and Science and Technology Studies.

In addition, a number of interdisciplinary programs are also available. These programs are offered jointly between two or more departments within the school or with other Institute schools. HASS interdisciplinary degree programs include the following, all of which are explained in greater detail under the heading Interdisciplinary Programs and Research at the end of the HASS section of this catalog.

- Electronic Media, Arts, and Communication (EMAC) – The departments of Arts and of Communication and Media offer this B.S. degree, which combines theory and practice through electronic media arts studio and theory courses.
- Design, Innovation, and Society (DIS) – This innovative design program combines engineering courses, STS courses, and design studios.
- Games and Simulation Arts and Sciences (GSAS) is an innovative, second generation game development program that integrates arts, cognitive science, computer science, human-computer interaction, and management.

In all curriculum areas, HASS strives to provide flexibility whenever possible. As part of this effort, the department offers the Independent Study Program, which fills specialized educational needs in areas that regular departmental offerings do not adequately serve. Independent Study is an individualized reading or research program that a student proposes to a faculty member whose expertise covers a specific area of interest. Students interested in Independent Study must meet a number of conditions including:

- Demonstration of an ability to work independently as well as completion of the prerequisites needed to undertake the project successfully.
- Evidence that no equivalent course is available at Rensselaer or at any of the consortium institutions in the Capital District or that the student is unable to schedule such a course due to unusual curricular demands.
- The faculty member has sufficient time to supervise the proposed course of study.
- Development of a written agreement spelling out the scope of the work to be done, the expected deliverables, and the evaluation criteria to be applied.
- Provision of a description of the amount of work expected and an understanding that the level at which it is to be completed must be similar to the demands of an equivalent course.
- The ability of faculty members to place additional constraints on the participation in the Independent Study.

HASS Core Program

As part of their B.S. degree program, all Rensselaer undergraduates take a selection of HASS courses referred to as the HASS core. This core is the foundation of undergraduate education. In it, students develop the skills necessary for personal and professional success, and they also begin to explore the social and cultural areas of study and issues of debate that are important in the global society of the twenty-first century.

The core consists of 24 credit hours, or six courses distributed to afford students a breadth of perspective across the various disciplines as well as a more in-depth experience in at least one area. Engineering students automatically take two of the 24 credit hours as professional development in their engineering design sequence and take a two-credit HASS professional development course in their junior year.

To ensure breadth in the core courses, students must select at least two courses (eight credit hours) from each of the lists below.

### HUMANITIES

<table>
<thead>
<tr>
<th>HUMANITIES</th>
<th>CODE</th>
<th>SOCIAL SCIENCES</th>
<th>CODE</th>
</tr>
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<tbody>
<tr>
<td>Foreign Languages</td>
<td>LANG</td>
<td>Economics</td>
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<td>Literature</td>
<td>LITR</td>
<td>Science and Technology Studies, Social Science</td>
<td>STSS</td>
</tr>
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<td>Communication</td>
<td>COMM</td>
<td>Psychology</td>
<td>PSYC</td>
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<tr>
<td>Writing</td>
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<td>Interdisciplinary Studies</td>
<td>IHSS</td>
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<td>Arts</td>
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<tr>
<td>Philosophy</td>
<td>PHIL</td>
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<tr>
<td>Science and Technology Studies, Humanities</td>
<td>STSH</td>
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</tr>
<tr>
<td>Interdisciplinary Studies</td>
<td>IHSS</td>
<td></td>
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</tbody>
</table>

IHSS interdisciplinary courses may be substituted for courses in either category.

196 SCHOOL OF HUMANITIES, ARTS, AND SOCIAL SCIENCES
To ensure depth in the HASS core, students must also take at least two courses within a single area code (STSH and STSS can be counted as a single area), at least one of which is taken at an advanced level (above 1000). No course within the depth sequence may be taken as Pass/No Credit.

No more than three 1000-level HASS courses may be applied toward the HASS core requirement, no more than six credits may be taken as Pass/No credit, and at least one course (four credits) must be at the 4000 level.

Students entering Rensselaer in their first year may transfer up to two HASS courses (up to eight credit hours) toward their HASS core requirement (including Advanced Placement credit).

Transfer students from an accredited collegiate program who have completed at least one college year but who come to Rensselaer with first-year status may qualify for additional core transfers at the discretion of the HASS curriculum adviser. Transfer students entering Rensselaer at the sophomore level or above are not limited in the number of courses they may transfer for HASS core credit. All others must take at least 16 credit hours of their HASS core at Rensselaer.

Enrolled Rensselaer students wishing to take an HASS course for credit at another accredited institution must obtain prior approval for the course from the core curriculum adviser. Applicants must furnish a catalog description of the proposed course and a completed copy of Rensselaer’s Transfer Credit Approval form to the core curriculum adviser. A maximum of two courses (up to eight credit hours) of transfers is allowed (including AP courses).

Special Undergraduate Opportunities

Accelerated Prelaw Program – This opportunity is offered within the Department of STS in cooperation with Albany Law School and other law schools. For additional details, see the Science and Technology Studies section of this catalog.

Overview of Graduate Programs

The School of Humanities, Arts, and Social Sciences offers both master’s and doctoral level programs. In addition, it provides a selection of special certificate program opportunities.

Master’s Programs

Within HASS, three types of master’s degrees are available. Among these are 30-credit-hour M.S. degrees, offered within the departments of Language, Literature, and Communication, Economics, and Science and Technology Studies.

Another 30-credit-hour Professional Master’s program is intended for individuals already in the work force who are seeking a professional focus. Professional Master’s are available in Ecological Economics, Values, and Policy (EEVP). Finally, HASS offers a 60-credit-hour Master of Fine Arts in Electronic Arts through the Arts Department.

Doctoral Programs

Programs leading to the Doctor of Philosophy degree (Ph.D.) are offered in Electronic Arts, Cognitive Science, Ecological Economics, Science and Technology Studies, and Communication and Rhetoric. Individual courses and opportunities for directed study are also available in other areas.

Special Graduate Opportunities

Certificate Programs – The Department of LL&C offers two specialization certificates, one in Graphics and the other in Human-Computer Interaction, as options in the master’s degree in technical communication.
Arts

Acting Head: Caren Canier

Director of Graduate Studies: Curtis Bahn

Department Home Page: http://www.arts.rpi.edu/

The Department of the Arts is dedicated to interdisciplinary creative research in electronic arts. It offers a unique environment to develop and realize innovative art within a technological university. The department offers three degree programs in Electronic Arts: a Bachelor of Science, a Master of Fine Arts, and a Doctor of Philosophy. Also offered jointly with the Department of Communication and Media is a B.S. in Electronic Media, Arts, and Communication. These programs provide students with an opportunity to pursue a degree with a particular emphasis on the use of technology and an interdisciplinary approach to electronic arts.

Within this department, studio courses engage students in hands-on activities that stress creative and expressive development. They also encourage students to develop their perceptual sensitivity, as well as to build their confidence to apply creative exploration and problem-solving skills to a wide range of aesthetic challenges. In addition to a full complement of traditional disciplines such as drawing, painting, sculpture, music, filmmaking, and performance, the department offers courses in electronic media including digital video, computer imaging and animation, interactivity, multimedia installation, and computer music.

Research Innovations and Initiatives

Arts department faculty members take varying approaches to the use of electronic media in artistic creation and performance. All are active artists/theoreticians whose works are represented internationally in museums, galleries, and performance venues.

Arts majors are required to become familiar with creative tools in a variety of electronic media and are encouraged to work with combinations of media. The center of such creative work is the Integrated Electronic Arts at Rensselaer (iEAR) Studios, which include professional quality facilities in electronic and computer music, digital video production and post production, computer imaging and animation, interactive media, installation art, and performance art. In addition, qualified students in the M.F.A. and Ph.D. programs may use elective credits to explore Rensselaer’s extensive technological resources. Opportunities to engage in creative or research projects with students or faculty from other departments or schools within the Institute are also possible.

Faculty *

Professors

Canier, C.—M.F.A. (Boston University); painting, drawing, 2D design.

Century, M.—M.A. (University of California, Berkeley); new media history and theory, contemporary music performance, innovation studies.

Goebel, J.—M.A. (Staatliche Hochschule für Music und Theater); music composition and performance.

Kagan, L.—M.A. (University at Albany); studio arts.

Miller, B.—M.F.A. (New York University Graduate Film and Television Program); video art, media art.

EMPAC Affiliated Faculty and Professors of Practice

Knowles, E. A.—Ph.D. (University at Albany); African and Afro-Cuban music and dance.

Oliveros, P.—Honorary Dr. of Music (DeMontfort University UK); music composition, electronic music, improvisation.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
**Associate Professors**

Bahn, C.—Ph.D. (Princeton University); computer music and interactive performance.

Bustamante, N.—M.F.A. (San Francisco Art Institute); new genres, performance art, video/filmmaking, sculpture installation.

Chang, B.—M.F.A. (School of Art Institute of Chicago); virtual reality, experimental games, interactive installation, open source software.

Hahn, T.—Ph.D. (Wesleyan University); ethnomusicology, performance art, dance.


Lawson, S.—M.F.A. (School of the Art Institute of Chicago); real-time graphics, interactive installation, locative media.

Ruiz, K.—abd Ph.D. (Europäische Universität für Interdisziplinäre Studien, EGS); interactive simulation, game studies, photography and emerging multidisciplinary genres.

Staniszewski, M.—Ph.D. (Graduate School and University Center, City University of New York); modern and contemporary art, culture, and media history.

Vamos, I.—M.F.A. (University of California at San Diego); tactical media, video, film production and theory.

**Undergraduate Programs**

At Rensselaer, the Department of the Arts offers bachelor’s degree programs in Electronic Arts (EART); Electronic Media, Arts, and Communication (EMAC); Games and Simulation Arts and Sciences (GSAS); and Information Technology and Web Science-Arts. Information and requirements specific to each program are described below.

**Baccalaureate Programs**

As explained in the Humanities, Arts, and Social Sciences introduction, all baccalaureate students take 24 credit hours of core courses. The Institute also requires all students to complete a 24-credit-hour math/science requirement. Required courses in mathematics and sciences are: MATH 1500 Calculus I for Humanities and Social Science, MATH 1620 Contemporary Ideas in Math, CSCI 1100 Computer Science or CSCI 1010 Introduction to Computer Programming, and BIOL 1010, Introduction to Biology. MATH 1010 Calculus I and MATH 1020 Calculus II may be substituted for MATH 1500 and MATH 1620, respectively. For more information, see a departmental adviser.

**Electronic Arts**

The B.S. degree in Electronic Arts (EART) provides a foundation for students who aspire to careers as practicing artists in the digital age. Combining traditional studio and theory courses in the Fine Arts with Electronic Arts disciplines, the program familiarizes students with the full range of creative digital media and allows them to select areas of concentration in such fields as video, animation and visualization, computer music and sound design, game design, multimedia, installation, interactivity, and performance art.

Situated within the context of a technological university, Rensselaer’s art program offers a unique creative environment in which to explore the relationship between the creative arts and emerging technologies.

Rensselaer’s location within a thriving community of technological innovation and proximity to art and cultural centers such as Williams College, Massachusetts Museum of Contemporary Art (MASS MoCA), Dia: Beacon, Bard College, and Bennington College further strengthens its arts programs.

Applicants must submit a portfolio and written statement of interest. In this statement, an applicant should address his or her specific interests in the program, desire to work with electronic media, and a description of work submitted in the portfolio. The successful portfolio should include 10 to 20 examples of work that shows excellence as an artist and a desire to work with electronic arts tools. The portfolio should represent what the applicants consider to be their best work in any medium.

All majors in the Electronic Arts take a total of 60 credits in the field, including a 24-credit sequence of Arts foundation courses, as well as eight credits of Creative Seminar. The remaining 28 credits for the major are configured to allow the student to concentrate in one of four tracks:

- Visual Arts & Animation
- Computer Music & Sound Art
- Media, Ecology, Entrepreneurship and Experimentation

Typical programs for each of the concentrations are shown in the four templates below:
## COMPUTER MUSIC AND SOUND ART CONCENTRATION

### FIRST YEAR

<table>
<thead>
<tr>
<th>Fall</th>
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<tr>
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<tr>
<td>ARTS 1200: Basic Drawing</td>
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<tr>
<td>MATH 1010: Calculus I</td>
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<tr>
<td>or</td>
<td></td>
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<tr>
<td>MATH 1500: Calculus for Architecture, Management, and HASS</td>
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</table>

<table>
<thead>
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<tbody>
<tr>
<td>ARTS 1020: Media Studio: Imaging</td>
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<td>ARTS 2400: Music Theory I</td>
<td>4</td>
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<tr>
<td>ARTS 2540: The Multimedia Century</td>
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<td>MATH 1620: Contemporary Mathematical Ideas in Society</td>
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### SECOND YEAR

<table>
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<tr>
<td>ARTS 2020: Computer Music</td>
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<td>CSCI 1010: Introduction to Computer Programming</td>
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<td>or</td>
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<td>CSCI 1100: Computer Science I</td>
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</thead>
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<tr>
<td>ARTS 4400: Music Theory II</td>
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</tr>
<tr>
<td>ARTS 4410: Deep Listening</td>
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</tr>
<tr>
<td>BIOL 1010: Introduction to Biology</td>
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<tr>
<td>ARTS xxxx: Performance Elective</td>
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<tr>
<td>HASS Elective</td>
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</table>

### THIRD YEAR

<table>
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<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 4130: New Media Theory</td>
<td>4</td>
</tr>
<tr>
<td>ARTS xxxx: Advanced Technical Elective</td>
<td>4</td>
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<tr>
<td>ARTS xxxx: Performance Elective</td>
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<tr>
<td>Science Elective</td>
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<thead>
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<th>Spring</th>
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<tbody>
<tr>
<td>ARTS xxxx: History/Culture Elective</td>
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<tr>
<td>ARTS xxxx: Performance Elective</td>
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### FOURTH YEAR

<table>
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<tr>
<th>Fall</th>
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<tr>
<td>ARTS 4840: Creative Seminar I</td>
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<td>ARTS 4850: Creative Seminar II</td>
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1 BIOL 1010 is not required if first major is Engineering.
Electives

Performance Electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 2300</td>
<td>Rensselaer Orchestra</td>
<td>1</td>
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<tr>
<td>ARTS 2310</td>
<td>Rensselaer Concert Choir</td>
<td>1</td>
</tr>
<tr>
<td>ARTS 2320</td>
<td>Percussion Ensemble</td>
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<tr>
<td>ARTS 2330</td>
<td>Jazz Ensemble</td>
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<tr>
<td>ARTS 2340</td>
<td>Introduction to Afro-Cuban Percussion</td>
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</tr>
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<td>ARTS 296x</td>
<td>Performance Topics Courses</td>
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History/Culture Electives

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<tr>
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<td>ARTS 2500</td>
<td>History of Western Music</td>
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<td>History of Jazz</td>
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<tr>
<td>ARTS 2520</td>
<td>World Music</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 296x</td>
<td>Audio Culture</td>
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<tr>
<td>ARTS 496x</td>
<td>History/Theory Topics Courses</td>
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Advanced Technical Electives and Advanced Studio

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<tr>
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</tr>
<tr>
<td>ARTS 4030</td>
<td>Multimedia Performance Systems</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4050</td>
<td>Professional Collaboration</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 496x</td>
<td>Advanced Computer Music</td>
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<tr>
<td>ARTS 496x</td>
<td>Creative Collaborations</td>
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<tr>
<td>ARTS 496x</td>
<td>Music Composition</td>
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<tr>
<td>ARTS 496x</td>
<td>Technical/Studio Topics Courses</td>
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MEDIA, ECOLOGY, ENTREPRENEURSHIP AND EXPERIMENTATION CONCENTRATION

FIRST YEAR

Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 1200</td>
<td>Basic Drawing</td>
<td>4</td>
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<tr>
<td>ARTS 2530</td>
<td>Art History I: From Paleolithic to Renaissance</td>
<td>4</td>
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<tr>
<td>or IHSS 196x</td>
<td>Explorations in Media</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
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<tr>
<td>or MATH 1500</td>
<td>Calculus for Architecture, Management, and HASS</td>
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Spring

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 1010</td>
<td>Music and Sound</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 1020</td>
<td>Media Studio: Imaging</td>
<td>4</td>
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<tr>
<td>ARTS 2540</td>
<td>The Multimedia Century</td>
<td>4</td>
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<tr>
<td>MATH 1620</td>
<td>Contemporary Mathematical Ideas in Society</td>
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SECOND YEAR

Fall

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<td>ARTS 2010</td>
<td>Intermediate Video</td>
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<tr>
<td>ARTS 4410</td>
<td>Deep Listening</td>
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<td>CSCI 1010</td>
<td>Introduction to Computer Programming</td>
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<td>or CSCI 1100</td>
<td>Computer Science I</td>
<td>4</td>
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<td>HASS Elective</td>
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Spring

<table>
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<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>ARTS 2040</td>
<td>Intermediate Digital Imaging</td>
<td>4</td>
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<td>or ARTS 2070</td>
<td>Graphic Storytelling</td>
<td>4</td>
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<tr>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
<td>4</td>
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<tr>
<td>HASS Elective</td>
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1 Biol 1010 is not required if first major is Engineering.
### Third Year

<table>
<thead>
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<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Fall</td>
<td>ARTS 4130</td>
<td>New Media Theory</td>
<td>4</td>
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<tr>
<td>Fall</td>
<td>ARTS 4xxx</td>
<td>Advanced Video Topics</td>
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<td>Science Elective</td>
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<td>HASS Elective</td>
<td>4</td>
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<tr>
<td>Spring</td>
<td>ARTS 4xxx</td>
<td>Advanced Radical Culture Topics</td>
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### Fourth Year

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<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Fall</td>
<td>ARTS 4840</td>
<td>Creative Seminar I</td>
<td>4</td>
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<td>Fall</td>
<td>ARTS 49xx</td>
<td>Advanced Video Topics</td>
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<tr>
<td></td>
<td></td>
<td>or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ARTS 4xxx</td>
<td>Advanced Radical Culture Topics</td>
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<td>Spring</td>
<td>ARTS 4850</td>
<td>Creative Seminar II</td>
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### Recommended Classes

- ARTS 496X Advanced Video: Topics (including Postproduction; TV Content & Development Studio, Writing and Directing for Video, Speculative Fiction, Expanded Video)
- ARTS 496X Advanced Radical Culture; Topics (including Art, Community and Technology; Eco Chic; Creative Activism Globalism; Urban Survival)
- ARTS 496X Pure Performance
- ARTS 496X Inflatables Public Sculpture
- ARTS 2060 Fundamentals of Animation
- ARTS 4010 Interactive Arts Programming
- ARTS 4060 Animation I

### Visual Arts and Animation Concentration

### First Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Fall</td>
<td>ARTS 1020</td>
<td>Media Studio: Imaging</td>
<td>4</td>
</tr>
<tr>
<td>Fall</td>
<td>ARTS 1200</td>
<td>Basic Drawing</td>
<td>4</td>
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<tr>
<td></td>
<td>MATH 1010</td>
<td>Calculus I</td>
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<td>MATH 1500</td>
<td>Calculus for Architecture, Management, and HASS</td>
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<td>HASS Elective</td>
<td>4</td>
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<tr>
<td>Spring</td>
<td>ARTS 2530</td>
<td>Art History I: From Paleolithic to Renaissance</td>
<td>4</td>
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<td></td>
<td>MATH 1620</td>
<td>Contemporary Mathematical Ideas in Society</td>
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## SECOND YEAR

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<th>Title</th>
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<td>ARTS 1010</td>
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<td>CSCI 1010</td>
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<td>CSCI 1100</td>
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<tr>
<td>ARTS 2xxx</td>
<td>2000 Visual Arts Elective</td>
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### Spring

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<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>ARTS 2540</td>
<td>The Multimedia Century</td>
<td>4</td>
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<tr>
<td>BIOL 1010</td>
<td>Introduction to Biology¹</td>
<td>4</td>
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<tr>
<td>ARTS 2xxx</td>
<td>2000 Visual Arts Elective</td>
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## THIRD YEAR

### Fall

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<tr>
<td>ARTS 4130</td>
<td>New Media Theory</td>
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## FOURTH YEAR

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<tbody>
<tr>
<td>ARTS 4840</td>
<td>Creative Seminar I</td>
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<td>ARTS 4xxx</td>
<td>4000 Visual Arts Elective</td>
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### Spring

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<tr>
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<td>ARTS 4xxx</td>
<td>4000 Visual Arts Elective</td>
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### Electives

#### 2000-Level Visual Arts Electives

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<td>ARTS 2010</td>
<td>Intermediate Video</td>
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<tr>
<td>ARTS 2040</td>
<td>Intermediate Digital Imaging</td>
<td>4</td>
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<tr>
<td>ARTS 2060</td>
<td>Fundamentals of Animation</td>
<td>4</td>
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<td>ARTS 2070</td>
<td>Graphic Storytelling</td>
<td>4</td>
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<td>ARTS 2210</td>
<td>Sculpture I</td>
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<tr>
<td>ARTS 2220</td>
<td>Fundamentals of 2-D Design</td>
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#### 4000-Level Visual Arts Electives

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<tr>
<td>ARTS 4010</td>
<td>Interactive Arts Programming</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4020</td>
<td>Advanced Digital 3-D Projects</td>
<td>4</td>
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<tr>
<td>ARTS 4060</td>
<td>Animation I</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4070</td>
<td>Animation II</td>
<td>4</td>
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<tr>
<td>ARTS 4200</td>
<td>Advanced Drawing</td>
<td>4</td>
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<tr>
<td>ARTS 4210</td>
<td>Sculpture II</td>
<td>4</td>
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<tr>
<td>ARTS 4220</td>
<td>Painting</td>
<td>4</td>
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<td>ARTS 4510</td>
<td>Experimental Game Design</td>
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<tr>
<td>ARTS 496x</td>
<td>Advanced Video</td>
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<td>ARTS 49xx</td>
<td>Topics Courses</td>
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<td>ARTS 4530</td>
<td>Game Development I (If not GSAS/EART dual major)</td>
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<tr>
<td>ARTS 4530</td>
<td>Game Development II (If not GSAS/EART dual major)</td>
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¹ BIOL 1010 is not required if first major is Engineering.
Information Technology and Web Science—Arts

The Information Technology and Web Science degree with a concentration in Arts presents an exciting program of study that emphasizes the creativity of studio arts in shaping and influencing information technology. The courses in this program are supported by the Integrated Electronic Arts at Rensselaer (iEAR) studios, an extensive state-of-the-art facility dedicated to interdisciplinary research and artistic development in interactivity, digital video, computer imaging, digital audio, animation, virtual reality, Web design, multimedia installation, and performance art. A series of courses is designed to give students hands-on experience with a full range of arts practice within Rensselaer’s unique technological environment. Intermediate and advanced courses offer the opportunity to focus on a specialized research area and develop innovative collaborative projects. This study in the Arts concentration provides both the theoretical foundation and practical experience needed for the many fast-growing digital arts and media careers. The degree is described in detail under the heading Information Technology and Web Science.

Minor Programs

Electronic Arts Minor

An electronic arts minor consists of 16 credits from the electronic arts curriculum. Students may follow one of the two options listed below to complete the minor. For more information, see departmental adviser.

Option A
- Two out of three introductory electronic arts courses: ARTS 1010, ARTS 1020, ARTS 1030
- One 2000-level electronic arts studio course
- One electronic arts history or theory course

Option B
- One of the three introductory electronic arts courses: ARTS 1010, ARTS 1020, ARTS 1030
- One 2000-level electronic arts studio course
- One 4000-level electronic arts studio course
- One electronic arts history or theory course

Music Minor

A music minor consists of 20 credits from the music curriculum. Students may fulfill the Music minor by fulfilling the requirements in one of the three tracks listed below:

Option A (Theory Track)
- ARTS 1010, ARTS 2400, and ARTS 4400
- One of ARTS 2500, ARTS 2530 or ARTS 2510
- One of ARTS 49xx (Music Composition), ARTS 4410 or ARTS 2020
  OR
- 4 Credits of Music Ensembles

Option B (Performance Track)
- ARTS 1010 - Music and Sound Credit Hours: 4
- ARTS 2400 - Music Theory I Credit Hours: 4
- 8 Credit hours of Performance Ensemble
  One out of three:
  - ARTS 2500 - History of Western Music Credit Hours: 4
  - ARTS 2530 - Art History I Credit Hours: 4
  - ARTS 2510 - History of Jazz Credit Hours: 4

Option C (Music Technology Track)
- ARTS 1010 and ARTS 2400
- ARTS 2020 - Computer Music Credit Hours: 4
- Select one of the following: ARTS 4010 - Interactive Arts Programming Credit Hours: 4, ARTS 49xx (Advanced Computer Projects), ARTS 4030 - Multimedia Performance Systems Credit Hours: 4 or ART 494x (Oliveros Research Seminar)
- Select one of the following: ARTS 2500 - History of Western Music Credit Hours: 4, ARTS 2520 - World Music Credit Hours: 4 or ARTS 2510 - History of Jazz Credit Hours: 4
  OR
- 4 credits of music ensembles
Studio Arts Minor

A studio arts minor consists of 16 credits from the studio arts curriculum, which includes courses in drawing, painting, and sculpture. All studio arts minors must take at least three studio courses, and at least one of these must be at the 4000 level. The remaining four credits may be filled by another studio course or an art history course.

Special Undergraduate Opportunities

Visiting Artists Series

The Department of the Arts supports the iEAR Presents! series which brings leading composers, performers, theorists, and media artists to campus for performances, exhibitions, lectures, and workshops. All students are encouraged to attend the rich variety of events both on campus and in the Capital District area.

Ensembles

The department offers credit-bearing ensembles that may be applied toward the music minor: Rensselaer Orchestra, Rensselaer Concert Choir, Jazz Ensemble, Percussion Ensemble, Intro to Afro-Cuban Percussion, and Chamber Music Ensemble. Many noncredit ensembles, dictated by student interest, are available on campus. Typical examples have included symphonic band, pep band, swing band, and vocal groups such as the Rensselyrics and the Rusty Pipes.

Graduate Programs

Master of Fine Arts in Electronic Arts

The M.F.A. program is designed for students pursuing artistic and academic careers emphasizing electronic media. Admission is highly competitive, and applicants must have completed a bachelor’s degree and display a high level of ability in any artistic medium. The primary consideration in the selection process is evidence of talent and commitment to personal development as a creative artist.

The M.F.A. degree requires 60 credit hours of coursework at Rensselaer, including up to nine credit hours of master’s thesis. Completion of the degree generally takes two years. Independent creative work done under a faculty mentor’s supervision is encouraged. The degree emphasizes developing creative skills in digital video, computer music, imaging, animation, interactive media, performance, and installation art. The student’s work at Rensselaer culminates in a required thesis project, submission of written thesis document, and a thesis defense. The thesis project is a major artistic effort and may include a full-length performance, installation, or exhibition.

All students are expected to develop competency in using various media available in the iEAR Studios as well as in the theoretical and critical issues relevant to their fields of interest. Since the program is geared towards preparing students to participate actively in the art and music communities, practical aspects of production and presentation of creative work are emphasized.

The M.F.A. Plan of Study consists of 60 credit hours beyond the bachelor’s degree, including:

1. at least 30 credit hours in 6000-level courses
2. three history or theory courses at the 4000 or 6000 level, one of which must be: Electronic Arts Overview (ARTS 6110)
3. a demonstration of competency in interdisciplinary electronic arts
4. four credits of artistic residency through Professional Collaboration (ARTS 4050)
5. enrollment in Electronic Arts Practice (ARTS 6080) every fall semester of residency
6. two to nine credits of Master’s Thesis (ARTS 6990) in the second year of residency
7. required public presentation and participation in critiques at the end of each semester

1 Individual requirements can be waived, in exceptional circumstances, by the department without decreasing the total number of credits for the degree. It is possible to reduce the total number of credits taken at Rensselaer by transferring up to six credits of previous graduate work.
2 History/theory courses may be either four credits (4000-level courses) or 3 credits (6000-level courses).
3 Competency is demonstrated through two qualifying reviews. Each student will participate in two end-of-semester departmental critiques, which will be judged by the Electronic Arts Faculty. The first review will identify the technical and creative areas to be addressed in the second review. The faculty must agree that the student’s work shows competency and artistic merit in interdisciplinary media in order for the student to progress toward his or her final thesis.
4 When enrolled for Master’s Thesis credits, students will also be expected to have regular individual meetings with their advisers. In their final two semesters of residency, students must enroll in a minimum of one thesis credit each semester. The maximum number of thesis credits in which a student can enroll is nine.
Doctoral Programs

Electronic Arts Ph.D.

The Ph.D. in Electronic Arts is an interdisciplinary arts degree that integrates arts practice with theoretical and historical research. The core of the program is the student’s own creative work, enhanced by course work and culminating in a dissertation.

Rensselaer’s Department of the Arts is generally considered to be the first integrated electronic arts program within a research university in the United States. Continuing its leadership in the fields of electronic and multidisciplinary arts, Rensselaer is one of the first universities in the United States to offer a practice-based Ph.D. in the arts.

During the past fifteen years, the character of graduate education in the arts has been changing. The most visible new features are the prominence of the electronic arts, the development of interdisciplinary approaches, and, related in part to the previous two factors, Ph.D.s in interdisciplinary arts. New professional standards and opportunities require Ph.D.s in several areas.

1) Many artists are now exploring new domains of creativity, which necessitate advanced research in a variety of fields—communication technologies, biology, and gaming—to name a few.

2) In the university teaching market, many art and interdisciplinary arts departments have expanded what were previously positions filled only by those individuals with M.F.A.s to candidates who hold Ph.D.s.

3) There are a number of institutions for advanced creative study that offer research positions for individuals with Ph.D.s in the creative arts.

4) Curatorial positions in museums and university galleries are another professional option for individuals with a practice-based Ph.D.

Students must have an M.A., M.M., M.S., or an M.F.A. to be admitted to the program.

In addition to the standard transcripts, recommendations, and statement of background and goals, prospective students submit a portfolio of creative work, a research proposal, and a scholarly writing sample. Evaluation for admission to the program includes not only artistic merit, but also evidence of a creative orientation that is research-based and appropriate for the type of in-depth interdisciplinary scholarly study the Ph.D. program will provide.

The program is flexible in order to afford each student an opportunity to plan a course of study suited to his or her own creative and research objectives. To assure a coherent program, students maintain, with the adviser’s guidance, a Plan of Study that is established at the beginning of their first semester and amended as the student progresses through the program. The Plan of Study may include courses offered by the Arts Department as well as other Rensselaer departments and programs such as: video, computer music, science and technology studies, architecture, animation, cultural studies, Internet interventions, bio-technology, information technologies, genomic studies, musicology, cognitive science, mechanical engineering, acoustics, computer science, biomedical engineering, performance, and communication studies.

Requirements

Students are required to take at least 90 credit hours. At least two-thirds of the total credit hours, excluding dissertation credits, must contain the suffix numbers 6000-7990. Students must take a minimum of 18 credits of Dissertation (ARTS 9990).

Students will enroll in one or two research methods course/s:

1) A research methods course taken in the first year integrates theoretical and historical research methods with arts practice. This course will include the study of humanities research methods used for academic scholarship and writing.

2) Students dealing with empirical or social science issues will also be directed to take another research methods course in an appropriate discipline.

Colloquium

The Ph.D. Arts colloquium provides doctoral discourse and community for Arts at Rensselaer. The Ph.D. students will curate a series of guest speakers representing artists, researchers, theoreticians, historians, and curators to present their work at the colloquium. Related readings and writing assignments will be based on colloquium presentations. Ph.D. students are required to take the colloquium each semester until they have passed their Candidacy Examination.

Minimum 18 credits for Dissertation

Exams

Upon entering the program, the graduate student will meet with their academic adviser to discuss their interests, skills, and their projected Plan of Study. The academic adviser will discuss this information with the graduate program director and they will make recommendations.
concerning the student’s potential resource needs and the areas of study that would be beneficial for the student to develop as they prepare for their Candidacy Exam. In certain cases, the student may be asked to take courses in which credits are not applied to the final degree requirements.

**Entrance Evaluation**

All students will have to pass a Candidacy Exam, which is taken no earlier than the end of the second semester and within the first two years of the program. This examination determines if the student has made satisfactory progress. The Candidacy Exam is tailored to their areas of research. Exam questions are provided by the Doctoral Committee. Once students have passed the Candidacy Exam, they can proceed to dissertation research.

A student may apply for the candidacy examination, given by the doctoral committee, when his or her course work nears completion or when he or she has the approval of the doctoral committee.

A student is admitted to candidacy for the doctorate when he or she has passed the candidacy examination and received formal approval for such candidacy from his or her doctoral committee and department. When these requirements are met, the chair of the doctoral committee (the student’s adviser) should notify the Office of Graduate Education of the student's candidacy.

**Dissertation and Final Examination (Defense)**

The Electronic Arts dissertation can take either one of two formats:

- a traditional humanities or social science text presenting original research in the electronic arts; or
- an innovative creative project and a dissertation text, with the project and text presenting a unified, original contribution to the field of electronic arts.

When the dissertation is completed, the candidate must defend it in a public examination conducted by his or her doctoral committee.

**Course Descriptions**

Courses related to all Arts curricula are described in the Course Descriptions section of this catalog under the department code ARTS.
Research Innovations and Initiatives

Graduate training in Cognitive Science emphasizes research, modeling, and building of integrated cognitive systems. Within this broad scope the department has special strength in the following areas.

Artificial Intelligence
At Rensselaer AI is taken to be the field devoted to either engineering computational systems whose behavior is on par, or at least approaches, that of humans; or computational systems whose intelligence is regarded to be at once high by humans but qualitatively different than the capacities seen in humans. Of course, AI can be pursued in different ways. Here, given how AI is viewed, guidance as to how to engineer the relevant systems often comes from careful study of the cognitive powers of humans, including what forms of intelligence those powers classify as truly impressive.

Cognitive Engineering
Cognitive Engineering is the application of cognitive science theories to human factors problems. Putting cognitive theories to the test of real-world applications is a means of maintaining a focus on the truly important cognitive issues. At Rensselaer, cognitive engineering has two components; (1) research directed at solving applied problems, and (2) research directed at developing engineering tools that others with less cognitive training can use to solve applied problems.

Cognitive Robotics
Cognitive robotics is a field devoted to engineering robots whose actions are a function of knowledge, belief, preferences, plans, and so on. In short, a cognitive robot acts on the basis of the things that underlie the actions of human beings.

Computational Cognitive Modeling
Understanding an integrated cognitive system can be very complex. The possibilities for interaction among cognitive, perceptual, and action operations is astounding. The interplay of each of these with the other and with the external world cannot be simply predicted. Computational cognitive models provide a vehicle to manage this complexity with the goal of making progress towards understanding how integrated cognitive systems effect and are affected by their environment.

Computational Linguistics
We focus on language use that involves a deep understanding of semantics and intent. Work in the department includes integrating language parsing with reasoning about the world and people’s beliefs and desires; logically controlled languages for learning by reading; and using human language to retrieve and analyze information from heterogeneous sources.

Human and Machine Reasoning
Foci include logic-based and knowledge-based AI, theorem-proving, and psychology of reasoning. The multi-disciplinary group of researchers involved is known as Rensselaer Reasoning Group, which works out of the Rensselaer AI & Reasoning (RAIR) Lab.

Perception and Action
This area of research focuses on perception with an emphasis on its role in the performance of both routine and skilled goal-directed action. Current research topics include visually guided locomotion in real and virtual environments, the coordination of eye and hand movements, and the integration of perception and action with higher-level cognition (e.g., learning and attention). At Rensselaer, these topics are investigated from various theoretical perspectives, including ecological psychology, dynamical systems theory, and computational cognitive modeling.

Faculty*

Professors
Bringsjord, S.—Ph.D. (Brown University); logic and artificial intelligence, foundations of artificial intelligence and cognitive science, computational creativity.
Gray, Wayne D.—Ph.D. (University of California at Berkeley); interactive behavior, computational cognitive modeling, cognitive science.
Hendler, J.—Ph.D. (Brown University); artificial intelligence, semantic Web, agent-based computing and high performance processing.
Koller, J.M.—Ph.D. (University of Hawaii); Asian and comparative thought, social philosophy, philosophy of religion (emeritus).
McGuinness, D.L.—Ph.D. (Rutgers University); knowledge representation and reasoning, explanation, proof, trust, ontologies, semantic Web.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Puka, W.J.—Ph.D. (Harvard University); ethics, cognitive-moral psychology, and applied cognitive science.

Rea, M.S.—Ph.D. (Ohio State University); visual psychophysics, lighting.

Reid, L.D.—Ph.D. (University of Utah); physiological psychology of reinforcement, drug and alcohol addiction.

Sun, R.—Ph.D. (Brandeis University); computational cognitive modeling, cognitive architectures, skill learning, computational studies of consciousness, multi-agent interaction, connectionist and hybrid models.

Wallace, W.A.—Ph.D. (Rensselaer Polytechnic Institute); decision processes and cognition, decision support systems, improvisation, visualization and modeling.

Associate Professors

Cassimatis, N. L.—Ph.D. (Massachusetts Institute of Technology); integrated cognitive models, human-level artificial intelligence, physical reasoning, natural language understanding.

Fajen, B. R.—Ph.D. (University of Connecticut); visual perception, perception and action, ecological psychology, dynamical systems modeling; virtual reality.

Kalsher, M.J.—Ph.D. (Virginia Polytechnic Institute and State University); human factors, industrial/organizational psychology, applied experimental psychology.

Noble, R.G.—Ph.D. (University of California, Berkeley); psychobiology of choice and decision making.

Yang, Y.—Ph.D. (New York University); cognitive psychology, thinking, reasoning and decision-making, and cognitive science.

Assistant Professor

Si, M.—Ph.D. (University of Southern California); interactive narrative/serious game, embodied conversational agent (ECA), computational modeling of decision-making and emotion, emotion detection, human-computer interaction, multi-agent system.

Research Associate Professor

Schoelles, M.—Ph.D. (George Mason University); computational cognitive modeling, interactive behavior, natural language processing.

Lecturers

Destefano, M.—Ph.D. (Rensselaer Polytechnic Institute); games design, psychology of play, system dynamics.

Hubbell, C.L.—Ph.D. (University at Albany); behavioral neuroscience; psycho-pharmacology, learning.

Thero, D.—Ph.D. (University of Albany, SUNY); philosophy of religion, philosophy of science, ethics, history of philosophy.

Traver, H.—Ph.D. (University at Albany); affirmative action, interactive learning, sexual harassment, industrial/organizational psychology.

van Heuveln, B.—Ph.D. (State University of New York at Binghamton); reasoning and logic, philosophy of computation, philosophy of mind, artificial intelligence, cognitive science.

VerWys, C.—B.S. (University at Albany); social psychology, forensic psychology.

Walf, A.A.—Ph.D. (University at Albany); behavioral neuroscience, neuroendocrinology, behavioral endocrinology, plasticity in learning and emotions, hormonal modulation of growth of brain and body.

Adjunct Faculty

Anderson, K.—Ph.D. (University of Georgia); counseling/clinical psychology.

Carcasole, J.—M.A. (University at Albany); moral and political philosophy, justice and punishment, philosophy of mind, philosophy of language, epistemology.

Krueger, D.—M.A. (Northern Illinois University); Hume, personal identity, history of philosophy, and logic.

Milanese, J.—M.S. (University at Albany); philosophy of science, epistemology, environmental philosophy.

Ruecker, A.—M.A., MPA (City University of New York); cognitive and positive psychology; environmental psychology and human factors, health psychology, social psychology.
Undergraduate Programs

Baccalaureate Programs

At the undergraduate level, the department maintains separate programs in cognitive science, philosophy, and psychology, leading to the Bachelor of Science degree in each discipline, respectively. An important goal of the undergraduate program is to prepare students for careers in the rapidly growing “Information Economy,” marked by the confluence of computation and cognition.

Cognitive Science

Cognitive science is the scientific study of cognitive phenomena such as reasoning, decision making, memory, learning, language, perception, and action. This young and emerging interdisciplinary field lies at the intersection of psychology, computer science, and philosophy, and has further important links to neuroscience, linguistics, anthropology, mathematics, biology, and education.

Cognitive Science tries to understand one of the most complex and fascinating entities in the known universe — the human mind. Cognitive science also tries to understand other kinds of minds, whether they be animal minds, alien minds, or artificial minds. Thus, Cognitive Science promises to be the next ‘basic’ science, in line with physics, chemistry, and biology, as much of the research being conducted is aimed at discovering fundamental principles that underlie minds in general.

Just as the technologies based on physics, chemistry, and biology have had a tremendous impact on our lives, technology based on our understanding of cognitive systems has the potential to profoundly change the way we live and who we are. From using knowledge of human cognition to build ‘cognitively ergonomic’ tools and environments, to building devices to repair and augment cognitive skills and capacities, to creating artificially intelligent computers and robots, the applications of this discipline are right in line with Rensselaer’s slogan: “Why not change the world?”.

The Cognitive Science Department at Rensselaer is perfectly positioned to offer one of the very best degree programs of its kind in the world. While many cognitive science programs in the country have a definite focus on one of the contributing disciplines — whether this is psychology, computer science, philosophy, neuroscience, or linguistics — the cognitive science program at Rensselaer is truly interdisciplinary in that it carefully balances all of the important contributing fields. Moreover, students have ample opportunity to perform undergraduate research in any of the associated laboratories and research groups.

FIRST YEAR

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<td>BIOL 1010</td>
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<td>Minds &amp; Machines ..................................................... 4</td>
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<td>or PHIL 2130</td>
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SECOND YEAR

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<td>or PHIL 4480</td>
<td>Metaphysics and Consciousness ................................................ 4</td>
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<td>or PSYC 4370</td>
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THIRD YEAR

Fall

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Spring

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FOURTH YEAR

Fall

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Cognitive Science Elective Options

Choose two from:

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<td>PSYC 2xxx</td>
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<td>CSCI 4100</td>
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<td>CSCI 4480</td>
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<td>CSCI 4490</td>
<td>Robotics II</td>
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<td>ECSE 4540</td>
<td>Introduction to Image Processing</td>
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<td>PHIL 1120</td>
<td>Minds and Machines</td>
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<td>IHSS 1964</td>
<td>Minds &amp; Machines</td>
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<td>PHIL 2100</td>
<td>Critical Thinking</td>
<td>4</td>
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<td>PHIL 2130</td>
<td>Introduction to Philosophy of Science</td>
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<td>PHIL 4140</td>
<td>Intermediate Logic</td>
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<td>PHIL 4260</td>
<td>Philosophy of Artificial Intelligence</td>
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<td>PSYC 4110</td>
<td>Motivation and Performance</td>
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Philosophy

Philosophy is a search for understanding and wisdom through inquiry into fundamental questions regarding existence, knowledge and “how to live a good life.” Through research and reflection, philosophy seeks to answer humanity’s eternal questions: What is the nature of human consciousness? Does God exist? What is time? Space? Are numbers real? Is there only one way to reason? How are right and wrong determined? Of what does the good life consist? Does life have meaning?

Agreeing with Socrates that “the unexamined life is not worth living,” the department encourages students to develop their own philosophical understanding, helping them to think critically and creatively about their own experiences, values, and goals. The hoped for result is the development of a coherent and critical personal perspective that provides the foundation for a full and satisfying life, for the practice of responsible citizenship, and for the exercise of leadership in a changing world.
Whether working toward a bachelor’s degree in philosophy alone or toward a dual degree, students must complete at least 32 credit hours of work in philosophy or in related areas approved by their adviser. These must include:

1. At least one of either Introduction to Philosophy (PHIL 1110) or Minds & Machines (IHSS 1964, PHIL 1120) or Revolutions in Thought (IHSS 19xx) or Introduction to Philosophy of Science (PHIL 2130) or Introduction to Philosophy of Religion (PHIL 2830).

2. Introduction to Logic (PHIL 2140).

3. Capstone Experience in Philosophy (PHIL 4990).

4. Five additional courses in philosophy at least three of which are at the 4000 level or higher.

Each major will develop a Plan of Study in consultation with a departmental adviser in one of three general areas: Logic, Computation, and Mind; Philosophy of Science and Mathematics; or Philosophy of Human Values and Cultures. In the senior year, all philosophy majors must take PHIL 4990, Capstone Experience in Philosophy in which they will construct and carry out an in-depth investigation/activity relating to some area of philosophy and write a research report (undergraduate thesis) detailing their findings. Preparing this document will provide students with early training in thesis writing in the event that they pursue further study. Students will participate in their Capstone Experience under the guidance of a professor of their choosing or one selected based on the professor’s familiarity with the research topic.

### FIRST YEAR

#### Fall

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| BIOL 1010 | Introduction to Biology
| MATH 1010 | Calculus I
| or MATH 1500 | Calculus for Architecture, Management, and HASS
| IHSS 19xx | First Year Studies
| or Science Sequence option I |

#### Spring

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<th>Course</th>
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| MATH 1020 | Calculus II
| or MATH 1620 | Contemporary Mathematical Ideas in Society
| PHIL 1110 | Introduction to Philosophy
| Science Sequence option I |

### SECOND YEAR

#### Fall

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<th>Course</th>
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| PHIL 2140 | Introduction to Logic
| Science or Math Elective |
| Humanities Elective (2000 level) |
| Free Elective |

#### Spring

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### THIRD YEAR

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<tr>
<td>HASS Elective [same code 2000 level]</td>
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</tr>
</tbody>
</table>

#### Spring

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>Philosophy Elective</td>
<td></td>
</tr>
<tr>
<td>Philosophy Elective</td>
<td></td>
</tr>
<tr>
<td>Free Elective</td>
<td></td>
</tr>
<tr>
<td>HASS Elective [same code 4000 level]</td>
<td></td>
</tr>
</tbody>
</table>

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1 BIOL 1010 is not required if first major is Engineering.
Psychology

The field of psychology uses scientific methods and procedures to study all aspects of behavior and cognitive processes. Knowledge acquired about such topics as motivation, perception, learning, memory, personality, and social interaction is of major practical value in many settings (e.g., industry, education, health care).

Through the applied focus of many of its course offerings, the department provides a wide range of practical skills and knowledge that are useful in many different employment settings. At the same time, all undergraduate psychology students are equally well prepared for graduate work.

The department’s philosophy is to provide each student maximum flexibility in devising a specific Plan of Study. Psychology major requirements include the completion of four basic psychology courses (PSYC 1200 General Psychology, PSYC 4370 Cognitive Psychology or PSYC 4410 Sensation and Perception, PSYC 4310 Experimental Methods and Statistics, and PSYC 4990 Undergraduate Thesis) and the completion of at least 16 additional credit hours within the department. The latter courses are electives and students will choose them in consultation with departmental advisers.

In addition, students must complete the basic degree requirements in physical, life, and mathematical sciences. Again, students will consult with their advisers in selecting specific courses to meet these requirements in accordance with their individual interests and goals.

As is evident in the typical four-year program outlined below, PSYC 1200 General Psychology is usually taken in the first year, PSYC 4370 Cognitive Psychology or PSYC 4410 Sensation and Perception and PSYC 4310 Experimental Methods and Statistics in the third year and PSYC 4990 Undergraduate Thesis in the fourth year.

Due to the flexibility permitted in course selection, individual curricula may vary considerably within the framework of basic Institute degree requirements. Students are encouraged to supplement basic requirements in science and mathematics whenever feasible in order to take full advantage of Rensselaer’s education opportunities. A minimum of 124 credit hours is required to complete this curriculum.

FIRST YEAR

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1010</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1500</td>
<td>4</td>
</tr>
<tr>
<td>IHSS 19xx</td>
<td>4</td>
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</tbody>
</table>

1 BIOL 1010 is not required if first major is Engineering.
# SECOND YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>Science or Math Elective</td>
<td>4</td>
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<tr>
<td>Psychology Elective</td>
<td>4</td>
</tr>
<tr>
<td>Humanities Elective (2000 level)</td>
<td>4</td>
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<tr>
<td>Free Elective</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychology Elective (2000/4000 level)</td>
<td>4</td>
</tr>
<tr>
<td>Social Sci. Elective (2000 level)</td>
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</tr>
<tr>
<td>Free Elective</td>
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<tr>
<td>Free Elective</td>
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# THIRD YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 4370</td>
<td>Cognitive Psychology</td>
</tr>
<tr>
<td>PSYC 4410</td>
<td>Sensation and Perception</td>
</tr>
<tr>
<td>Psychology Elective</td>
<td>4</td>
</tr>
<tr>
<td>Psychology Elective</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective [same code 2000 level]</td>
<td>4</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 4310</td>
<td>Experimental Methods and Statistics</td>
</tr>
<tr>
<td>HASS Elective [same code 4000 level]</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
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</tr>
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</table>

# FOURTH YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 4990</td>
<td>Undergraduate Thesis</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

## Dual Majors

Dual majors are available in all (cognitive science, philosophy and psychology) department curriculum areas.

### Cognitive Science

Cognitive Science lends itself very well as a dual major with Computer Science, Games and Simulation Arts and Sciences, Mathematics, or Biology. Students majoring in Computer Science can be inspired by the findings in cognitive science to develop or improve algorithms used in Artificial Intelligence, or to design more ‘cognitively ergonomic’ computer interfaces. Students majoring in Games and Simulation Arts and Sciences could use Cognitive Science to figure out how to make virtual more engaging, or how to make synthetic characters more psychologically plausible. Mathematics majors can try to mathematically describe the complex workings of the human mind or brain. And finally, students majoring in biology may be interested in the effects of hormones or other chemicals on the brain and their subsequent effects on cognition and behavior.

### Philosophy

Majors that may be combined with philosophy to form a dual major include computer science, physics, mathematics, biology, architecture, and various engineering majors (e.g., computer systems engineer). These dual programs serve the needs of those students desiring to combine the virtues of a liberal arts education with those of science, architecture, or engineering to achieve an education that is practical, stimulating, and diverse.

For example, a student majoring in computer science or mathematics could take eight additional philosophy courses that might include PHIL 2140 Introduction to Logic, PHIL 4140 Intermediate Logic and PHIL 4420 Computability and Logic. For a biology-philosophy dual major, key courses might include PHIL 2960 Philosophy of Biology, PHIL 4300 Environmental Philosophy and PHIL 4310 Scientific Revolutions.
Psychology
Dual majors with psychology may include computer science; electrical, computer, and systems engineering; and decision science and engineering systems. A dual major in management and psychology is also available. The Lally School of Management has established certain requirements that must be completed for this major in addition to those described above. For further information and a list of requirements for this dual major, see the Lally School of Management section of this catalog.

Minor Programs
The Department of Cognitive Science provides a variety of minor programs within its curricula.

Brain and Behavior Minor
Program Requirements
This minor focuses on understanding how the structure, physiology, and chemistry of the brain shape human behavior and the practical implications of this understanding for medicine, psychology, and biotechnology. PSYC 1200 General Psychology is a prerequisite for this minor, and PSYC 4320 Behavioral Neuroscience is required for completion of the minor. The remaining two courses should be chosen from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 2940</td>
<td>Readings in Brain and Behavior</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 2960</td>
<td>Topics in Brain and Behavior</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4110</td>
<td>Motivation and Performance</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4410</td>
<td>Sensation and Perception</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4450</td>
<td>Learning</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4500</td>
<td>Drugs, Society, and Behavior</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4600</td>
<td>Cognition and the Brain</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4770</td>
<td>Psychopharmacology and Behavioral Toxicology</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4940</td>
<td>Readings in Psychology</td>
<td>1 to 4</td>
</tr>
<tr>
<td>PSYC 4960</td>
<td>Topics in Psychology</td>
<td>1 to 4</td>
</tr>
</tbody>
</table>

Cognition Minor
Program Requirements
This minor is designed to focus on those aspects of psychology relevant to the field of cognitive science. PSYC 1200 General Psychology is a prerequisite for this minor, and PSYC 4370 Cognitive Psychology is required for completion of the minor. The remaining two courses should be chosen from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 2120</td>
<td>Introduction to Cognitive Science</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4410</td>
<td>Sensation and Perception</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4510</td>
<td>Cognitive Modeling</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4620</td>
<td>Cognitive Engineering</td>
<td>4</td>
</tr>
</tbody>
</table>

Cognitive Science Minor
Each student seeking a minor in cognitive science will develop a Plan of Study in consultation with a departmental adviser. To complete the minor in cognitive science, a student chooses a minimum of four cognitive science courses.

COGS 2120 Introduction to Cognitive Science (required)

Three additional cognitive science courses, at least two of which are at the 4000 level.

Community and Health Psychology Minor
Program Requirements
This minor covers the applications of psychology in developing the understanding people need to exert a constructive control over their own behavior and their interactions in real-world social situations. PSYC 1200 General Psychology is a prerequisite, and PSYC 4720 Abnormal Psychology is a requirement for this minor. An additional two courses should be chosen from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 2730</td>
<td>Social Psychology</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 2940</td>
<td>Readings in Community and Health Psychology</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 2960</td>
<td>Topics in Community and Health Psychology</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4110</td>
<td>Motivation and Performance</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4340</td>
<td>Human Sexuality</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4400</td>
<td>Personality</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4500</td>
<td>Drugs, Society, and Behavior</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4770</td>
<td>Psychopharmacology and Behavioral Toxicology</td>
<td>4</td>
</tr>
<tr>
<td>PSYC 4940</td>
<td>Readings in Psychology</td>
<td>1 to 4</td>
</tr>
<tr>
<td>PSYC 4960</td>
<td>Topics in Psychology</td>
<td>1 to 4</td>
</tr>
</tbody>
</table>
**General Psychology Minor**
This customized minor is designed for students who want to take a set of psychology courses that do not satisfy the requirements of any of the other psychology minors. The courses must be chosen in consultation with an adviser and must share a common theme.

**Requirements**
The student must consult with an adviser before the third psychology course is selected to determine the remaining two courses. Four courses are required for this minor with at least one of the courses at the 4000 level.

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 1200 General Psychology (required)</td>
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**Human Factors Minor**

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 2940 Readings in Human Factors</td>
</tr>
<tr>
<td>PSYC 2960 Topics in Human Factors</td>
</tr>
<tr>
<td>PSYC 4160 Human Factors Seminar</td>
</tr>
<tr>
<td>PSYC 4370 Cognitive Psychology</td>
</tr>
<tr>
<td>PSYC 4940 Readings in Psychology</td>
</tr>
<tr>
<td>PSYC 4960 Topics in Psychology</td>
</tr>
</tbody>
</table>

**Industrial/Organizational Psychology Minor**

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 2730 Social Psychology</td>
</tr>
<tr>
<td>PSYC 4110 Motivation and Performance</td>
</tr>
<tr>
<td>PSYC 4940 Readings in Psychology</td>
</tr>
<tr>
<td>PSYC 4960 Topics in Psychology</td>
</tr>
<tr>
<td>PSYC 2940 Readings in Industrial/Organizational Psychology</td>
</tr>
<tr>
<td>PSYC 2960 Topics in Industrial/Organizational Psychology</td>
</tr>
</tbody>
</table>

**Logic, Computation, and Mind**

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHIL 2100 Critical Thinking</td>
</tr>
<tr>
<td>PHIL 2120 Introduction to Cognitive Science</td>
</tr>
<tr>
<td>PHIL 2140 Introduction to Logic</td>
</tr>
<tr>
<td>PHIL 4140 Intermediate Logic</td>
</tr>
<tr>
<td>PHIL 4260 Philosophy of Artificial Intelligence</td>
</tr>
<tr>
<td>PHIL 4420 Computability and Logic</td>
</tr>
<tr>
<td>PHIL 4440 Knowledge and Rationality</td>
</tr>
<tr>
<td>PHIL 4480 Metaphysics and Consciousness</td>
</tr>
</tbody>
</table>

**Philosophy Minor**
Each student seeking a minor in philosophy will develop a Plan of Study in consultation with a departmental adviser in one of three areas: Logic, Computation and Mind, Philosophy of Science and Mathematics, or Philosophy of Human Values and Cultures. To complete the minor in philosophy, a student chooses a minimum of four philosophy courses. These must include:

1. At least one of either Introduction to Philosophy (PHIL 1110) or Minds & Machines (IHSS 1964, PHIL 1120) or Introduction to Philosophy of Science (PHIL 2130) or Introduction to Philosophy of Religion (PHIL 2830).

2. Three additional philosophy courses in the minor area at least two of which are at the 4000 level or higher.
Philosophy of Human Values and Cultures

This minor studies the nature of values together with the natures of the religious, artistic, and cultural institutions of the societies that embody them.

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHIL 2100  Critical Thinking ...................................................... 4</td>
</tr>
<tr>
<td>PHIL 2500  Bioethics ........................................................... 4</td>
</tr>
<tr>
<td>PHIL 2600  Moral Development .................................................... 4</td>
</tr>
<tr>
<td>PHIL 2830  Introduction to Philosophy of Religion ....................................... 4</td>
</tr>
<tr>
<td>PHIL 4220  Social and Political Philosophy ............................................ 4</td>
</tr>
<tr>
<td>PHIL 4240  Ethics ............................................................. 4</td>
</tr>
<tr>
<td>PHIL 4520  Existentialism ........................................................ 4</td>
</tr>
<tr>
<td>PHIL 4740  Philosophy of Law ..................................................... 4</td>
</tr>
</tbody>
</table>

Philosophy of Science and Mathematics

Program Requirements

This minor explores the underlying assumptions, conceptual structures, and implications of scientific and mathematical knowledge.

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHIL 2130 Introduction to Philosophy of Science ....................................... 4</td>
</tr>
<tr>
<td>PHIL 2140  Introduction to Logic ................................................... 4</td>
</tr>
<tr>
<td>PHIL 2500  Bioethics ........................................................... 4</td>
</tr>
<tr>
<td>PHIL 4140  Intermediate Logic ..................................................... 4</td>
</tr>
<tr>
<td>PHIL 4300  Environmental Philosophy ............................................... 4</td>
</tr>
<tr>
<td>PHIL 4310  Scientific Revolutions ................................................... 4</td>
</tr>
<tr>
<td>PHIL 4360  Philosophical Problems of Space and Time .................................... 4</td>
</tr>
<tr>
<td>PHIL 4380  Philosophy of Mathematics .............................................. 4</td>
</tr>
<tr>
<td>PHIL 4440  Knowledge and Rationality ............................................... 4</td>
</tr>
</tbody>
</table>

Psychology Minor

To complete the minor in psychology, a student chooses a minimum of four psychology courses (15 or 16 credits), with at least one at the 4000 level.

Social Psychology Minor

Program Requirements

This minor focuses on the personal and situational factors influencing social behavior. Individuals will develop techniques to enhance their social perception, decision-making, group influences on behavior and attitudes. PSYC 1200 General Psychology is a prerequisite for this minor and PSYC 2730 Social Psychology is a requirement. An additional two courses should be chosen from the following:

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 2600  Moral Development ...................................................... 4</td>
</tr>
<tr>
<td>PSYC 2940  Readings in Social Psychology</td>
</tr>
<tr>
<td>PSYC 2960  Topics in Social Psychology</td>
</tr>
<tr>
<td>PSYC 4340  Human Sexuality ...................................................... 4</td>
</tr>
<tr>
<td>PSYC 4400  Personality .......................................................... 4</td>
</tr>
<tr>
<td>PSYC 4720  Abnormal Psychology .................................................. 4</td>
</tr>
<tr>
<td>PSYC 4940  Readings in Psychology .............................................. 1 to 4</td>
</tr>
<tr>
<td>PSYC 4960  Topics in Psychology ................................................ 1 to 4</td>
</tr>
</tbody>
</table>

Sport Psychology Minor

Program Requirements

This minor focuses on the psychological study of human behavior in sport and physical activity. Individuals will develop and refine their knowledge of the relationship between sport and a variety of traditional areas of psychology such as the principles of learning and behavior, motivation, social psychology, personality theory, and psychological assessment. This knowledge, in turn, may be applied to traditional issues in sport and physical activity such as effective coaching, enhancing athletic motivation, and exercise adherence. PSYC 1200 General Psychology is a prerequisite for this minor and PSYC 2800 Introduction to Sport Psychology is a requirement. PSYC 4961 Sport Psychology Seminar is recommended. An additional two courses should be chosen from the following:

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC 2730 Social Psychology ...................................................... 4</td>
</tr>
<tr>
<td>PSYC 2940  Readings in Sport Psychology</td>
</tr>
<tr>
<td>PSYC 4110  Motivation and Performance ............................................ 4</td>
</tr>
<tr>
<td>PSYC 4400  Personality .......................................................... 4</td>
</tr>
<tr>
<td>PSYC 4410  Sensation and Perception ................................................ 4</td>
</tr>
<tr>
<td>PSYC 4450  Learning ............................................................ 4</td>
</tr>
<tr>
<td>PSYC 4940  Readings in Psychology .............................................. 1 to 4</td>
</tr>
</tbody>
</table>
Graduate Programs

Master’s Programs

The Cognitive Science Department offers a Master of Science degree in Cognitive Science. The degree is open only to two groups of students. The first group is those who are already admitted to Rensselaer in a doctoral program. This includes students in the Cognitive Science doctoral program as well as students in other doctoral programs (e.g., Decision Sciences and Engineering Systems, Computer Science, and so on). Rensselaer doctoral students who desire a Master’s in Cognitive Science should contact the department directly. Other students able to obtain a Master of Science degree in Cognitive Science are those in our five-year program that combines the Bachelor of Science in Psychology or Philosophy with the Cognitive Science master’s. See co-terminal B.S./M.S. programs for more information.

Co-terminal B.S./M.S. Programs

Qualified students, in consultation with an academic adviser, may design a five-year program to complete requirements for the Bachelor of Science in Psychology or Philosophy and the Master of Science in Cognitive Science. An additional 30 credit hours are required beyond the B.S. degree. Students must apply to the program prior to or early in the first semester of their junior year. This is a research-oriented Cognitive Science program that allows students to focus on one of the department's research areas. Prior to applying, it is expected that students will have taken introductory courses in cognitive psychology, philosophy of mind, and cognitive science, as well as been involved in one of the several research labs sponsored by department faculty.

Doctoral Program

The mission of the doctoral program in Cognitive Science is to train the next generation of world-class cognitive scientists and make seminal contributions to the field. In keeping with the interdisciplinary nature of cognitive science, this program trains students to integrate theories, methods, and tools from a variety of fields.

Because there are no traditional qualifiers, students become engaged in research from the beginning of their first semester in the program. Students work closely with individual faculty as well as teams of faculty, post-docs, and graduate students whose research interests include computational cognitive modeling, artificial intelligence, human and machine reasoning, computational linguistics, perception and action, theoretical neuroscience, cognitive robotics, cognitive engineering and advanced synthetic characters. There is a strong emphasis on building models of natural and artificial cognitive systems using formal, quantitative, and mathematical tools. The department has excellent research facilities, such as eye tracking equipment, an array of robotics equipment, and a large-scale immersive virtual environment lab. For information and guidance about applying to this new Ph.D. program, please contact Betty Osganian, Student Services Administrator at the undergraduate and graduate levels at osgiane@rpi.edu.

Course Descriptions

Undergraduate courses in Philosophy or Psychology are described under the department codes PHIL and PSYC. Graduate courses in Cognitive Science are described in the Course Descriptions section under COGS.

Communication and Media

Acting Head: Patricia Search

Department Home Page: http://www.cm.rpi.edu/

The Department of Communication and Media is an internationally recognized center for interdisciplinary education, research, and theory development. The department’s programs span areas including Human-Computer Interaction (HCI), composition and writing, computer-mediated communication (CMC), graphics and visual communication, literature and cultural studies, rhetoric, and technical communication.

The department offers four undergraduate degrees. The first, a B.S. in Communication offers general studies in communication. Also offered is a B.S. in Communication with a Concentration in Graphic Design. This program prepares students for professional practice and graduate study in creative problem solving for print and electronic media. The B.S. in Electronic Media, Arts, and Communication (EMAC) prepares students to be creative problem solvers, critical thinkers, team leaders, and entrepreneurs. The B.S. in Information Technology and Web Science (ITWS) with Communication as the Second Discipline is offered in cooperation with the program in Information Technology and Web Science. For more information about any of these programs, please visit http://www.cm.rpi.edu/pl/undergraduate.

The department also offers a Ph.D. and three M.S. degrees. The Ph.D. in Communication and Rhetoric has a unique focus on communication in technologically mediated contexts. With the M.S. in Human-Computer Interaction (HCI), students can take a unique approach to human-computer interaction centered in communication. Also offered is one of the oldest technical communication degrees in the nation, the M.S. in Technical Communication. This program enables students to gain design skills that have obsolescence and the capacity to
generate content for several electronically based communication media. Finally, the M.S. in Communication and Rhetoric prepares students for applied research in industry or government, or for further study in a doctoral program. For information about graduate study in Communication and Media, please visit http://www.cm.rpi.edu/pl/graduate.

The growing need for people who understand the new communication technologies and their impact on society and individuals creates a demand for all Communication and Media program graduates. B.S. graduates seek employment in fields related to graphic/communication design, communication technology and technical communication, multimedia design and production, and careers in the emerging Internet technologies. The M.S. graduates pursue careers as information architects, Web designers, multimedia specialists, graphic designers, electronic communication specialists, technical communicators, usability engineers, and instructional interface designers. The M.S. programs also provide a foundation for doctoral study. Ph.D. graduates find careers in business and government and in academia.

Research Innovations and Initiatives
In research, the department’s mission is to develop and assess new understandings of how people create and manage their social and professional worlds through the mediation of symbol systems and communication technologies. The major thrusts of department research are described below.

Communication and Technology
Research in this area focuses on technologically mediated communication, design of human-computer interactions, information technologies in community development and networking, and technical and professional communication practices.

Rhetoric, Culture, and Communication Technology
Specific research projects in this area include cultural studies of film, photography, advertising, and cyberspace; rhetorical theory and analysis, with particular emphasis on digital, visual, and cultural rhetoric; and language in collaborative design work. Also underway is research in cultural rhetoric, which includes ethnographic studies of themed cultural environments.

Media Design and Theory
Design of hypermedia text and artwork, writing for print and digital media, visual communication and design, and the integration of visual with verbal code are current areas of research in this category.

Research Facilities
To support these programs, Communication and Media maintains a variety of research-centered laboratories and facilities:

Center for Communication Practices This free-consultation service, located on the first floor of the Folsom Library, offers to all Rensselaer students one-on-one feedback as they draft written, oral, and electronic communication products. Additional information about the Center’s resources (including on-line publications) can be accessed on its Web site at http://www.ccp.rpi.edu/.

Seminar Room Located in the heart of the department, the Seminar Room in Sage 4304 provides facilities for small group and seminar interaction with colleagues at a distance. It supports Web conferencing, video-streaming, and teleconferencing.

Media Classroom Located in Sage 4711, the Media Classroom provides a facility to support display and control of high-quality film and video.

VAST Lab (Visualization, Animation, and Simulation Technology) Located in Sage 2411, the VAST Lab is an advanced digital imaging lab consisting of 26 high-end PCs running a full complement of digital imaging and animation software.

Faculty *

Professors
Odell, C. L.—Ph.D. (University of Michigan); composition theory and research; integrating visual and verbal information; writing in nonacademic settings; writing in engineering; rethinking “literacy”; education reform.

Search, P.—M.A. (Goddard College); visual design theory and practice; interaction design and multimedia art; computer animation and hypermedia interface design; indigenous knowledge and interaction design; multiliteracy models for intercultural communication.

Whitburn, M.—Ph.D. (University of Iowa); history and teaching of technical communication; history of rhetoric; rhetoric bibliography; history of English studies.

Zappen, J. P.—Ph.D. (University of Missouri); contemporary rhetorical theory; digital rhetoric/digital media; design and implementation of community information systems.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions including end-of-year promotions, please refer to the Faculty Roster Section of this catalog which is current of the May 2013 Board of Trustees meeting.
Professor of Practice
Grice, R.—Ph.D. (Rensselaer Polytechnic Institute); information usability; human-computer interaction; communicating on the WWW; usability testing and evaluation; analysis of interactive interfaces; effective teaching and learning in the virtual classroom; designing the total user experience.

Associate Professors
Bennett, A.—M.F.A. (Yale University); theory and research on the design of images for culturally-specific and cross-cultural communication across different media.
Deery, J.—D.Phil. (Oxford University); media studies; television and new media; advertising and culture; popular culture; utopian literature; literature and science.
Esrock, E. J.—Ph.D. (New York University); cognitive/neuropsychological approaches to literature and visual art; visual culture; theory and history of photography; literary theory; modern and contemporary literature; women writers.
Gordon, T.—Ph.D. (University of California-Berkeley); religion and media; ethnographic methods; discourse analysis; documentary theory; visual culture; themed environments; South Pacific and U.S.
Haskins, E.—Ph.D. (University of Iowa); rhetorical theory and history; visual rhetoric; rhetorics of public memory and national identity.
Sheldon, L.—M.F.A. (California Institute of the Arts); writing and designing commercial and serious video games; alternate reality games; virtual worlds and interactive media; designing classes as games; television and film writing and production; mystery writing.

Assistant Professor
Godoy, C.G.—Ph.D., J.D. (University of Southern California; University of California, Berkeley); social-psychological consequences of human interaction with media; health communication; message framing; developmental factors in risk-taking; modeling realistic personality in virtual agents; designing characters for video games; pedagogical agents; interactive media as an unobtrusive behavioral measure; socially optimized learning in virtual environments.

Lecturers
Klatt, C.—Ph.D. (University of Minnesota; T.T.S., Mayo Clinic); developing, implementing, and assessing health communication interventions; social change; attitude change; behavior modification; message design elements; social support and feedback in medical encounters.
Lewis, B.—Ph.D. (Rensselaer Polytechnic Institute); composition theory and research; writing center theory and research; theory and practice of peer tutoring; writing in disciplines across the curriculum; especially in engineering design.
Lynch, M.—Ph.D. (University of Connecticut); interactive storytellng, especially the design of better game world and story world characters through the use of appropriate cognitive architectures; artificial intelligence (AI) in games, including in the emerging areas of social intelligence, conversational agents, and the modeling of emotion in non-player characters; game design/development; the history and culture of games.
Miyamoto, P.—M.F.A. (Otis Art Institute); visual communication design theory and practice; exploration of paint-based medium as an expressive art form.

Professor Emeritus (Active)
Halloran, S.M.—Ph.D. (Rensselaer Polytechnic Institute); memory studies; the role of museums and historical artifacts in preserving collective memory; historical sites as sites of rhetorical education and citizen formation; rhetorical tradition(s) in the United States.

Undergraduate Programs
Undergraduate programs in Communication and Media provide students with the multidisciplinary education that is essential for leadership in an “information society,” a society that is continuously being transformed by new communication processes and technologies. Building on Rensselaer’s strong technological infrastructure, these programs offer students hands-on education in new communication technologies and theoretical frameworks in order to understand and shape the cultural impact of these technologies. Our programs prepare students for advanced study of communication or for employment in the fields related to communication technology, technical communication, graphic design, or multimedia production.
Undergraduates in our programs may use some of their elective credits to complete a Certificate in Communication Design.
Communication

The B.S. in Communication requires a total of 124 credit hours, including 44 credit hours of major requirements. Of the remaining credit hours, 32 are free electives, 24 meet Rensselaer requirements in the humanities, arts, and social sciences, and 24 are taken in math and science.

**FIRST YEAR**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>BIOL 1010</td>
<td>Introduction to Biology  4</td>
</tr>
<tr>
<td>COMM 1510</td>
<td>Introduction to Communication Theory  4</td>
</tr>
<tr>
<td>MATH 1500</td>
<td>Calculus for Architecture, Management, and HASS  4</td>
</tr>
<tr>
<td>WRIT 2110</td>
<td>Rhetoric and Writing  4</td>
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<table>
<thead>
<tr>
<th>Spring</th>
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</tr>
</thead>
<tbody>
<tr>
<td>COMM 2610</td>
<td>Introduction to Visual Communication  4</td>
</tr>
<tr>
<td>MATH 1620</td>
<td>Contemporary Mathematical Ideas in Society  4</td>
</tr>
<tr>
<td>Humanities Elective/First-Year Studies  4</td>
<td></td>
</tr>
<tr>
<td>One Literature (LITR) course  4</td>
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**SECOND YEAR**

<table>
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<tr>
<th>Fall</th>
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<tbody>
<tr>
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<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Math/Science Elective</td>
<td>4</td>
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<tr>
<td>Major Requirement 1</td>
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<table>
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<th>Credit Hours</th>
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<td>Major Requirement 1</td>
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<tr>
<td>HASS Elective</td>
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<td>Math/Science Elective</td>
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**THIRD YEAR**

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<th>Fall</th>
<th>Credit Hours</th>
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<tr>
<td>HASS Elective</td>
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<td>Math/Science Elective</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
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<tr>
<td>Major Requirement 1</td>
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<tr>
<td>Social Science Elective</td>
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**FOURTH YEAR**

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<td>HASS Elective</td>
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<tr>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
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<td>Major Requirement 1</td>
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<td>Free Elective</td>
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<tr>
<td>Free Elective</td>
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</tbody>
</table>

Communication (Concentration in Graphic Design)

The B.S. in Communication with a Concentration in Graphic Design: Theory, Research, Practice provides a curriculum for undergraduate students who seek professional careers in graphic design. This concentration will prepare students for professional practice and graduate study in creative problem solving for print and electronic media. Students completing this sequence will know how to apply theory to the creation of conventional and unconventional communication objects (that includes but is not limited to advertising campaigns, editorial layouts, corporate communications including annual reports and corporate standards, event announcements, advocacy campaigns, and Web pages) that convey information to a target audience.

---

1. Major Requirement (44 credit hours required); all communication majors are required to take COMM 1510 and COMM 2610. Students who are following the General Communications major (i.e., those who are not following the Graphic Design Concentration) are also required to take LITR 2110 and WRIT 2110. The remaining 28 credit hours are comprised of courses taken from the Language, Literature, and Communication Department. Courses with the codes COMM, LANG, LITR, and WRIT fulfill the requirement.

2. BIOL 1010 is not required if first major is Engineering.
The B.S. in Communication with a Concentration in Graphic Design requires a total of 124 credit hours. It consists of 52 credit hours of major requirements; 24 credit hours of free electives; and the Rensselaer requirements of 24 credit hours in the humanities, arts, and social sciences and 24 credit hours in math and science. The four-credit Communication Internship focusing on graphic design is also required.

### FIRST YEAR

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Fall</td>
<td>COMM 1510</td>
<td>Introduction to Communication Theory</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>COMM 2610</td>
<td>Introduction to Visual Communication</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH 1500</td>
<td>Calculus for Architecture, Management, and HASS</td>
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<td></td>
<td>HASS Core</td>
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<tr>
<td>Spring</td>
<td>COMM 4570</td>
<td>Typography</td>
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<td>CSCI 1010</td>
<td>Introduction to Computer Programming</td>
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<td>or</td>
<td>CSCI 1100</td>
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<tr>
<td></td>
<td>MATH 1620</td>
<td>Contemporary Mathematical Ideas in Society</td>
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<tr>
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<td>HASS Core</td>
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### SECOND YEAR

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<tr>
<td>Fall</td>
<td>COMM 4460</td>
<td>Visual Design: Theory and Application</td>
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<td>Free Elective</td>
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<td></td>
<td>Writing Requirement¹</td>
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<td></td>
<td>Social Science Core</td>
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<td>4</td>
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<tr>
<td>Spring</td>
<td>BIOL 1010</td>
<td>Introduction to Biology³</td>
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<tr>
<td></td>
<td>COMM 4690</td>
<td>Interface Design: Hypermedia Theory and Application</td>
<td>4</td>
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<td></td>
<td>or</td>
<td>COMM 4780</td>
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<tr>
<td></td>
<td></td>
<td>Interactive Narrative</td>
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<td>HASS Core in Art History⁴</td>
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<tr>
<td></td>
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<td>Communication Courses in Theory, Research</td>
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### THIRD YEAR

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Fall</td>
<td></td>
<td>Communication Courses in Theory, Research²</td>
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<td>Math/Science Core</td>
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<td>Free Elective</td>
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<tr>
<td></td>
<td></td>
<td>Writing Requirement</td>
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<tr>
<td>Spring</td>
<td>COMM 4400</td>
<td>Cross-Cultural Media: Analysis and Application</td>
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<td>or</td>
<td>COMM 4650</td>
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<td></td>
<td></td>
<td>Marketing Communication Design</td>
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<td>HASS Core</td>
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<tr>
<td></td>
<td></td>
<td>Math/Science Core</td>
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<tr>
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<td>Social Science Core</td>
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### FOURTH YEAR

<table>
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<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>Fall</td>
<td>COMM 4470</td>
<td>Information Design</td>
<td>4</td>
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<tr>
<td></td>
<td>HASS Core in Art or Design⁵</td>
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<td></td>
<td>Free Elective</td>
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<tr>
<td></td>
<td>Free Elective</td>
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<td></td>
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<tr>
<td>Spring</td>
<td>COMM 4300</td>
<td>Communication Internship</td>
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<td>COMM 4730</td>
<td>Graphic Design for Corporate Identity</td>
<td>4</td>
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<tr>
<td></td>
<td>Free Elective</td>
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<td></td>
</tr>
</tbody>
</table>

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1 Students should choose four credits from the following set of courses: WRIT 2510, WRIT 1110, WRIT 2110, WRIT 4120, and WRIT 4550.
2 Students should choose two of the following courses: COMM 2620 Visual Culture, COMM 296x Color Theory, COMM 4580, LITR 2420, LITR 4410, COMM 2410, COMM 4560, and/or a course in HCI. A comprehensive list of courses will be provided to the adviser each term.
3 Students may choose between CSCI 1010 or CSCI 1100. The latter is recommended for students who want to minor in Computer Science.
4 Students should choose two of the following courses: ARTS 2530 and ARTS 2540, or another course that the adviser approves.
5 A list of appropriate courses will be provided to the adviser each term.
6 Students should choose eight credits from the following set of courses: STSS 1510, STSS 1210, STSS 1110, or another course that the adviser approves. Four credits must be in a design-related course.
7 BIOL 1010 is not required if first major is Engineering.
Information Technology and Web Science and Communication (ITWS/Comm)

The B.S. in ITWS/Communication is an information technology and web science degree with a concentration that includes 32 credits taken in Communication and Media. This degree prepares students for leadership roles in careers such as communication specialists and corporate information officers. Beginning courses introduce students to the basics of communication theory, literacy theory, and written and visual communication. Students in ITWS/Comm should consider taking course work in one or more of the following Communication and Media pursuits: communication in new media, visual communication, and human-computer interaction.

All Communication and Media undergraduate programs strive to accommodate students’ differing academic and professional goals, while ensuring that they gain a depth of knowledge in one or more specific areas. Following are some sample programs of study:

<table>
<thead>
<tr>
<th>FIRST YEAR</th>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CSCI 1100</td>
<td>Computer Science I</td>
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<tr>
<td>ITWS 1100</td>
<td>Introduction to Information Technology and Web Science</td>
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</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>WRIT 2110</td>
<td>Rhetoric and Writing</td>
<td>4</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM 1510</td>
<td>Introduction to Communication Theory</td>
</tr>
<tr>
<td>CSCI 1200</td>
<td>Data Structures</td>
</tr>
<tr>
<td>ITWS 1220</td>
<td>IT and Society</td>
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<table>
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<tr>
<th>SECOND YEAR</th>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM 2610</td>
<td>Introduction to Visual Communication</td>
<td>4</td>
</tr>
<tr>
<td>ITWS 2110</td>
<td>Web Systems Development</td>
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</tr>
<tr>
<td>One of: CSCI 2200</td>
<td>Foundations of Computer Science</td>
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<tr>
<td>ECSE 2610</td>
<td>Computer Components and Operations</td>
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<tr>
<td>ENGR 2350</td>
<td>Embedded Control</td>
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<table>
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<tr>
<th>Spring</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ITWS 2210</td>
<td>Introduction to Human Computer Interaction</td>
</tr>
<tr>
<td>ITWS 4200</td>
<td>Web Science</td>
</tr>
<tr>
<td>LITR 2110</td>
<td>Introduction to Literature</td>
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<tr>
<td>One of: CSCI 2500</td>
<td>Computer Organization</td>
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<tr>
<td>ECSE 2660</td>
<td>Computer Architecture, Networks, and Operating Systems</td>
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<table>
<thead>
<tr>
<th>THIRD YEAR</th>
<th>Fall</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>CSCI 2300</td>
<td>Introduction to Algorithms (CSCI Track only)</td>
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<tr>
<td>ITWS 4310</td>
<td>Managing IT Resources</td>
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<tr>
<td>One of: CSCI 2500</td>
<td>Communication or Writing Elective</td>
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<tr>
<td>LITR 2110</td>
<td>Life Science Elective (BIOL xxxx)</td>
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<tr>
<td>Free Elective (ENGR track only)</td>
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<table>
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<th>Spring</th>
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<tr>
<td>ITWS Elective (one of): CSCI 4380</td>
<td>Database Systems</td>
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<td>MGMT 4170</td>
<td>Data Resource Management</td>
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<td>Communication, Writing, or Language Elective</td>
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<td>HASS Elective²</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
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</tbody>
</table>

1 Select either the three-course ECSE sequence or the three-course CSCI sequence. If a student is planning to apply to the co-terminal MS in IT program, they need to take the CSCI sequence.

2 See HASS requirements listed in the front of this document.
FOURTH YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Communication or Writing Elective</td>
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<tr>
<td>Humanities Elective²</td>
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<tr>
<td>Physical Science Elective (PHYs xxxx)</td>
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<td>One of:</td>
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<tr>
<td>ITWS 4100</td>
<td>Information Technology and Web Science Capstone (Professional Track)³</td>
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<td>ITWS 499D</td>
<td>Senior Thesis (Research Track)</td>
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<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITWS 4990</td>
<td>Senior Thesis (Research Track only)</td>
</tr>
<tr>
<td>Thesis Communication⁴</td>
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<tr>
<td>Social Sciences Elective²</td>
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<tr>
<td>HASS Elective²</td>
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<tr>
<td>Free Elective</td>
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</tbody>
</table>

Minor Programs

Students in all undergraduate degree level programs are strongly advised to develop a minor in a compatible field of interest. Participation in an internship or co-op is also recommended to allow students to gain professional work experience.

The Department of Communication and Media offers a selection of minors, all of which require at least 16 credit hours.

### Chinese Minor

To complete this minor, students must take LANG 2420 Chinese III; LANG 2430 Chinese IV; LANG 496X Chinese V; and COMM 496X Language and Culture, or internship abroad, or advanced coursework abroad in Chinese language and/or culture (the last two must be conducted in Chinese).

### Communication Minor

To complete this minor, students must take COMM 1510 Introduction to Communication Theory and one 4000-level communication course. Two additional four-credit communication courses under the codes COMM XXXX or WRIT XXXX are also required.

### French Minor

This minor consists of French III, French IV, Business French I, and Business French II.

### Literature Minor

A literature minor requires four four-credit courses in literature (LITR XXXX), for which students can substitute up to two of the following: Creative Writing: Poetry (WRIT 2310), Creative Writing: Short Story (WRIT 2330), or Creative Nonfiction (WRIT XXXX).

### Professional Writing Minor

To complete this minor, students must take COMM 1510 Introduction to Communication Theory, and choose one WRIT course from WRIT 1110, WRIT 2110, WRIT 2510, or WRIT 296X Writing in the Digital Age. Students must also choose two additional courses from COMM 4780, WRIT 2340, WRIT 4550, WRIT 4120, COMM 4570, COMM 4470, WRIT XXXX, Creative Writing: Nonfiction, WRIT 496X Writing for Promotion and Marketing, WRIT 496X Science Writing, or WRIT 496X Peer Response to Writing.

### Graduate Programs

The Department of Communication and Media addresses the communicative processes by which humans construct and share meaning in all media including the new electronic media. It is a multidisciplinary scholarly community embracing literacy study, speech communication, composition and rhetoric, media studies, visual design, human-computer interaction, and technical communication.

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² See HASS requirements listed in the front of this document.
³ Co-terminal students would replace ITWS 4100 Information Technology and Web Science Capstone with ITWS 498D Special Projects which will be the culminating experience.
⁴ Thesis Communication (one of):
  • COMM 4180 Studio Design in HCI
  • COMM 4210 Designing Interactive Characters for Digital Games
  • COMM 4300 Communication Internship
  • COMM 4420 Foundations of HCI Usability
  • COMM 4470 Information Design
  • COMM 4560 Media and Popular Culture
  • COMM 4690 Interface Design: Hypermedia Theory and Application
  • COMM 4730 Graphic Design for Corporate Identity

NOTE: Students are expected to notify the instructor at the beginning of the thesis course that they are taking it for thesis credit, and they should confer with the instructor to define the course project.
More than a dozen faculty are involved in graduate education. They comprise a large, diverse, yet integrated community dedicated to teaching and mentoring graduate students. They make an exceptionally strong contribution to research in communication in technologically mediated contexts through an active program of publication in a variety of fields and in the production of artistic media. They are also successful in securing external funding for their work. Recent research has been supported by the National Science Foundation, the Society for Technical Communication, the Fund for the Improvement of Post-Secondary Education, the Elsevier Foundation, and the California HIV/AIDS Program (IDEA Grant). At last count, Communication and Media faculty had won over 30 awards including numerous fellowships, awards for best articles, visiting professorships, and professional society awards. They come from such organizations as the National Science Foundation, College Art Association, the Fulbright Program, the Game Developer’s Conference, the IEEE Professional Communication Society, the International Visual Literacy Association, the National Communication Association, the Popular Culture Association, the Rhetoric Society of America, and the Society for Technical Communication.

Currently, the Department of Communication and Media's graduate programs consist of three master's level degree programs, a Ph.D. in Communication and Rhetoric, and two certificate programs.

**Doctoral Program**

The mission of the Ph.D. in Communication and Rhetoric is to enable students to make a contribution with rigor, depth, and creativity on issues related to Communication in Technologically Mediated Contexts.

For almost 40 years, our graduates have been the leaders in the study of the relationship between communication and technology. As new forms of technologically mediated communication emerge, research and scholarship are needed to describe their nature and account for their unique effects. We are uniquely positioned to provide an environment for graduate study in communication in technologically mediated contexts. We combine the resources of a premier technological university with a faculty strongly grounded in theory and research as well as technology and media.

The key to the Ph.D. in Communication and Rhetoric is its multidisciplinary nature. Our program draws from numerous disciplines across the humanities, the social sciences, and the arts. Students in the Ph.D. in Communication and Rhetoric take advantage of this multidisciplinary base to design dissertation projects that are both innovative and rich. In the Ph.D. program in Communication and Rhetoric, all students complete a two-course core, two methods courses, and at least three graduate seminars. Students may also take up to three application courses in areas such as graphics, human-computer interaction, hypermedia, Web design and development, or writing. With this structure, our program is highly tailored to the individual career goals of each student. Students who join the Communication and Media community are expected to become active researchers and scholars. All students must have at least four public presentations, publications or grant proposals prior to completing the degree.

Ph.D. students also have numerous opportunities to further their teaching. All students teach under the direction of a faculty supervisor. We value professional service and offer graduate students opportunities to undertake important service obligations to the department and community. Students are supported through teaching and/or research assistantships. Ph.D. students are also very competitive for university-level fellowships.

The Ph.D. in Communication and Rhetoric requires satisfactory completion of 90 credit hours beyond the bachelor’s degree, which includes an appropriate master’s degree, which will be counted as 30 of the required 90 credit hours. After completion of an appropriate master’s degree, students are required to take 36 credit hours of course work at Rensselaer. Some Plans of Study may require additional course work beyond this 36-credit-hour minimum, typically not to exceed 42 credits. More information about this program can be found at [http://www.cm.rpi.edu/pl/phd-communication-rhetoric-647](http://www.cm.rpi.edu/pl/phd-communication-rhetoric-647).

**Special Graduate Opportunities**

**Certificate Programs** The Department of Communication and Media offers two specialization certificates, one in Graphics and the other in Human-Computer Interaction, as options in the master’s programs, though additional courses over the 10-course minimum required for the M.S. degree may be required to pursue either certificate, if certificate courses are not listed as part of the M.S. core curriculum.

**Cooperative Education** Participation in the Cooperative Education Program is encouraged as part of our departmental degree offerings. The intent of co-op is to provide a full-time, career-related work experience that will enhance students’ knowledge and skills in their chosen professional field. Students who accept co-op assignments typically work from one to two terms (one of which must be an academic semester) prior to graduation. As a result, it is not uncommon for co-op participants to extend their graduation date.

Since graduate funding may be forfeited in any semester (not including summer) during which students are away from campus and unable to fulfill Teaching Assistant (T.A.) or Research Assistant (R.A.) duties, funded students should discuss their situation with their adviser and with the department’s Graduate Programs Coordinator before accepting a co-op position.
Before accepting a co-op assignment, graduate students must have completed the core requirement of a graduate writing course or Foundations of HCI Usability (COMM 6820), one additional Communication and Media course (such as COMM 6530, Communication Research I), and have matriculated in the department as a graduate student for at least one semester.

Students may continue their education while on assignment by registering for Communication Studies (COMM 6940), or they may petition the department’s M.S. or Ph.D. Policy Committees to take credits elsewhere. While working on co-op, students will also be registered for Co-op Industrial Assignment and will be considered full-time, regular students.

Please note that international students with an F1 visa must receive permission to work from the Cooperative Education and International Student Services offices to fulfill Immigration and Naturalization Service requirements.

Course Descriptions
Courses related to all Communication and Media curricula are described in the Course Descriptions section of this catalog under the department codes COMM, LITR, or WRIT.

Economics
Head: Shawn Kantor
Director Ph.D. Program in Ecological Economics: Shawn Kantor
Department Home Page: http://www.economics.rpi.edu/

Economics training provides students with a set of analytical and empirical tools to understand economic decision-making, industry or economy-wide dynamics, and public policy. The major enables students to engage in active learning, through their own independent research, to think critically about real-world problems in a rigorous manner. Economists are widely sought as potential employees by leading financial institutions, businesses, consulting firms, and the public sector. Economics training at Rensselaer also provides a solid foundation for graduate work in economics or professional training in such areas as business or law. At Rensselaer, undergraduate students are introduced to the key ideas of economics that revolve around scarcity of resources and the function of market, political, and social institutions. They learn to evaluate choices among alternatives that may only achieve some desirable outcomes. An education in economics helps students to delineate clearly the benefits and costs of choosing one course of action over others.

Through a sequence of progressively more advanced courses, students learn the concepts and analytical and empirical tools of economics. These tools are applied to a variety of different settings ranging from business decision-making to public policy issues dealing with economic growth and technological change, resource scarcity and environmental pollution, unemployment, inflation, poverty, government spending and taxation, and regulation. Primary emphasis is on the analysis of how markets perform the central economic task of allocating scarce resources among competing ends. However, several courses such as public finance, government regulation, and cost-benefit analysis focus on public-sector decision-making. For engineers, scientists, and managers, career options often heavily involve work that requires the ability to analyze economic data, to evaluate economic tradeoffs, and to critically assess policy choices.

The basic one-semester course, ECON 1200 Introductory Economics, creates an awareness of the central ideas in economic analysis and furnishes students with the basic tools with which they can reach independent, rational judgments on economic decision-making and public policy questions. The course provides a general introduction to economic principles and institutions. It is a self-contained course and is also a prerequisite for other economics courses.

Prospective students should also be aware that the department administers the Edward J. Holstein Memorial Award for Excellence in Economics and the Shavell-Weinman Fund. Faculty members are actively involved in research that provides numerous opportunities for undergraduate students to engage directly in research projects.

Research Innovations and Initiatives
At the graduate level the program allows students to apply the body of economics knowledge and techniques to a variety of issues in academic, government, and business settings. Department faculty and students focus their research in selected areas, including economics of technological change, environmental economics, law and economics, behavioral economics, economic regulation, and international competitiveness.
Faculty*

Professors

Adams, J.D.—Ph.D. (University of Chicago); growth and technical change, labor, public economics.

Duchin, F.—Ph.D. (University of California, Berkeley); input-output analysis, structural economics, ecological economics, economic development, technological change.

Estrella A.—Ph.D. (Harvard University); macroeconomics, econometrics, financial modeling, financial regulation.

Gowdy, J.M.—Ph.D. (West Virginia University); ecological economics, industrial organization and public regulation, regional economics.

Kantor, S.—Ph.D. (California Institute of Technology); political economy, law and economics, economics of innovation, U.S. economic history, economic development, and public economics.

Associate Professor

Simons, K.—Ph.D. (Carnegie Mellon University); industrial organization and technical change, dynamics of economic systems.

Assistant Professors

DeAngelo, G.—Ph.D. (University of California, Santa Barbara); applied microeconomics, law and economics, experimental/behavioral economics.

Shawhan, D.—Ph.D. (Cornell University); environmental and resource economics, electricity markets, experimental economics, behavioral economics.

Lecturers

Heim, J.—Ph.D. (University at Albany); macroeconomics, money and banking, international economics, econometrics.

Jones, R.—Ph.D. (Rensselaer Polytechnic Institute); money and banking, macroeconomics, introductory economics, econometrics.

Parrales, S.—Ph.D. (Rensselaer Polytechnic Institute); introductory economics, money and banking.

Emeritus Faculty

Hohenberg, P.M.—Ph.D. (Massachusetts Institute of Technology); economic history, economics of technological change.

Vitaliano, D.—Ph.D. (City University of New York); private and public sector efficiency, corporate social responsibility, gender pay differences.

Undergraduate Programs

Rensselaer’s undergraduate major in economics differs from other programs in three important respects. First, it requires that about one-fourth of the student’s program be in mathematics and the natural sciences. Second, students must apply quantitative tools to real economic problems, notably in problem labs that employ regression, linear programming, and risk analysis. Finally, in addition to dedicated courses, students can pursue various courses relevant to their interests and other courses at Rensselaer. Students interested in economic policy questions or data analytics will find a wide array of course offerings.

Economics

A major in economics requires 34 credit hours in the discipline and must include the following: ECON 1200 Introductory Economics, ECON 2010 Managerial Economics, ECON 2020 Intermediate Macroeconomics or ECON 4130 Money and Banking, ECON 4570 Introduction to Econometrics, and ECON 4900 Seminar in Economics (minimum two units). Courses in Mathematics and Statistics are also required as prerequisites.

Although specific courses will vary, the template below illustrates a typical bachelor of science curriculum within the Department of Economics. This curriculum requires a minimum of 124 credit hours.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
## First Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Fall</td>
<td>MATH 1010</td>
<td>Calculus I</td>
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<tr>
<td>Fall</td>
<td>Science Option I</td>
<td>4</td>
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<tr>
<td>Fall</td>
<td>First Year Studies</td>
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<tr>
<td>Fall</td>
<td>HASS Elective</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>ECON 1200</td>
<td>Introductory Economics</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>MATH 1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>Science Option II</td>
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<tr>
<td>Spring</td>
<td>HASS Elective</td>
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## Second Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course</th>
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<th>Credit Hours</th>
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<tr>
<td>Fall</td>
<td>ECON 2010</td>
<td>Managerial Economics</td>
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<tr>
<td>Fall</td>
<td>Statistics Option</td>
<td>4</td>
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<tr>
<td>Fall</td>
<td>HASS Elective</td>
<td>4</td>
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<tr>
<td>Spring</td>
<td>Economics Elective</td>
<td>4</td>
<td></td>
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<tr>
<td>Spring</td>
<td>Elective</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>Select one of the following ECON courses:</td>
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<tr>
<td>Summer</td>
<td>ECON 2020</td>
<td>Intermediate Macroeconomics</td>
<td>4</td>
</tr>
<tr>
<td>Summer</td>
<td>ECON 4130</td>
<td>Money and Banking</td>
<td>4</td>
</tr>
<tr>
<td>Summer</td>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
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## Third Year

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<th>Course</th>
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<td>Fall</td>
<td>ECON 4570</td>
<td>Econometrics</td>
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<td>HASS Elective</td>
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<tr>
<td>Fall</td>
<td>Elective</td>
<td>4</td>
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<tr>
<td>Fall</td>
<td>Elective</td>
<td>4</td>
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<tr>
<td>Spring</td>
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<td>HASS Elective</td>
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<td>Spring</td>
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<td>Fall</td>
<td>Economics Elective</td>
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<tr>
<td>Fall</td>
<td>HASS Elective</td>
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<td>Fall</td>
<td>Elective</td>
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<tr>
<td>Spring</td>
<td>Economics Elective</td>
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<tr>
<td>Spring</td>
<td>HASS Elective³</td>
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</tr>
<tr>
<td>Spring</td>
<td>Electives</td>
<td>8</td>
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</tbody>
</table>

### Concentrations

Work in the major field can easily be combined with meaningful concentrations of study in other fields of interest. Some possibilities include:

- Emphasizing electives in, for example, policy studies related to science and technology;
- Pursuing a minor concentration of 15 to 18 credit hours in a related professional field, such as environmental or transportation engineering, management, or computer science.

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1 Science options are CHEM 1100, CHEM 1200, PHYS 1100, PHYS 1200, ERTH 1030, ERTH 1040 (recommended). Other sequences may be substituted with approval.
2 BIOL 1010 is not required if first major is Engineering.
3 As required.
Dual Major Programs

Students are encouraged to consider a dual major as a means of enhancing their employment and graduate school prospects. Training in economics can provide an edge in either situation. A dual major is NOT a double degree, which requires 30 additional credits beyond the first degree. Dual majors may use their economics courses to fulfill the social science portion of the 24-credit HASS Core. Otherwise, the requirements are the same as for the single major in economics.

For those students who are interested in a degree that emphasizes both science and technology and environmental issues there is an opportunity to pursue a dual major in Economics and Science, Technology and Society. This combination of majors combines the best of both departments – economic analysis and a broader humanities and social science analysis that emphasize the role science and technology plays in today’s global economy and culture.

Minor Programs

At least 16 credit hours are required to complete an economics minor. These must include ECON 1200 Introductory Economics and ECON 2010 Managerial Economics. All courses must be taken for a grade to count towards the minor (or major). For further information on minors in economics contact Shawn Kantor, Department Head, Kantors@rpi.edu.

Special Undergraduate Opportunities

Accelerated Programs
In consultation with an academic adviser, a student may design a five-year program to complete requirements for the Bachelor of Science in Economics and the Master of Science in Operations Research and Statistics or the Master of Business Administration. Participation in these programs may require admission by the Office of Graduate Education. They are designed to prepare the student for employment or for advanced graduate or professional training.

Graduate Programs

The Department of Economics offers a Master of Science degree aimed at developing skills in economic analysis and an interdisciplinary Ph.D. in Ecological Economics. These programs stress important applications in industry, government, and education.

Graduate level research projects cover a wide range of economic issues, including technological change and the structure and scope of economic activity, energy and environment, international competitiveness and global economic cooperation, industrial development, regulation and other topics in law and economics.

Master's Programs

Though students must become competent in certain fundamental areas such as economic theory and econometrics, programs in economics are quite flexible and can readily accommodate those wishing to combine a graduate-level major in economics with a minor concentration in some related area. An economics minor can also be developed to complement a graduate program in another discipline.

Economics M.S.
Applicants for the M.S. in Economics program should have completed a bachelor’s program at an approved institution or should be in a bachelor’s degree program at Rensselaer. Preparation prior to entering the M.S. program should include basic undergraduate courses in economics and mathematics, including calculus. Some background in statistics is strongly recommended. In the program, candidates must complete 30 credit hours of work selected in consultation with the program adviser, with a thesis option, and pass a comprehensive oral examination. There is no foreign language requirement. Before applying, prospective applicants should check the current status of admissions to the M.S. program, on the master’s program page of the Department of Economics Web site.

Doctoral Programs

The Economics Department offers an interdisciplinary Ph.D. degree in ecological economics that allows for individual research specialization and independent study in an atmosphere of close contact between faculty and students.

The program combines traditional training in advanced economics, expected of Ph.D.s in economics, with the broader interdisciplinary perspective on economic, social, and environmental systems provided by ecological economics. Ecological economics is the transdisciplinary field that integrates diverse perspectives on human resource use, development, and the environment. In addition to traditional economic policy concerns regarding efficiency and equity, ecological economics focuses on sustainability. Research interests include: global pollution, land use, and resource scarcities; analyzing scenarios for a sustainable economy; economic development and environment quality; household consumption; lifestyle change; energy and the environment; electricity policy; climate change; regional air pollution; power grid modeling; renewable energy policy; and the economics of nuclear energy. The department has a strong empirical focus using techniques including econometrics, input-output analysis, electricity network simulation modeling and time series analysis.
The Ph.D. in economics requires at least 72 credits beyond the baccalaureate degree and 48 credits beyond an M.A. or M.S. in economics or a related field. For the post-master’s Ph.D., a minimum of 30 credits of course work or 10 three-credit courses must be taken. However, students can choose to take more courses and may be required to do so if their background so indicates. At least two-thirds of the total credit hours, excluding thesis, must be at the 6000 level, with the further limitation that no more than 21 credit hours of 4000-level courses are to be allowed. For example, if a student is taking 30 credits of course work in a post-master’s Ph.D., a maximum of 10 credits at the 4000 level is allowed. A maximum of 15 credits can be taken at institutions other than Rensselaer.

Students must complete a core course sequence in economic theory, quantitative methods, and ecological economics. Students can receive waivers if they have previously completed a course with a substantially similar content and at a similarly advanced level.

The core economic theory and quantitative methods courses are: ECON 6550 Advanced Microeconomic Analysis, ECON 6590 Advanced Macroeconomic Analysis, and ECON 6570 Econometrics. The course ECON 6120 Advanced Quantitative Methods is recommended preparation for ECON 6570.

The ecological economics sequence consists of ECON 6230 Advanced Environmental Economics and ECON 6250 Advanced Ecological Economics.

To complete their coursework, students may choose other advanced courses offered by the economics department, other Rensselaer departments, and cross-registered colleges that are relevant to students’ interests.

Students are strongly encouraged to attend seminars conducted regularly in the economics department as well as in other Rensselaer departments.

An initial adviser will be assigned to each student. Immediately upon entering the economics Ph.D. program, students should draft a study plan. These plans must be kept current, as they will likely undergo periodic changes. The program director or co-director must approve the Plan of Study. The Plan of Study also indicates the student’s curriculum adviser and expected date of graduation.

Economics Ph.D. students must also pass written comprehensive exams that cover theory and application in the four required core fields of microeconomics, macroeconomics, quantitative methods, and ecological economics. The exams are commonly scheduled in late May or in mid December with other dates scheduled as appropriate and necessary.

Upon successfully completing the qualifying exams, students choose an adviser and then organize a dissertation committee with that adviser, complying with Rensselaer’s requirements for a doctoral dissertation committee.

Students will prepare a dissertation proposal in consultation with their adviser that covers the theoretical and applied literature in the chosen field of study for the dissertation and outlines the planned dissertation research. The candidacy exam consists of an open presentation of the proposal. This constitutes an additional oral field exam in a chosen area of specialization. This exam is scheduled in consultation with the thesis adviser after the candidate has passed all required comprehensive exams. After passing the candidacy exam, a Ph.D. student is considered a candidate with only the dissertation and dissertation defense remaining to complete the requirements of the Ph.D. program.

Course Descriptions
Courses related to all economics curricula are described in the Course Descriptions section of this catalog under the department code ECON.

Science and Technology Studies
Acting Head: Linnda R. Caporael
Director of Graduate Programs: Edward Woodhouse
Department Home Page: http://www.rpi.edu/dept/sts/

The Department of Science and Technology Studies (STS) conducts interdisciplinary teaching and research on the human dimensions of science and technology. The department also provides undergraduate instruction in anthropology, history, political science, and sociology. Department faculty members are drawn from these disciplines as well as from philosophy and psychology. Wherever individuals work and live, they must understand the ways in which all aspects of society influence, and are influenced by, science and technology. Rather than holding a divided view of science and technology verses human values and society, STS recognizes both the social aspects of science and technology, and the scientific and technological dimensions of human existence.
Research and Innovation Initiatives

The Science and Technology Studies Department at Rensselaer Polytechnic Institute is an interconnected network of scholars, activists, and students invested in studying science and technology from multiple perspectives. The strength of the department lies in its intellectual diversity. The department has faculty members trained in and students studying the traditional disciplines of anthropology, design, geography, history, philosophy, political science, sociology, and social psychology. Theoretical approaches encompass critical policy studies, cognitive sciences, cultural theory, ethics, linguistics/semiotics, political economy, simulation/ethnomathematics, and social theory. Objects of study range from the material to artificial worlds. Research within the department has focused on the environment, health, information technology, engineering, and design. The Science and Technology Studies Department is a place where faculty and students pursue studies of power, gender, race, colonialism, and the interactions between research and activism. This matrix of disciplines, theoretical approaches, objects of study, and topical issues inform the scholarship of the department and creates an open, productive, and collaborative intellectual location from which to engage in exploring the multifaceted relationships among science, technology, and human existence.

Faculty *

Professors

Campbell, N.—Ph.D. (University of California, Santa Cruz); drugs and pharmaceutical policy, gender and feminist theory, bioethics, neuroscience.

Caporael, L.R.—Ph.D. (University of California, Santa Barbara); human evolutionary theory; decision making, social psychology, interpersonal dimensions of computing.

Eglash, R.—Ph.D. (University of California, Santa Cruz); African studies, anthropology, black history, cybernetics and virtual communities, math and science education.

Fortun, K.—Ph.D. (Rice University); environmental sciences and politics, environmentalism, and the law, ethnographic methods.

Layne, L.—Ph.D. (Princeton University); medicine and culture, new reproductive technologies, popular images of nature, feminist methods, emerging faculty structures.

Winner, L.—Ph.D. (University of California, Berkeley); political theory, politics of technology.

Woodhouse, E.J.—Ph.D. (Yale University); science and technology policy, democratic theory, sustainability studies.

Associate Professors

Akera, A.—Ph.D. (University of Pennsylvania); history of scientific and technical computing, history of engineering education, innovation studies.

Breyman, S.—Ph.D. (University of California, Santa Barbara); political economy of environment, science, and society.

Fortun, M.—Ph.D. (Harvard University); historical and ethnographic studies of genomics, life sciences and critical scientific literacy.

Assistant Professors

Kinchy, A.J.—Ph.D. (University of Wisconsin-Madison); sociology, social movements, food and agriculture, environment, politics of biotechnology, expertise.

Nieusma, D.—Ph.D. (Rensselaer Polytechnic Institute); technological sustainability and development; interdisciplinary design pedagogy.

Masacarenhas, M.—Ph.D. (Michigan State University); environmental racism and environmental justice, science and technology studies, political economy, and development and globalization.

Adjunct Instructor

Swearingen, J.—Ph.D. (University of Chicago); east Asian history, modern European history, international relations.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Undergraduate Programs

The Department of Science and Technology Studies initiated a bachelor of science degree program in 1983. Rensselaer is a leader among the many American colleges and universities that grant degrees in the field. The STS degree program—Science, Technology, and Society (STS)—is a liberal arts program that prepares students for life and work in a technoscience-based society. Many STS majors choose a dual major in management, science, or engineering. Some graduates will attend professional schools to study corporate or patent law, medicine, policy analysis, or the management of science and technology. Others will use the program to obtain broad exposure in the social sciences and humanities prior to committing to a single discipline for the M.S. or Ph.D. Those entering the job market directly following graduation will find a growing need in consulting firms, major corporations, and government agencies for their unique combination of technical competence and conceptual, writing, and speaking abilities. The Rensselaer STS graduate, therefore, has a distinct advantage over other liberal arts graduates.

Baccalaureate Program in Science and Technology Studies

The STS bachelor’s program of study requires 124 credit hours, including the standard Rensselaer 24-credit hour humanities and social sciences requirement and 24-credit hour science requirement (including math). At least 32 credit hours are required within the student’s major. These must be accompanied by 16 credit hours in a technical area (the Technical Option) relevant to this STS major.

The 32 credit hours includes the following: STSH/STSS 1110 Science, Technology, and Society, two 2000-level courses, five 4000-level courses, including two methods courses; a public service internship, and a senior project or thesis. Students work with their advisers to develop an individual plan of study.

Students must also satisfy the humanities and social science core program, which can be achieved through STSH courses for humanities credit and STSS courses for social sciences credit. Some STS courses are offered with the IHSS code in the first year studies program; all courses with an IHSS code may be counted for either humanities or social sciences credit.

Built into the program are several important elements. Among these is a part-time internship in a government agency or other setting where social issues in science and technology are addressed. Additional elements include skills training in research methods; strong development of speaking and writing skills; and opportunities to serve as faculty research assistants.

In cooperation with a curriculum adviser and faculty mentor, each student tailors a program of study to his or her interests. So, for example, a student interested in bioengineering issues can combine technical courses from the Department of Biomedical Engineering with STS courses such as STSS 2400 Medicine and Society, STSH 4210 Engineering Ethics, STSS 4350 Politics of Design and STSS 4560 Gender, Science and Technology. An internship with a surgical robotics medical practice, a women’s health center, or a state senator’s office reporting on technology and health care and a senior project defining the STS issues for audiences of policy makers are among the many opportunities for students interested in technology and health care. A comparable set of coursework and internship opportunities may be arranged for those interested in other professional and pre-professional tracks including medicine, law, engineering, and information technology, as well as for those interested in pursuing graduate studies in STS.

The template below provides a sample STS curriculum. Courses below referred to as advanced options are 4000-level courses. Alternative courses can be chosen with a faculty adviser.
**FIRST YEAR**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1500 Calculus for Architecture, Management, and HASS1</td>
<td>4</td>
</tr>
<tr>
<td>STSS 1110 Science, Technology, and Society</td>
<td>4</td>
</tr>
<tr>
<td>Science Elective</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1520 Mathematical Methods in Management and Economics1</td>
<td>4</td>
</tr>
<tr>
<td>STSS 2350 Science, Values, and Public Policy: Perspectives on Science and Technology</td>
<td>4</td>
</tr>
<tr>
<td>Science Elective</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
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</table>

**SECOND YEAR**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS 2300 Environment and Society</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Math/Science Elective</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>BIOL 1010 Introduction to Biology2</td>
<td>4</td>
</tr>
<tr>
<td>STS Advanced Option</td>
<td>4</td>
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<tr>
<td>HASS Elective</td>
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<tr>
<td>Free Elective</td>
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**THIRD YEAR**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS 4800 Public Service/Professional Careers Internships</td>
<td>4</td>
</tr>
<tr>
<td>STS Technical Option</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STS Technical Option</td>
<td>4</td>
</tr>
<tr>
<td>Advanced STS Option</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
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<td>Free Elective</td>
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</table>

**FOURTH YEAR**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STS Technical Option</td>
<td>4</td>
</tr>
<tr>
<td>Advanced STS Option</td>
<td>4</td>
</tr>
<tr>
<td>Free Electives</td>
<td>8</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS 4980 Senior Project</td>
<td>4</td>
</tr>
<tr>
<td>STS Technical Option</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**Baccalaureate Program in Sustainability Studies**

The STS Sustainability Studies degree prepares students to use techniques and insights from the social sciences and humanities to address environmental problems. Students learn the history of the environmental thought and law, about current environmental controversies, and about sustainable pathways and design. Threats to human health in different locations are put in ecological and global context, drawing out how culture, politics, industry, and every-day ways of living impact the environment and human well-being.

Rensselaer’s STS Sustainability Studies degree has significant social science and humanities depth. The degree requires 40 social science and humanities credit hours (10 courses), including four communication-intensive courses. During the senior year, students move through a capstone sequence that includes a methods and research design course, and a senior thesis. Rigorous and creative teaching of social science methods is a signature aspect of the program. The degree also requires a four-course “technical option” in which students develop sustainability-oriented expertise in another department. Alternatively, students can pursue a dual degree, pairing the STS Sustainability Studies degree with a degree in physics, mechanical engineering, economics, or a wide array of other choices.

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1 Other mathematics options may be selected with the permission of the student’s adviser.
2 BIOL 1010 is not required if the first major is Engineering.
### FIRST YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1500</td>
<td>4</td>
</tr>
<tr>
<td>STSx-1xxx</td>
<td>4</td>
</tr>
<tr>
<td>Calculus for Architecture, Management, and HASS</td>
<td>4</td>
</tr>
<tr>
<td>Sustainability Debates</td>
<td>4</td>
</tr>
<tr>
<td>HASS Core Elective</td>
<td>4</td>
</tr>
<tr>
<td>Science Option</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
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<tbody>
<tr>
<td>MATH 1620</td>
<td>4</td>
</tr>
<tr>
<td>STSS 2300</td>
<td>4</td>
</tr>
<tr>
<td>Contemporary Mathematical Ideas in Society</td>
<td>4</td>
</tr>
<tr>
<td>Environment and Society</td>
<td>4</td>
</tr>
<tr>
<td>HASS Core Elective</td>
<td>4</td>
</tr>
<tr>
<td>Science Option</td>
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### SECOND YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>STSH 2310</td>
<td>4</td>
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<tr>
<td>STSS 2310</td>
<td>4</td>
</tr>
<tr>
<td>A Century of Environmental Thought</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td>4</td>
</tr>
<tr>
<td>HASS Core Elective</td>
<td>4</td>
</tr>
<tr>
<td>Biology Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
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</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>STSSx-4xxx</td>
<td>4</td>
</tr>
<tr>
<td>Sustainability Studies Option</td>
<td>4</td>
</tr>
<tr>
<td>Science Elective</td>
<td>4</td>
</tr>
<tr>
<td>Technical Option I</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
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</table>

### THIRD YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>STSSx-4xxx</td>
<td>4</td>
</tr>
<tr>
<td>STSSx-4xxx</td>
<td>4</td>
</tr>
<tr>
<td>Sustainability Studies Option</td>
<td>4</td>
</tr>
<tr>
<td>Sustainability Studies Option</td>
<td>4</td>
</tr>
<tr>
<td>HASS Core Elective</td>
<td>4</td>
</tr>
<tr>
<td>Technical Option II</td>
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<table>
<thead>
<tr>
<th>Spring</th>
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<tbody>
<tr>
<td>STSS-4xxx</td>
<td>4</td>
</tr>
<tr>
<td>Sustainability Studies Careers Seminar</td>
<td>4</td>
</tr>
<tr>
<td>HASS Core Elective</td>
<td>4</td>
</tr>
<tr>
<td>Technical Option III</td>
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</tr>
<tr>
<td>Free Elective</td>
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### FOURTH YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>STSSx-4xxx</td>
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</tr>
<tr>
<td>STSSx-4xxx</td>
<td>4</td>
</tr>
<tr>
<td>Sustainability Studies Capstone Methods</td>
<td>4</td>
</tr>
<tr>
<td>Sustainability Studies Option</td>
<td>4</td>
</tr>
<tr>
<td>Technical Option IV</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
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</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSSx-4xxx</td>
<td>4</td>
</tr>
<tr>
<td>Sustainability Studies Capstone Thesis</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

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1. This course may be substituted with IHSS 19xx Nature/Society, IHSS 19xx, Environment and Politics, or other appropriate first-year seminar as approved by the advisor or the STS Sustainability Studies Working Group.
2. MATH 1010 may be substituted. Dual majors should follow the math requirements of their other major.
3. MATH 1020 or MATH 1520 may be substituted; other MATH or MATP courses may be substituted with approval of advisor.
4. Science Options I and II including the following approved sequences: CHEM 1100 and CHEM 1200, ERTH 1030 and ERTH 1040, and PHYS 1100 and PHYS 1200. Other sequences may be substituted with approval of advisor. Dual majors should follow the Science core requirements of their other major.
5. Sustainability Studies Options include all STSH/S 43xx, STSH/S 45xx, and selected other 4000-level STSH or STSS courses. At least one of these courses must be designated communication intensive. Dual majors should work with their advisor to select these courses in a way that ensures coherence, and ensures that the HASS humanities and social sciences distribution requirements are met.
6. Students may elect BIOL 1010, but any BIOL course will satisfy the requirement. Dual majors should follow the Science core requirements of their other major, which may override this BIOL requirement.
7. The Technical Option sequence is equivalent to a minor outside of STS: four sustainability-related courses, usually from a single department, two of which must be at the 4000 level. Students are encouraged to earn an official minor with this sequence. Dual majors automatically satisfy this requirement.
8. May be met through an approved list of existing courses containing a substantial methods component.
9. May be met by the existing course, STSS 4980 Senior Project. A dedicated course for the Sustainability Studies major will be developed upon sufficient enrollment.
Dual Major Programs

Many STS majors choose to fulfill the requirements for a second major. For example, a pre-med student taking courses in medicine, biology and public health in the STS major may pursue a dual major with biology, or an STS major taking courses on engineering, information technology, or design may pursue a dual major with engineering, computer science, or information technology. There are dozens of other dual major possibilities.

For those students who are interested in a degree that emphasizes both science and technology and environmental issues there is an opportunity to pursue a dual major in Economics and Science, Technology and Society. This combination of majors combines the best of both departments – economic analysis and a broader humanities and social science analysis that emphasize the roles science and technology play in today’s global economy and culture.

Minor Programs

The STS department offers a minor in STS. In addition, STS administers minors in several traditional HASS disciplines; interdepartmental minors in Ecological Economics, Values, and Policy (EEVP); Gender, Science, and Technology; Sustainable Studies; and the Interschool Minor in Energy. These minors are described in the Programs section of this catalog. Requirements for a minor include a total of at least 16 credit hours, eight of which must be at the 4000 level. No Pass/Fail courses may be applied to a minor, and only one transfer or AP course may count for four to six credits. For further information on forming a minor, see the departmental adviser.

Gender, Science, and Technology Minor

This gender studies minor focuses on the ways that gender influences and is influenced by science and technology. Requirements include a total of at least 16 credit hours, eight of which must be at the 4000 level. In addition, all students must take one of the 1000-level courses and the course STSS 4560 Gender Science and Technology.

<table>
<thead>
<tr>
<th>1000 Level (must take at least one)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>IHSS 1963 Science, Technology, and Society*</td>
<td>4</td>
</tr>
<tr>
<td>STSH 1110 Science, Technology, and Society</td>
<td>4</td>
</tr>
<tr>
<td>STSS 1110 Science, Technology, and Society</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2000 Level</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS 2100 Television and Culture</td>
<td></td>
</tr>
<tr>
<td>COMM 2800 Interpersonal Communication</td>
<td></td>
</tr>
<tr>
<td>LITR 2770 Women Writers</td>
<td>4</td>
</tr>
<tr>
<td>PHIL 2500 Bioethics</td>
<td>4</td>
</tr>
<tr>
<td>PHIL 2600 Moral Development</td>
<td>4</td>
</tr>
<tr>
<td>STSH 2960 Topics in Science and Technology Studies - Psychology, Culture, and Design</td>
<td>4</td>
</tr>
<tr>
<td>STSS 2400 Medicine and Society</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4000 Level</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students may cross-register for up to two courses in the Women's Studies Program at Russell Sage College. Contact Linda Layne, program coordinator, at <a href="mailto:laynel@rpi.edu">laynel@rpi.edu</a> for more information.</td>
<td></td>
</tr>
<tr>
<td>ARTS 6960 Topics in Electronic Arts – Electronic Arts Theory: Contemporary Art and Culture</td>
<td>3 to 6</td>
</tr>
<tr>
<td>COMM 4640 Language and Power</td>
<td></td>
</tr>
<tr>
<td>COMM 4960 Topics in Communication – Advertising and Culture</td>
<td>4</td>
</tr>
<tr>
<td>STSH 4340 Environmental Philosophy</td>
<td>4</td>
</tr>
<tr>
<td>STSH 4960 Topics in Science and Technology Studies: Feminist Theory</td>
<td>4</td>
</tr>
<tr>
<td>STSS 4460 Body: Self, Symbol, and Politics</td>
<td>4</td>
</tr>
<tr>
<td>STSS 4560 Gender, Science, and Technology</td>
<td>4</td>
</tr>
</tbody>
</table>

Interschool Minor in Energy (SHSS)

Any thoughtful discussion of the challenges faced in the 21st century will refer to energy. Rensselaer is uniquely able to offer students in any undergraduate major an opportunity to learn about the wide variety of issues involved in understanding energy. The interschool minor in energy includes fundamental courses in architecture, engineering, management, science, and the humanities, arts, and social sciences. Any student wishing to develop a multidisciplinary background in energy should consider this minor.

The minor requires a minimum of four courses. Three of these courses, ENGR 1200 Engineering Graphics and CAD, MANE 4960 Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics, and ERTH 4400 Energy and Mineral Resources, are required.

* Course designated IHSS 1963 is offered in the First Year Studies Program
If any of the above courses are also required for a student’s major, the student should substitute an additional course from Option Two below. At least one more course must also be taken from Option One.

<table>
<thead>
<tr>
<th>Option One</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 4240</td>
<td>Natural Resource Economics 4</td>
</tr>
<tr>
<td>STSH 4340</td>
<td>Environmental Philosophy 4</td>
</tr>
<tr>
<td>STSS 2300</td>
<td>Environment and Society 4</td>
</tr>
<tr>
<td>STSS 4370</td>
<td>Environmental Politics and Policy 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Option Two</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANE 4700</td>
<td>Solar Devices and Renewable Energy 3</td>
</tr>
<tr>
<td>MGMT 4960</td>
<td>Topics in Management – Electric Utilities and Environmental Management 4</td>
</tr>
</tbody>
</table>

**Science, Technology, and Society Minor**

A minor in STS is any four STS courses, with two at the 4000 level, that total 16 credit hours. Students are encouraged to focus the minor on a sequence of courses listed under the four concentration options for the major in STS. An ideal sequence would be IHSS 1963 Science, Technology and Society; and a 2000-level survey and two of the STS Advanced Options in one area of concentration.

**Sustainability Studies Minor**

The STS Sustainability Studies minor prepares students to use techniques and insight from the social sciences and humanities to address environmental problems. Students learn the history of environmental thought and law, about current environmental controversies, and about sustainable pathways and design.

<table>
<thead>
<tr>
<th>Choice of one of the following:</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>IHSS 19xx (FYS) Environment and Politics 4</td>
<td></td>
</tr>
<tr>
<td>IHSS 19xx (FYS) Politics of the Global Environment 4</td>
<td></td>
</tr>
<tr>
<td>IHSS 19xx (FYS) Nature/Society 4</td>
<td></td>
</tr>
<tr>
<td>STSH 1110 Science, Technology, and Society 4</td>
<td></td>
</tr>
<tr>
<td>STSS 1110 Science, Technology, and Society 4</td>
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</table>

<table>
<thead>
<tr>
<th>Required:</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS 2300 Environment and Society 4</td>
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</table>

<table>
<thead>
<tr>
<th>Choice of two of the following:</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS 4300 Social Entrepreneurs and Sustainable Communities 4</td>
<td></td>
</tr>
<tr>
<td>STSS 4330 21st Century Risks—Robotics, Nanotechnology, Cloning, and Other Technologies 4</td>
<td></td>
</tr>
<tr>
<td>STSH 4340 Environmental Philosophy 4</td>
<td></td>
</tr>
<tr>
<td>STSS 4370 Environmental Politics and Policy 4</td>
<td></td>
</tr>
<tr>
<td>STSS 4500 Globalization and Development 4</td>
<td></td>
</tr>
<tr>
<td>STSH 4800 Public Service/Professional Careers Internships 4</td>
<td></td>
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<tr>
<td>STSS 4820 Sustainability Problems 4</td>
<td></td>
</tr>
<tr>
<td>STSS 4800 Public Service/Professional Careers Internships 4</td>
<td></td>
</tr>
<tr>
<td>STSS 4960 Topics in Science and Technology Studies 4</td>
<td></td>
</tr>
<tr>
<td>STSH 49xx Sustainability Problems 4</td>
<td></td>
</tr>
</tbody>
</table>

**Special Undergraduate Opportunities**

**Accelerated STS-Law Program**

In cooperation with Albany Law School and Columbia University Law School, Rensselaer offers a unique program leading to the B.S. and Juris Doctor (J.D.) in six years rather than the usual seven. Admission to this program is restricted. For Albany Law School, most students are admitted as incoming first-year students. Selected applicants must meet the admission requirements of Albany Law School of Union University. Thus a prospective STS-law student may be able to assure admission to law school prior to beginning an undergraduate career at Rensselaer. Transfer from other Rensselaer curricula to this program is limited to students who have demonstrated academic excellence.

Although guaranteed admission to Albany Law School is only available to selected first-year students, conditional admission is available to accepted Rensselaer students who meet specified achievement levels in their undergraduate program. Accelerated Law students have also applied successfully to such law schools as Harvard, Stanford, Cornell, and the University of Virginia for early admission. The STS Department provides whatever assistance possible for such students. Students should notify the STS undergraduate adviser before the end of the sophomore year to inform him that they wish to be nominated.

**Five Year B.S.-M.S.**

A five-year combined B.S.-M.S. program is available for Rensselaer undergraduates who wish to earn a graduate degree in STS. Students may apply to the program on completion of their sophomore year.
Graduate Programs

STS graduate programs lead to the Master of Science and the Doctor of Philosophy degrees in a field of inquiry encompassing the historical, political, and social dimensions of technological civilization. Faculty from a broad range of disciplines mentor students in learning the conceptual frameworks, research methods, and capacities for project choice necessary to contribute to forefront scholarship in the service of a more just, democratic, and environmentally sustainable world.

A significant fraction of the faculty is interested in environmental sustainability and/or in technological design, but would-be STS scholars of every variety are welcome. Research projects range broadly from the science/politics of asthma to the philosophy of biology, from ethnomathematics to robotics and other emerging technological risks/opportunities, from feminist and anti-racist theory to the history of computing. Some faculty orient their research explicitly to illuminate and criticize selected facets of contemporary technoscience and the consumer culture it facilitates, while other faculty conduct scholarship with a more purely disciplinary or interdisciplinary focus.

A majority of graduate students in recent years have pursued ethnographic fieldwork as an important component of their dissertations, but there is no formal or informal departmental restriction on acceptable methods and approaches. Many dissertations focus on issues outside the U.S.; the gun culture of Guatemala, the importation of hormone replacement therapy to Turkey, sanitation for the poorest urban dweller in Mumbai. Other graduate students focus on domestic topics, from military communications technologies to organizations opposing mountain top removal in Appalachia. Dissertations based in social movement theory, democratic theory, philosophy of technoscience, public policy, archival research, simulation, discourse analysis, and other methods are considered equally valid.

For a full list of dissertations and faculty research projects, please see the department Web site.

Master’s Programs

Master of Science

This program is designed for students with undergraduate training in the natural and social sciences, engineering, or humanities and social sciences. In addition, many entering students have substantial career experience relevant to this program.

Completing the M.S. degree in STS requires 30 credit hours, including a six-credit-hour master’s thesis or internship. Among the required core courses are STSS 6010 Concepts in Science and Technology Studies, STSS 6110 Research Methods for STS, STSS 6020 Research Seminar, and STSH 6020 Values and Policy. Also required is one additional 6000-level STS seminar (or an independent readings course with three or more students enrolled).

The program offers an opportunity to take technical courses in other Rensselaer departments that are relevant to the student’s Plan of Study. It also offers substantial individual consultation and flexibility in designing course work and developing the thesis/internship option.

Five-Year B.S./M.S.

As mentioned in the department’s Special Undergraduate Opportunities section, a five-year combined B.S.-M.S. program or co-terminal degree is available for Rensselaer undergraduates wishing to earn an STS graduate degree. Students may apply to the program on completion of their sophomore year.

Doctoral Programs

The STS Department’s doctor of philosophy program primarily trains professionals for stewardship of technological civilization and researchers, teachers, planners, and advisers in academic, government, and private institutions.

The curriculum requires a total of 72 credit hours (up to 30 in dissertation). Required courses in the core are STSS 6200 Science Studies, STSS 6040 Technology Studies, STSS 6100 Policy Studies, STSS 6120 Advanced Research Methods, and a theory option. STSS 6360 Advanced Contemporary Political Thought, and topics courses such as STSS 6961 Structuralism and Post-Structuralism, STSS 6962 Social Theory, and STSS 6963 Feminist and Postcolonial Theory, or other STS graduate courses approved by the graduate committee meet the theory option. The graduate director may also approve substitutions of other relevant courses. Remaining course work is drawn from policy studies, science studies, and technology studies. Students who enter the program without a master’s degree may earn one along the way to the Ph.D.

Master of Science/Doctor of Philosophy

Students must take the core doctoral courses and at least one of the following capstone experiences: a research seminar (generally offered as a topics course) or an independent study course, either of which must result in an article-length research project of publishable quality; a master’s thesis; or a master’s internship. After completing the core doctoral courses, capstone experience, and 30 credit hours, students will be awarded the degree of Master of Science in Science and Technology Studies.
Course Descriptions

Courses for all STS curricula are described in the Course Descriptions section of this catalog under the department codes STSH and STSS. Students often take courses in other departments appropriate to their specific interests.

Interdisciplinary Degree Programs

Few institutions better understand that, in an increasingly complex world, individuals often need a broader range of knowledge than can be obtained through study of a single discipline. As a result, the School of Humanities, Arts, and Social Sciences has developed a strong selection of multidisciplinary academic and research programs. These programs cross not only disciplines, but allow Rensselaer schools to offer the highest possible degree of multidisciplinary education.

In addition to opportunities in the School of Humanities, Arts, and Social Sciences described in the Programs section of this catalog, other interdisciplinary programs available at Rensselaer are listed in the Interdisciplinary Studies Index of this catalog and are described fully in the section pertaining to the associated Institute school or division.

Design, Innovation, and Society

Director: Dean Nieusma

The interdisciplinary Design and Innovation program entails a set of integrated, studio-based curricula that span the social sciences, engineering, management, and communication. All Design Innovation students pursue a B.S. degree in Design, Innovation, and Society (DIS), which is offered by the Department of Science and Technology Studies. Design and Innovation students also pursue a dual major in one of the following areas: Mechanical Engineering, Management, and Communication/Graphic Design. Other dual major combinations are possible.

The DIS curriculum teaches inspired, hands-on design as well as the cultural, ethical, historical, and policy dimensions of design, providing insight into a wide range of potential spaces for innovation. The core of the DIS curriculum is a sequence of design studios, where students gain experience conceiving, developing, and iterating real-world solutions to the problems facing humanity today. The DIS studio sequence entails five design studios, which are common across all Design and Innovation curricula. Two additional studios are offered in each student’s area of specialization (e.g., Mechanical Engineering, Management, Communication, DIS). In total, seven design studios are offered across eight semesters. This sequence of studios helps students explore and develop their creative problems solving skills while building a portfolio of design experience continuously throughout all four years.

While all Design and Innovation students satisfy the DIS degree requirements, students pursuing dual majors also satisfy the degree requirements in their other area of specialization. Design and Innovation dual major curricula have been designed to meet both sets of degree requirements in eight semesters - the same as for a single major. For technically oriented students, the dual major in Mechanical Engineering provides an ABET-accredited education in engineering with a focus on design methodology in general and mechanical design techniques in particular. For students interested in business, the dual major in Management teaches management theory and practice, with course offerings in product design and development, marketing, and entrepreneurship. For students interested in creative design, the dual major in Communication (with a concentration in graphic design) teaches communication and visual theory and hands-on skills in print and electronic media.

The interdisciplinary Design and Innovation program provides students with a wide range of design experiences covering a breadth of problems, from focused problems facing specific groups of consumers to larger, systemic problems facing communities and the planet, so students are exposed to all the different applications of design practice. The Design and Innovation program provides all the elements necessary to put students’ creativity to work as leaders of design and innovation, whether it is in a multinational corporation at the cutting edge of the global marketplace or in a start-up business venture that creates a unique solution to an important problem.
### Baccalaureate Programs
#### Design, Innovation, and Society

#### FIRST YEAR

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1. Students are advised, but not required, to pursue a design-oriented course during this semester.
2. The technical option can be counted toward the requirements of a dual major degree, or it can be four courses in a single field that are all taken for a grade, of which two are at the 4000 level.
3. HASS technical option sequences may be approved by the adviser.
4. Candidate courses include STSS 4350, STSS 4960, STSH 4210, STSS 4310, STSS 4510, and STSH 4510.
5. The STS Senior Project can be combined with the Capstone Design Studio to make an eight-credit capstone studio project. The Capstone Design Studio may be taken as an independent course with an STS faculty member of an approved design studio.
### FIRST YEAR

#### Fall

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<td>STSH or STSS 4xxx</td>
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## Design, Innovation, and Society and Management

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1. PDI Management students are not required to take the Management Leadership sequence, and MGMT 2100 also fulfills the science core requirement.
2. The STS Advanced Option includes any 4000-level STS course, but for PDI students the following are especially recommended: STSS 4350; STSS 4960; STSH 4230; STSS 4560; and STSS 4650.
3. For management students, Design Studio 7 and 8 may be replaced by MGMT 4510 and MGMT 4530. They may also be taken as vertical studios with PDI 5 and 6 or other capstone courses worked out in coordination with the PDI program director and STS advisor.
# Design, Innovation, and Society/Mechanical Engineering

## FIRST YEAR

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<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ENGR 1100</td>
<td>Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 1300</td>
<td>Engineering Processes(^1)</td>
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</tr>
<tr>
<td>ENGR 2020</td>
<td>Product Design and Innovation Design Studio II(^2)</td>
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</tr>
<tr>
<td>MATH 1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>STSS 2200</td>
<td>Engineering, Design, and Society</td>
<td>4</td>
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<tr>
<td>or</td>
<td>STSS 2210 Design, Culture, and Society</td>
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## SECOND YEAR

### Fall

<table>
<thead>
<tr>
<th>Course</th>
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<tr>
<td>CSCI 1190</td>
<td>Beginning C Programming for Engineers</td>
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<td>ENGR 1500</td>
<td>Materials Science for Engineers</td>
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<tr>
<td>IHSS 2610</td>
<td>Product Design and Innovation Studio III</td>
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<tr>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 1100</td>
<td>Physics I</td>
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### Spring

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<tbody>
<tr>
<td>ENGR 2050</td>
<td>Introduction to Engineering Design</td>
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</tr>
<tr>
<td>ENGR 2090</td>
<td>Engineering Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 2530</td>
<td>Strength of Materials</td>
<td>4</td>
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<tr>
<td>PHYS 1200</td>
<td>Physics II</td>
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## THIRD YEAR

### Fall

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<tr>
<td>ENGR 2350</td>
<td>Embedded Control</td>
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<tr>
<td>ENGR 2600</td>
<td>Modeling and Analysis of Uncertainty</td>
<td>3</td>
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<tr>
<td>ENGR 2710</td>
<td>General Manufacturing Processes(^3)</td>
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<td>MATH 2010</td>
<td>Multivariable Calculus and Matrix Algebra</td>
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<tr>
<td>STSH 4610</td>
<td>Product Design and Innovation Studio V</td>
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### Spring

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<tr>
<td>ENGR 496x</td>
<td>PDI Studio VI(^2)</td>
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<td>STSS 4xxx</td>
<td>STS Advanced Option(^3)</td>
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<tr>
<td>ENGR 2250</td>
<td>Thermal and Fluids Engineering I</td>
<td>4</td>
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<tr>
<td>MANE 4050</td>
<td>Modeling and Control of Dynamic Systems</td>
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<tr>
<td>PSYC 4170</td>
<td>Professional Development II: Leadership Theories</td>
<td>2</td>
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<td>or</td>
<td>STSS 4840 Professional Development II</td>
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## FOURTH YEAR

### Fall

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<tr>
<td>ENGR 4010</td>
<td>Professional Development III</td>
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<tr>
<td>MANE 4030</td>
<td>Elements of Mechanical Design</td>
<td>4</td>
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<tr>
<td>MANE 4040</td>
<td>Mechanical Systems Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>MANE 4260</td>
<td>Design of Mechanical Systems</td>
<td>3</td>
</tr>
<tr>
<td>STSS 4xxx</td>
<td>STS Advanced Option(^3)</td>
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### Spring

<table>
<thead>
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<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>ENGR 2300</td>
<td>Electronic Instrumentation</td>
<td>4</td>
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<tr>
<td>MANE 4010</td>
<td>Thermal and Fluids Engineering II</td>
<td>4</td>
</tr>
<tr>
<td>MANE 4020</td>
<td>Thermal and Fluids Engineering Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>STSS 4980</td>
<td>Senior Project(^4)</td>
<td>4</td>
</tr>
</tbody>
</table>

---

\(^1\) These courses can be taken in any order.
\(^2\) PDI II, VI, and General Manufacturing Processes satisfy the ME requirements for the concentration electives.
\(^3\) Candidate courses include STSS 4350, STSS 4960, STSS 4110, STSS 4250, STSS 4310, STSS 4560, and STSS 4650.
\(^4\) The STS Senior Project can be combined with the PDI Capstone Design Studio VII to make a seven-credit capstone project. Coordination should be done with the DIS adviser.
Electronic Media, Arts, and Communication

Acting Head: Caren Canier, Arts
Acting Head: Patricia Search, Communication and Media

The Electronic Media, Arts, and Communication (EMAC) program offers undergraduates the opportunity to study electronic arts in relation to the communication field and prepares them for careers in the applied arts and communication. The B.S. degree in EMAC is earned from both the Department of the Arts and the Department of Communication and Media. It combines offerings in Communication and Media and Arts for a total of at least 60 credit hours and consists of courses taken at four levels.

Required introductory courses at Level One are COMM 1510 Introduction to Communication Theory; COMM 2610 Introduction to Visual Communication; and two of the following courses, per specific concentration; ARTS 1010 Music and Sound; ARTS 1020 Media Studio Imaging; ARTS 1030 Digital Filmmaking. In Level Two, students complete 24 credit hours in selected Communication and Media and Arts courses in writing (4), art history/theory (4), and a short list of intermediate courses in the areas of their specific concentration. Level Three consists of 12 credit hours of advanced courses in specific concentration areas. Senior students at Level Four take eight credits of creative seminar.

**FIRST YEAR**

<table>
<thead>
<tr>
<th>Sem</th>
<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Fall</td>
<td>ARTS 1010, Music and Sound</td>
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<tr>
<td>Spring</td>
<td>ARTS 1010, Music and Sound (concentration in Sound Design and Popular Culture)</td>
<td>4</td>
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<tr>
<td>Fall</td>
<td>ARTS 1020, Media Studio: Imaging (all concentrations except Sound Design and Popular Culture)</td>
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<tr>
<td>Spring</td>
<td>COMM 2610, Introduction to Visual Communication</td>
<td>4</td>
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<tr>
<td>Fall</td>
<td>MATH 1500, Calculus for Architecture, Management, and HASS</td>
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<tr>
<td>Spring</td>
<td>MATH 1620, Contemporary Mathematical Ideas in Society</td>
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**SECOND YEAR**

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<tr>
<td>Fall</td>
<td>BIOL 1010, Introduction to Biology</td>
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<tr>
<td>Spring</td>
<td>EMAC Art History/Theory Elective</td>
<td>4</td>
</tr>
<tr>
<td>Fall</td>
<td>EMAC Intermediate Course</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>Humanities Elective</td>
<td>4</td>
</tr>
<tr>
<td>Fall</td>
<td>Social Science Elective</td>
<td>4</td>
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<td>Spring</td>
<td>Math/Science Elective</td>
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**THIRD YEAR**

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<tr>
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<td>Spring</td>
<td>EMAC Concentration</td>
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<tr>
<td>Fall</td>
<td>EMAC Intermediate Course</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>Humanities Elective</td>
<td>4</td>
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<tr>
<td>Fall</td>
<td>Social Science Elective</td>
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<td>Spring</td>
<td>Math/Science Elective</td>
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<th>Credit Hours</th>
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<td>HASS Elective</td>
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## FOURTH YEAR

### Fall

<table>
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<th>Course</th>
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<tr>
<td>ARTS 4840</td>
<td>Creative Seminar I</td>
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<tr>
<td>EMAC Concentration</td>
<td>4</td>
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<tr>
<td>Free Elective</td>
<td>4</td>
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<tr>
<td>Free Elective</td>
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### Spring

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<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 4850</td>
<td>Creative Seminar II</td>
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<tr>
<td>EMAC Concentration</td>
<td>4</td>
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<tr>
<td>Free Elective</td>
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### Concentrations

#### EMAC: Digital Storytelling

**Required Courses (16 credits)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS 1020</td>
<td>Media Studio: Imaging</td>
</tr>
<tr>
<td>ARTS 4840</td>
<td>Creative Seminar I</td>
</tr>
<tr>
<td>ARTS 4850</td>
<td>Creative Seminar II</td>
</tr>
<tr>
<td>COMM 1510</td>
<td>Introduction to Communication Theory</td>
</tr>
<tr>
<td>COMM 2610</td>
<td>Introduction to Visual Communication</td>
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**Writing Course (4 credits)**

Select one:

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<tr>
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<td>Writing for Classroom and Career</td>
</tr>
<tr>
<td>WRIT 2110</td>
<td>Rhetoric and Writing</td>
</tr>
<tr>
<td>WRIT 4550</td>
<td>Proposing and Persuading</td>
</tr>
<tr>
<td>WRIT 4xxx</td>
<td>Writing for Promotion and Marketing</td>
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</table>

**Art History or Theory Course (4 credits)**

Select one:

<table>
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<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 2530</td>
<td>Art History I: From Paleolithic to Renaissance</td>
</tr>
<tr>
<td>ARTS 2540</td>
<td>The Multimedia Century</td>
</tr>
<tr>
<td>ARTS 4130</td>
<td>New Media Theory</td>
</tr>
<tr>
<td>ARTS 4960</td>
<td>Topics in the Arts - New Media Theory</td>
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</table>

### Intermediate Courses (16 credits)

Select one:

Any literature course (except a film course)

And select three courses (at least one from Arts and one from LL&C):

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 2010</td>
<td>Intermediate Video</td>
</tr>
<tr>
<td>ARTS 2020</td>
<td>Computer Music</td>
</tr>
<tr>
<td>ARTS 2040</td>
<td>Intermediate Digital Imaging</td>
</tr>
<tr>
<td>ARTS 2060</td>
<td>Fundamentals of Animation</td>
</tr>
<tr>
<td>ARTS 2070</td>
<td>Graphic Storytelling</td>
</tr>
<tr>
<td>ARTS 2220</td>
<td>Fundamentals of 2-D Design</td>
</tr>
<tr>
<td>COMM 2410</td>
<td>Perspectives on Photography</td>
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<td>COMM 2440</td>
<td>Documentary Film</td>
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<td>COMM-29xx</td>
<td>Visual Culture</td>
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### Advanced Courses (12 credits)

Select three courses:

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<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 496x</td>
<td>Advanced Video*</td>
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<tr>
<td>ARTS 4020</td>
<td>Advanced Digital 3-D Projects*</td>
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<tr>
<td>ARTS 4040</td>
<td>Rethinking Documentary: Video Production*</td>
</tr>
<tr>
<td>ARTS 4060</td>
<td>Animation I</td>
</tr>
<tr>
<td>ARTS 4070</td>
<td>Animation II*</td>
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<tr>
<td>ARTS 4080</td>
<td>Art, Community, and Technology</td>
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<tr>
<td>ARTS 4200</td>
<td>Advanced Drawing*</td>
</tr>
<tr>
<td>ARTS 4510</td>
<td>Experimental Game Design*</td>
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<tr>
<td>ARTS 4630</td>
<td>Writing and Directing for Video</td>
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<tr>
<td>COMM 4300</td>
<td>Communication Internship*</td>
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<tr>
<td>COMM 4660</td>
<td>Visual Literacy</td>
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<tr>
<td>COMM 4790</td>
<td>Interactive Narrative*</td>
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<tr>
<td>LITR 4410</td>
<td>Film Theory*</td>
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</table>
## EMAC: Marketing Communication and Design

### Required Courses (24 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ARTS 1020</td>
<td>Media Studio: Imaging</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4840</td>
<td>Creative Seminar I</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4850</td>
<td>Creative Seminar II</td>
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<tr>
<td>COMM 1510</td>
<td>Introduction to Communication Theory</td>
<td>4</td>
</tr>
<tr>
<td>COMM 2610</td>
<td>Introduction to Visual Communication</td>
<td>4</td>
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### Writing Course (4 credits)

Select one:
- WRIT 1110 Writing for Classroom and Career 4 credits
- WRIT 2110 Rhetoric and Writing 4 credits
- WRIT 4550 Proposing and Persuading 4 credits
- WRIT 4xxx Writing for Promotion and Marketing

### Art History or Theory Course (4 credits)

Select one:
- ARTS 2540 The Multimedia Century 4 credits
- ARTS 2550 New Media Theory 4 credits
- ARTS 4960 Topics in the Arts 3 to 4 credits
- ARTS 4130 New Media Theory 4 credits
- ARTS 4960 Topics in the Arts 3 to 4 credits

### Intermediate Courses (16 credits)

Select:
- MGMT 4430 Marketing Principles

And select three courses (at least one from Arts and one from LL&C):
- ARTS 2010 Intermediate Video 4 credits
- ARTS 2040 Intermediate Digital Imaging 4 credits
- ARTS 2200 Fundamentals of 2-D Design 4 credits
- COMM 4460 Visual Design: Theory and Application 4 credits
- COMM 4570 Typography 4 credits
- COMM 4660 Visual Literacy 4 credits

### Advanced Courses

Select one:
- MGMT 4470 Marketing Research
- MGMT 4490 Advertising Strategies and Promotions

And select two courses:
- ARTS 4080 Art, Community, and Technology 4 credits
- ARTS 4630 Writing and Directing for Video 4 credits
- COMM 4300 Communication Internship* 4 credits
- COMM 4400 Cross-Cultural Media: Analysis and Application 4 credits
- COMM 4470 Information Design* 4 credits
- COMM 4580 Advertising and Culture* 4 credits
- COMM 4650 Marketing Communication Design* 4 credits
- COMM 4690 Interface Design: Hypermedia Theory and Application* 4 credits
- COMM 4730 Graphic Design for Corporate Identity* 4 credits
- ARTS 4xxx Advanced Digital Imaging

## EMAC: Interaction Design

### Required Courses (24 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS 1020</td>
<td>Media Studio: Imaging</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4840</td>
<td>Creative Seminar I</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4850</td>
<td>Creative Seminar II</td>
<td>4</td>
</tr>
<tr>
<td>COMM 1510</td>
<td>Introduction to Communication Theory</td>
<td>4</td>
</tr>
<tr>
<td>COMM 2610</td>
<td>Introduction to Visual Communication</td>
<td>4</td>
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</tbody>
</table>

### Writing Course (4 credits)

Select one:
- WRIT 1110 Writing for Classroom and Career 4 credits
- WRIT 2110 Rhetoric and Writing 4 credits
- WRIT 4550 Proposing and Persuading 4 credits
- WRIT 4xxx Writing for Promotion and Marketing
Art History or Theory Course (4 credits)  
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS 2540</td>
<td>The Multimedia Century</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4130</td>
<td>New Media Theory</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4960</td>
<td>Topics in the Arts</td>
<td>3 to 4</td>
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Intermediate Courses (16 credits)  
Select four courses (at least one from Arts and one from LL&C):  
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<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 1200</td>
<td>Basic Drawing</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2010</td>
<td>Intermediate Video</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2020</td>
<td>Computer Music</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2040</td>
<td>Intermediate Digital Imaging</td>
<td>4</td>
</tr>
<tr>
<td>ITWS 2210</td>
<td>Introduction to Human Computer Interaction</td>
<td>4</td>
</tr>
<tr>
<td>COMM 496x</td>
<td>HCI Implementation: Flash</td>
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Advanced Courses (12 credits)  
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<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 4010</td>
<td>Interactive Arts Programming*</td>
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<td>ARTS 4080</td>
<td>Art, Community, and Technology</td>
<td>4</td>
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<tr>
<td>ARTS 4130</td>
<td>New Media Theory</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4180</td>
<td>Studio Design in Human-Computer Interaction*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4300</td>
<td>Communication Internship*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4400</td>
<td>Cross-Cultural Media: Analysis and Application</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4420</td>
<td>Foundations of HCI Usability*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4660</td>
<td>Visual Literacy</td>
<td>4</td>
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<tr>
<td>COMM 4690</td>
<td>Interface Design: Hypermedia Theory and Application*</td>
<td>4</td>
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<tr>
<td>COMM 4710</td>
<td>Communication Design for the WWW*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4770</td>
<td>User-Centered Design*</td>
<td>4</td>
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<tr>
<td>COMM 4780</td>
<td>Interactive Narrative*</td>
<td>4</td>
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EMAC: Sound Design and Popular Culture  

Required Courses (24 credits)  
Select one of the following:  
<table>
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<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS 1020</td>
<td>Media Studio: Imaging</td>
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</tr>
<tr>
<td>or</td>
<td>ARTS 1030</td>
<td>Digital Filmmaking</td>
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<tr>
<td>ARTS 1010</td>
<td>Music and Sound</td>
<td>4</td>
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<tr>
<td>ARTS 4840</td>
<td>Creative Seminar I</td>
<td>4</td>
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<tr>
<td>ARTS 4850</td>
<td>Creative Seminar II</td>
<td>4</td>
</tr>
<tr>
<td>COMM 1510</td>
<td>Introduction to Communication Theory</td>
<td>4</td>
</tr>
<tr>
<td>COMM 2610</td>
<td>Introduction to Visual Communication</td>
<td>4</td>
</tr>
</tbody>
</table>

Writing Course (4 credits)  
Select one:  
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRIT 1110</td>
<td>Writing for Classroom and Career</td>
<td>4</td>
</tr>
<tr>
<td>WRIT 2110</td>
<td>Rhetoric and Writing</td>
<td>4</td>
</tr>
<tr>
<td>WRIT 4550</td>
<td>Proposing and Persuading</td>
<td>4</td>
</tr>
<tr>
<td>WRIT 4xxx</td>
<td>Writing for Promotion and Marketing</td>
<td></td>
</tr>
</tbody>
</table>

Art History or Theory Course (4 credits)  
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS 2500</td>
<td>History of Western Music</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2510</td>
<td>History of Jazz</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2520</td>
<td>World Music</td>
<td>4</td>
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</tbody>
</table>

Intermediate Courses (16 credits)  
Select four courses (at least one from Arts and one from LL&C):  
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ARTS 2020</td>
<td>Computer Music</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2400</td>
<td>Music Theory I</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2500</td>
<td>History of Western Music</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2510</td>
<td>History of Jazz</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2520</td>
<td>World Music</td>
<td>4</td>
</tr>
<tr>
<td>LITR 2420</td>
<td>Art of the Film</td>
<td>4</td>
</tr>
</tbody>
</table>
### Advanced Courses (12 credits)  
**Select three courses:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS 4010</td>
<td>Interactive Arts Programming*</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4030</td>
<td>Multimedia Performance Systems*</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4100</td>
<td>Electronic Arts Theory Seminar</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4400</td>
<td>Music Theory II</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4410</td>
<td>Deep Listening</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 469x</td>
<td>Advanced Computer Music Topics*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4300</td>
<td>Communication Internship*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4780</td>
<td>Interactive Narrative*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4790</td>
<td>Social Impact of Electronic Media</td>
<td>4</td>
</tr>
<tr>
<td>LITR 4410</td>
<td>Film Theory*</td>
<td>4</td>
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### EMAC: Graphic Design

#### Required Courses (24 Credits)

<table>
<thead>
<tr>
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<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ARTS 1020</td>
<td>Media Studio: Imaging</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4840</td>
<td>Creative Seminar I</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4850</td>
<td>Creative Seminar II</td>
<td>4</td>
</tr>
<tr>
<td>COMM 1510</td>
<td>Introduction to Communication Theory</td>
<td>4</td>
</tr>
<tr>
<td>COMM 2610</td>
<td>Introduction to Visual Communication</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Writing Courses (4 Credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRIT 1110</td>
<td>Writing for Classroom and Career</td>
<td>4</td>
</tr>
<tr>
<td>WRIT 2110</td>
<td>Rhetoric and Writing</td>
<td>4</td>
</tr>
<tr>
<td>WRIT 4550</td>
<td>Proposing and Persuading</td>
<td>4</td>
</tr>
<tr>
<td>WRIT 4xx</td>
<td>Writing for Promotion and Marketing</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Art History or Theory Courses (4 Credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS 2530</td>
<td>Art History I: From Paleolithic to Renaissance</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2540</td>
<td>The Multimedia Century</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4130</td>
<td>New Media Theory</td>
<td>4</td>
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</tbody>
</table>

#### Intermediate Courses (16 Credits)

**Select two courses (at least one from Arts and one from Communication and Media)**

**Select:**
- COMM 4570  
  Typography  

**Select one:**
- ARTS 2220  
  Fundamentals of 2-D Design  
- COMM 4460  
  Visual Design: Theory and Application  

**Select two courses from:**
- ARTS 1200  
  Basic Drawing  
- ARTS 2010  
  Intermediate Video  
- ARTS 2040  
  Intermediate Digital Imaging  
- ARTS 2220  
  Fundamentals of 2-D Design  
- COMM 2620  
  Color Theory  
- COMM 4460  
  Visual Design: Theory and Application  
- COMM 4660  
  Visual Literacy  

#### Advanced Courses (12 Credits)

**Select three courses:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS 4080</td>
<td>Art, Community, and Technology</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4630</td>
<td>Writing and Directing for Video</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4300</td>
<td>Communication Internship*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4400</td>
<td>Cross-Cultural Media: Analysis and Application</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4470</td>
<td>Information Design*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4580</td>
<td>Advertising and Culture*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4650</td>
<td>Marketing Communication Design</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4670</td>
<td>Advanced Typography*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4690</td>
<td>Interface Design: Hypermedia Theory and Application*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4730</td>
<td>Graphic Design for Corporate Identity*</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4780</td>
<td>Interactive Narrative*</td>
<td>4</td>
</tr>
</tbody>
</table>

*An internship is strongly recommended for this concentration.*

### Required Thesis Sequence (8 Credits)

Thesis courses are designated with an asterisk in the list of Advanced Courses. Select two thesis courses. Students may also do one thesis course plus an internship.  
*An internship is strongly recommended for this concentration.*
Ecological Economics, Values, and Policy

The Department of Science and Technology Studies offers a 30-credit EEVP master’s program that builds on the department’s nationally recognized expertise in the social, political, economic, cultural, and ethical implications of interactions between science, technology, environment, and society. EEVP is meant for academically strong Rensselaer students who wish to complete their master’s degree in preparation for sustainability careers in industry, government, or academia. The program is open only to Rensselaer five-year co-terminal degree students who have a strong interest in the social sciences of sustainability.

Professional Master’s Program

The Department of Science and Technology Studies offers a 30-credit EEVP master’s program that builds on the department’s nationally recognized expertise in the social, political, economic, cultural, and ethical implications of interactions between science, technology, environment, and society. EEVP is meant for academically strong Rensselaer students who wish to complete their master’s degree in preparation for sustainability careers in industry, government, or academia. Program is open only to Rensselaer five-year co-terminal degree students who have a strong interest in the social sciences of sustainability.

Required and Required Elective Courses:

**Sustainability Careers** – 4000 or 6000 level. Offered fall term. Substitute any 6000-level sustainability course if took this as an undergraduate. 3 or 4 credits.

**Sustainability Research Methods** – 4000 level. Offered fall term. Substitute any 4000-level methods intensive course if student took this as an undergraduate. 4 credits

**Economics Option** – 6000 level, International Economics and Globalization, Ecological Economics, Environmental Economics, or Sustainability Economics, etc. 3 credits.

**Advanced Experimental Methods & Statistics** (COGS 6310) OR second ECON option. 4 credits

**Sustainability Internship** – 6000 level. Taken as an Independent Study, following STS internship guidelines. 3-5 credits.

**Sustainability Research Design** – 6000 level that meets with 4000 level or as independent study. Taken semester prior to Sustainability Projects. Fall term unless adviser approves. Okay to take even if took as an undergrad as it will be a new proposal design. 4 credits.

**Sustainability Projects** – 6000 level. May be taken as an Independent Study. May be repeated if already taken at the undergraduate level. Spring term unless adviser approves. 3-5 credits.

**Sustainability Events** – 6000 level. Take as an Independent Study. Students attend and write annotations about an array of public sustainability events – lectures, conferences, or films. 3-4 credits.

### Additional Requirements

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 6490 Introduction to Economic Theory</td>
<td>3</td>
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</tbody>
</table>

**And Two of the Following Three Courses:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 6230 Advanced Environmental Economics</td>
<td>3</td>
</tr>
<tr>
<td>ECON 6240 Advanced Natural Resource Economics</td>
<td>3</td>
</tr>
<tr>
<td>ECON 6250 Advanced Ecological Economics</td>
<td>3</td>
</tr>
</tbody>
</table>

### Sample Electives

**Credit Hours**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 4150 Economics of Government Regulation</td>
<td>3</td>
</tr>
<tr>
<td>ECON 4160 Public Finance</td>
<td>4</td>
</tr>
<tr>
<td>ECON 4190 International Economics and Globalization</td>
<td>4</td>
</tr>
<tr>
<td>ECON 6210 Advanced Cost-Benefit Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ECON 6550 Advanced Microeconomic Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ECON 6590 Advanced Macroeconomic Analysis</td>
<td>3</td>
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</table>

### STS Course Requirements for the EEVP Master’s

**Credit Hours**

**And One of the Following Two Courses:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>STSS 4330 21st Century Risks—Robotics, Nanotechnology, Cloning, and Other Technologies</td>
<td>4</td>
</tr>
<tr>
<td>STSS 4500 Globalization and Development</td>
<td>4</td>
</tr>
<tr>
<td>STSS 6010 Concepts/Research Seminar in Science and Technology Studies</td>
<td>3</td>
</tr>
<tr>
<td>STSH 6020 Values and Policy</td>
<td>3</td>
</tr>
<tr>
<td>STSS 6100 Policy Studies</td>
<td>3</td>
</tr>
<tr>
<td>STSS 6400 Environment and Health</td>
<td>3</td>
</tr>
</tbody>
</table>

### Additional Information

All together, the program totals 10 courses for a minimum of 30 credit hours and can be completed with all 6000-level courses at three credit hours. However, if students choose to take one or two 4000-level electives at four credit hours, they will earn either 31 or 32 credit hours.
Games & Simulation Arts and Sciences

Co-Director: Benjamin Chang, Arts

Co-Director: Lee Sheldon, Language, Literature and Communication

The School of Humanities, Arts, and Social Sciences offers a major program called Games and Simulation Arts and Sciences (GSAS) that provides the option of concentrations or dual majors in these areas: Arts, Cognitive Science, Computer Science, Human Computer Interaction (HCI) and Management.

The GSAS has two components. The first component is a program leading to the games and simulation arts and sciences B.S. degree. It is designed to ensure that every graduate has a suite of integrated skills that external reviewers, industry leaders and academics, and our faculty have identified as important for leaders in the field: experience working in interdisciplinary teams, proven abilities in producing work, as demonstrated by having a portfolio in hand at graduation, analytical and communication skills, and experience pushing the boundaries of present-day genres and technologies through research.

The GSAS is a comprehensive B.S. program that stresses acquiring both fundamental principles and skills in a range of disciplines and also obtaining some depth in a single area of concentration in game studies. The curriculum provides many team experiences and cycles of design, analysis, and iteration, as well as a formal research component. This core curriculum will help ensure that graduates can develop as leaders in the game industry as well as in other fields that make use of highly interactive media, e.g. training and simulation applications found in business, education, and government; business management in emerging new media fields.

The study of games and the game experience offers fascinating new opportunities for collaboration among academic disciplines in engineering, arts and visual design, cultural studies, social and behavioral sciences, computer sciences, and information technology.

The commercial and entertainment function of games and the industry’s explosive economic growth stimulates the study of digital games. But equally important, emerging applications for interactive simulation will create breakthroughs in communication, education, training, artistic expression, modeling complex systems, and social simulation and prediction. These burgeoning areas use games as software interfaces, simulation platforms, and as virtual communication environments and pose important questions for research and education.

The keys to success in this dynamic area of intellectual pursuit are a balance of disciplinary competence, a comprehensive understanding of interactive digital media, and a mastery of a clearly defined set of related disciplinary choices. One signature of our graduates is their ability to communicate and interact effectively within teams composed of individuals with highly diverse backgrounds, while bringing a strong disciplinary background and developed skill set of their own to the team.

Baccalaureate Program

FIRST YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>COGS 2520</td>
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</tr>
<tr>
<td>CSCI 1100</td>
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</tr>
<tr>
<td>MATH 1010</td>
<td>4</td>
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<tr>
<td>or</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1500</td>
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<tr>
<td>ARTS 1xxx</td>
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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1010</td>
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</tr>
<tr>
<td>COGS 4320</td>
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<tr>
<td>CSCI 1200</td>
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<tr>
<td>MATH 2800</td>
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SECOND YEAR

<table>
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<tr>
<td>PHYS 1100</td>
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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>COMM 1600</td>
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</tr>
</tbody>
</table>

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1 Students with sufficient programming background may substitute any other Computer Science course.
### THIRD YEAR

**Fall**

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ARTS 4xxx</td>
<td>Game Development</td>
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</tr>
<tr>
<td>COGS 4520</td>
<td>Game Development</td>
<td>4</td>
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<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSCI 4520</td>
<td>Game Development</td>
<td>4</td>
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<tr>
<td>or</td>
<td>HASS Core Elective</td>
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<tr>
<td>or</td>
<td>Concentration Course</td>
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**Spring**

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<tr>
<td>ARTS 4xxx</td>
<td>Game Development II</td>
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</tr>
<tr>
<td>COGS 4xxx</td>
<td>Game Development II</td>
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<tr>
<td>CSCI 4xxx</td>
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<td>or</td>
<td>HASS Core Elective</td>
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### FOURTH YEAR

**Fall**

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<tr>
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<td>Experimental Game Design</td>
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<td>or</td>
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<td></td>
</tr>
<tr>
<td>HASS Core Elective</td>
<td></td>
<td>4</td>
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<tr>
<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Elective</td>
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**Spring**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>IHSS 4xxx</td>
<td>GSAS Research Project</td>
<td>4</td>
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<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration Course</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Elective</td>
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</table>

**Concentrations**

### Human-Computer Interaction

<table>
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<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM 1510</td>
<td>Introduction to Communication Theory</td>
<td>4</td>
</tr>
<tr>
<td>COMM 2610</td>
<td>Introduction to Visual Communication</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4180</td>
<td>Studio Design in Human-Computer Interaction</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4420</td>
<td>Foundations of HCI Usability</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4470</td>
<td>Information Design</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4690</td>
<td>Interface Design: Hypermedia Theory and Application</td>
<td>4</td>
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<tr>
<td>COMM 4710</td>
<td>Communication Design for the WWW</td>
<td>4</td>
</tr>
<tr>
<td>COMM 4770</td>
<td>User-Centered Design</td>
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<td>or</td>
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<td></td>
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<tr>
<td>COMM 4520</td>
<td>Information Architecture</td>
<td>4</td>
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<tr>
<td>or</td>
<td></td>
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</tr>
<tr>
<td>PSYC 2220</td>
<td>Human Factors in Design</td>
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### Cognitive Science

<table>
<thead>
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<tbody>
<tr>
<td>CSCI 2300</td>
<td>Introduction to Algorithms</td>
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<tr>
<td>CSCI 4150</td>
<td>Introduction to Artificial Intelligence</td>
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</tr>
<tr>
<td>CSCI 2120</td>
<td>Introduction to Cognitive Science</td>
<td>4</td>
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</tr>
<tr>
<td>PHIL 2120</td>
<td>Introduction to Cognitive Science</td>
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<tr>
<td>PSYC 2120</td>
<td>Introduction to Cognitive Science</td>
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<tr>
<td>PHIL 2130</td>
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<tr>
<td>or</td>
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<td></td>
</tr>
<tr>
<td>IHSS 1xxx</td>
<td>Minds and Machines</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td></td>
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</tr>
<tr>
<td>PHIL 4260</td>
<td>Philosophy of Artificial Intelligence</td>
<td>4</td>
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<tr>
<td>or</td>
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<tr>
<td>PHIL 4440</td>
<td>Knowledge and Rationality</td>
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<tr>
<td>PHIL 4480</td>
<td>Metaphysics and Consciousness</td>
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<tr>
<td>PHIL 4xxx</td>
<td>Philosophy of Cognitive Science</td>
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<tr>
<td>PSYC 4320</td>
<td>Behavioral Neuroscience</td>
<td>4</td>
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<tr>
<td>PSYC 4410</td>
<td>Sensation and Perception</td>
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<tr>
<td>PSYC 4xxx</td>
<td>Structure of Language</td>
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<tr>
<td>PSYC 4510</td>
<td>Cognitive Modeling</td>
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<tr>
<td>COGS 4xxx</td>
<td>Programming for Cognitive Science and AI</td>
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### Electronic Arts

<table>
<thead>
<tr>
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<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>ARTS 1010</td>
<td>Music and Sound</td>
<td>4</td>
</tr>
<tr>
<td>or ARTS 1020</td>
<td>Media Studio: Imaging</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 1200</td>
<td>Basic Drawing C</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2040</td>
<td>Intermediate Digital Imaging</td>
<td>4</td>
</tr>
<tr>
<td>or ARTS 2060</td>
<td>Fundamentals of Animation</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2530</td>
<td>Art History I: From Paleolithic to Renaissance</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 2540</td>
<td>The Multimedia Century</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4060</td>
<td>Animation I</td>
<td>4</td>
</tr>
<tr>
<td>ARTS 4070</td>
<td>Animation II</td>
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### Computer Science

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<tr>
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<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CSCI 2300</td>
<td>Introduction to Algorithms</td>
<td>4</td>
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<tr>
<td>CSCI 2500</td>
<td>Computer Organization</td>
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<tr>
<td>CSCI 4210</td>
<td>Operating Systems</td>
<td>4</td>
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<td>CSCI 4440</td>
<td>Software Design and Documentation</td>
<td>4</td>
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<td>ECSE 4750</td>
<td>Computer Graphics</td>
<td>3</td>
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<tr>
<td>or CSCI 4xxx</td>
<td>Three Dimensional Computer Graphics</td>
<td>4</td>
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<tr>
<td>or CSCI 6xxx</td>
<td>Advanced Computer Graphics</td>
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<tr>
<td>CSCI 4xxx</td>
<td>Game AI</td>
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<tr>
<td>PSYC 4xxx</td>
<td>Game Architecture</td>
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### Management

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<th>Course Title</th>
<th>Credit Hours</th>
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<tr>
<td>ECON 1200</td>
<td>Introductory Economics</td>
<td>4</td>
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<tr>
<td>MGMT 1100</td>
<td>Introduction to Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 1260</td>
<td>Business Law and Ethics</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 2300</td>
<td>Fundamentals of Accounting for Decision Making</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 2320</td>
<td>Managerial Finance</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 2510</td>
<td>Microcomputers and Applications</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4430</td>
<td>Marketing Principles</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4850</td>
<td>Organizational Behavior in High Performance Organizations</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4870</td>
<td>Strategy and Policy</td>
<td>4</td>
</tr>
</tbody>
</table>

### Games Studies Minor

The interdisciplinary minor is comprised of current courses offered within the Departments of Arts; Cognitive Science; and Language, Literature, and Communication.

The courses that constitute the core of the interdisciplinary minor include:

- Game Design/Psychology

In addition, three courses coming from within each of the participating departments:

**Arts** considers games and simulation as newly evolving genres stemming from cinema, animation, interactivity, and digital media. Using creative hands-on studio practice combined with collaborative team work, alternate gaming paradigms and emerging forms are encouraged.

- Approved Independent Study Course
- Experimental Game Design

**Cognitive Science** follows the industry philosophy and approach using teams to foster strong collaborations, especially in making "synthetic characters."

- Game Artificial Intelligence
- Game Architecture
- Game Mechanics
- Game Development I

**Language, Literature, & Communication** analyzes games aesthetics and game design like character development and game experience.

- Designing Interactive Characters for Computer Games
- Interactive Narrative
Information Technology and Web Science

Director: Peter Fox  
Program Manager: Linda Kramarchyk  
Program Home Page: [http://itws.rpi.edu/](http://itws.rpi.edu/)

Information Technology and Web Science (ITWS) degrees available at Rensselaer include the Bachelor of Science in Information Technology and Web Science and the Master of Science in Information Technology. Opportunities for Ph.D. level work in Information Technology and Web Science are also available. Those holding these degrees are in great demand and command some of the highest starting salaries and bonuses in any profession.

Rensselaer’s ITWS degree programs are designed for students with an interest in computers that they wish to apply to other disciplines. Recognizing that Information Technology is the “enabler of the Information Age,” Rensselaer has made IT one of its top academic priorities. The Institute has developed a highly interdisciplinary program that emphasizes ITWS’s application to nearly every field from science and engineering to management to humanities and social sciences.

Rensselaer’s undergraduate and graduate ITWS degree programs consist of two components. The first is a set of core courses that focus on the effective use of computers to solve problems. The second is the concentration area in which students employ their technical expertise to a problem domain or discipline of their choice.

Each of Rensselaer’s five schools offers concentration area options to ITWS students. The ITWS curriculum draws its coursework from each of these academic schools. Many Rensselaer faculty members representing a wide variety of the disciplines taught at the Institute contribute to this program, thereby providing students with a broad range of perspectives on ITWS and the breadth of its impact on the world.

**Faculty**

Professors

- **Bailey, R.A.**—Ph.D. (McGill University); coordination chemistry and chemistry of molten salts (Chemistry and Chemical Biology Department).
- **Bennett, K.**—Ph.D. (University of Wisconsin); mathematical programming, machine learning, support vector machines, neural networks, artificial intelligence, parallel optimization, tabu search, automated drug discovery, data mining, bioinformatics, cheminformatics, molecular epidemiology, population biology, complementarity (Mathematical Sciences and Computer Science Departments).
- **Breneman, C.M.**—Ph.D. (University of California, Santa Barbara); physical organic chemistry (Chemistry and Chemical Biology Department).
- **Bringsjord, S.**—Ph.D. (Brown University); logic, philosophical logic, philosophy of artificial intelligence (Cognitive Science Department).
- **Carothers, C.**—Ph.D. (Georgia Institute of Technology); computer simulation, parallel simulation, parallel systems (Computer Science Department).
- **Century, M.**—M.A. (University of California, Berkeley); musicology, music composition, improvisation and performance (Arts Department).
- **Connor, K.**—Ph.D. (Polytechnic Institute of New York); electromagnetic theory, wave propagation, plasmas for fusion research and industrial applications, finite element methods (Electrical, Computer, and Systems Engineering Department).
- **De, S.**—Sc.D. (Massachusetts Institute of Technology); numerical methods in engineering, multimodal virtual environments, fast computational techniques of MEMS (Mechanical, Aerospace, and Nuclear Engineering Department).

*Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.*
Fox, P.—Ph.D. (Monash University); semantic web, semantic e-science, data intensive science, virtual observatories, virtual organizations, data grids, high performance computing, collaborative science, sensor web, solar-terrestrial physics, solar variability (Tetherless World Constellation Chair) (joint in Earth and Environmental Sciences/Computer Science Departments).

Gerhardt, L.A.—Ph.D. (State University of New York at Buffalo); communication systems, digital voice and image processing, adaptive systems and pattern recognition, integrated manufacturing (Electrical, Computer and Systems Engineering Department).

Goldberg, M.K.—Ph.D. (Institute of Mathematics, Novosibirsk, Russia); algorithms for combinatorial optimization, experimental algorithm design and analysis, computational learning theory, graph theory (Computer Science Department).

Gowdy, J.M.—Ph.D. (West Virginia University); ecological economics, industrial organization and public regulation, regional economics (Economics Department).

Hendler, J.—Ph.D. (Brown University); artificial intelligence, semantic web, agent based computing, high performance processing (Senior Constellation Professor, Tetherless World) (Computer Science Department).

Herron, I.—Ph.D. (Johns Hopkins University); applied mathematics, fluid mechanics, hydrodynamics, stability (Mathematical Sciences Department).

Hsu, C.—Ph.D. (Ohio State University); metadatabase and information systems, Internet enterprises planning, database and knowledge-based systems, computerized manufacturing, enterprise integration and modeling, information visualization, economic evaluation of cyberspace-augmented enterprises (Industrial and Systems Engineering Department).

Isaacson, D.—Ph.D. (New York University); mathematical physics, biomedical applications (Mathematical Sciences Department).

Jackson, Shirley Ann—Ph.D. (Massachusetts Institute of Technology); (President, Professor of Physics, Applied Physics, and Astronomy; Professor of Engineering).

Kapila, A.—Ph.D. (Cornell University); applied mathematics, combustion, fluid mechanics (Mathematical Sciences Department).

Magdon-Ismail, M.—Ph.D. (California Institute of Technology); machine learning, computational finance, bioinformatics (Computer Science Department).

McGuinness, D.—Ph.D. (Rutgers University); knowledge representation and reasoning, explanation, proof, trust, ontologies, semantic web (Constellation Professor, Tetherless World) (Computer Science Department).

Miller, B.—M.F.A. (New York University Graduate Film and Television Program); video art, media art (Arts Department).

Nierzwicki-Bauer, S.A.—Ph.D. (University of New Hampshire); plant molecular biology; subsurface microbiology (Biology Department).

Ravichandran, T.—Ph.D. (Southern Illinois University, Carbondale); management information systems (Lally School of Management and Technology).

Rolnick, N.B.—Ph.D. (University of California, Berkeley); music composition, electronic and computer music, electronic arts (Arts Department).

Saulnier, G.J.—Ph.D. (Rensselaer Polytechnic Institute); circuits and electronics, communication systems, digital signal processing (Electrical, Computer, and Systems Engineering Department).

Search, P.—M.A. (Goddard College); visual design theory and practice; interaction design and multimedia art; computer animation and hypermedia interface design; multi-literacy models for intercultural communication (Language, Literature, and Communication Department).

Siegmann, W.L.—Ph.D. (Massachusetts Institute of Technology); applied mathematics, wave propagation (Mathematical Sciences Department).

Spooner, D.L.—Ph.D. (Pennsylvania State University); database systems, database security, and database browsing and visualization (Computer Science Department).

Wallace, W.—Ph.D. (Rensselaer Polytechnic Institute); decision support systems, environmental management modeling process, disaster management (Industrial and Systems Engineering Department/joint in Civil Engineering and Cognitive Science Departments).

Willemain, T.—Ph.D. (Massachusetts Institute of Technology); probabilistic modeling, data analysis, forecasting (Industrial and Systems Engineering Department).
Associate Professors

Akera, A.—Ph.D. (University of Pennsylvania); history of scientific and technical computing, innovation studies (Science and Technology Studies Department).

Adali, S.—Ph.D. (University of Maryland); heterogenous distributed information systems, database systems (Computer Science Department).

Bystroff, C.—Ph.D. (University of California, San Diego); bioinformatics, protein folding, computational biology (Biology Department).

Durgee, J.—Ph.D. (University of Pittsburgh); marketing research and advertising (Lally School of Management and Technology).

Gupta, A.—Ph.D. (Stanford University); (Lally School of Management and Technology).

Hahn, T.—Ph.D. (Wesleyan University); ethnomusicology, Japanese & contemporary music and dance, choreography (Arts Department).

Hanna, M.H.—Ph.D. (University of Illinois); slime mold development and genetics (Biology Department).

Kalsher, M.J.—Ph.D. (Virginia Polytechnic Institute and State University); human factors, industrial/organizational psychology, applied experimental psychology (Cognitive Science Department).

Krishnamoorthy, M.S.—Ph.D. (Indian Institute of Technology); programming languages, analysis of algorithms (Computer Science Department).

Krueger, T.—M.Arch. (Columbia University); human-environment interaction, design (School of Architecture).

Magdon-Ismail, M.—Ph.D. (California Institute of Technology); machine learning, computational finance, bioinformatics (Computer Science Department).

Mistur, M.—B.Arch. (Rensselaer Polytechnic Institute); architectural design (School of Architecture).

Piper, B.R.—Ph.D. (University of Utah); computer-aided geometric design, numerical analysis, computer graphics (Mathematical Sciences Department).

Xiang, N.—Ph.D. (Ruhr University, Bochum, Germany); architectural acoustics, acoustic signal processing (School of Architecture).

Associate Professors

Akera, A.—Ph.D. (University of Pennsylvania); history of scientific and technical computing, innovation studies (Science and Technology Studies Department).

Adali, S.—Ph.D. (University of Maryland); heterogenous distributed information systems, database systems (Computer Science Department).

Borca-Tasciuc, T.—Ph.D. (University of California, Los Angeles); thermal and thermoelectric transport in nanostructures, nanostructured materials, and devices, thermoelectric energy conversion, heat transfer, microelectromechanical systems (Mechanical, Aerospace, and Nuclear Engineering Department).

Bystroff, C.—Ph.D. (University of California, San Diego); bioinformatics, protein folding, computational biology (Biology Department).

Duchin, E.—Ph.D. (University of California, Berkeley); achieving economic development while avoiding environmental disasters, input-output economics with industrial ecology (Economics).

Durgee, J.—Ph.D. (University of Pittsburgh); marketing research and advertising (Lally School of Management and Technology).

Gupta, A.—Ph.D. (Stanford University); (Lally School of Management and Technology).

Hahn, T.—Ph.D. (Wesleyan University); ethnomusicology, Japanese & contemporary music and dance, choreography (Arts Department).

Hanna, M.H.—Ph.D. (University of Illinois); slime mold development and genetics (Biology Department).

Kalsher, M.J.—Ph.D. (Virginia Polytechnic Institute and State University); human factors, industrial/organizational psychology, applied experimental psychology (Cognitive Science Department).

Kar, K.—Ph.D. (University of Maryland); routing and traffic engineering, congestion control and resource allocation, ad-hoc and sensor networks, multicasting (Electrical, Computer, and Systems Engineering Department).

Krishnamoorthy, M.S.—Ph.D. (Indian Institute of Technology); programming languages, analysis of algorithms (Computer Science Department).
Assistant Professors

Illeguer, T.—M.Arch. (Columbia University); human-environment interaction, design (School of Architecture).

Mistur, M.—B.Arch. (Rensselaer Polytechnic Institute); architectural design (School of Architecture).

Piper, B.R.—Ph.D. (University of Utah); computer-aided geometric design, numerical analysis, computer graphics (Mathematical Sciences Department).

Xiang, N.—Ph.D. (Ruhr University, Bochum, Germany); architectural acoustics, acoustic signal processing (School of Architecture).

Professors of Practice

Eberbach, E.—Ph.D. (Warsaw University of Technology); computer science, artificial intelligence, distributed and concurrent computing (Rensselaer at Hartford – Department of Engineering and Science).

Grice, R.—Ph.D. (Rensselaer Polytechnic Institute); information usability, human-computer interfaces, applications of computers to technical communication, information development in industry (Language, Literature, and Communication Department).

Younessi, H.—Ph.D. (Swinburne University of Technology, Australia); computer and information sciences, software and systems engineering (Rensselaer at Hartford – Department of Engineering and Science).

Lecturers

Hughes, G.—Ph.D. (Princeton University); global economics, economics of information technology (Information Technology and Web Science).

McDermott, M.—Ph.D. (University at Albany, SUNY); strategic management (Director of Undergraduate Programs) (Lally School of Management and Technology).

van Heuveln, B.—Ph.D. (State University of New York at Binghamton); philosophy of mind, artificial intelligence, logic, computation, reasoning, and cognition (Cognitive Science Department).

VerWys, C.—Ph.D. (University at Albany); (Lecturer, Cognitive Science).

Adjunct Faculty

Koll, J.—P.E., M.Eng. (Rensselaer Polytechnic Institute); management of information systems (Chief Information Officer, DotCIO) (Information Technology and Web Science).

Miner, J.—M.S. (Stevens Institute of Technology); information technology management, enterprise computing architectures (Assistant Vice President, Information Services, DotCIO) (Information Technology and Web Science).

Wright, E.—M.S.E.E. (Naval Postgraduate School); general management, manufacturing operations, international business (Lally School of Management and Technology).

Undergraduate Programs

The objectives of the B.S. in ITWS curriculum are to prepare students to enter a rewarding career in ITWS and to pursue further professional and/or graduate education. The program:

• synthesizes computing, systems, management, and humanities.
• extends the student’s horizons from the focused core of ITWS to the disciplinary knowledge of a student chosen application domain.

It also promotes the integration of traditional education with engaged learning and the spirit of entrepreneurship that pervades the ITWS industry. The program is designed especially for students with interests outside the technical world, but nevertheless requires substantial technical talents and skills.
Baccalaureate Program

Completion of the B.S. in Information Technology and Web Science requires a total of 128-130 credit hours, of which 56-58 credits constitute an ITWS Core and 32 credits are devoted to a concentration. The remaining credit hours fulfill Rensselaer degree requirements. The ITWS core requirements establish a solid foundation for applying ITWS to any discipline. The Rensselaer requirements ensure the degree’s breadth and its consistency with long-established Rensselaer traditions. The required concentration provides an opportunity for in-depth study of an ITWS application area. Concentration options include arts, communication and networks, law, management information systems, medicine, psychology, and numerous others. In consultation with a faculty adviser, students may also design their own concentration through the selection of courses that match their individual interests.

The specific requirements for the B.S. in Information Technology and Web Science are illustrated below. Both a professional and research track are offered for the B.S. in ITWS degree. For the research track, the capstone course is replaced with a two-semester thesis.

### Math and Science Requirements: (24 credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CSCI 1100</td>
<td>Computer Science I</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 1200</td>
<td>Data Structures</td>
<td>4</td>
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<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
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<td>Math Elective</td>
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<tr>
<td>Physical-Science Elective</td>
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<td>Life-Science Elective</td>
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### Humanities, Arts, and Social Sciences Requirements (HASS): (24 credits)

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<tr>
<td>ITWS 1220</td>
<td>IT and Society</td>
<td>4</td>
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<tr>
<td>ITWS 2210</td>
<td>Introduction to Human Computer Interaction</td>
<td>4</td>
</tr>
<tr>
<td>Humanities Elective</td>
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<td>4</td>
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<tr>
<td>Social Science Elective</td>
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### Free Elective Requirements: (12 credits)

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<tr>
<td>Free Elective</td>
<td></td>
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### ITWS Core Requirements: (40-46 credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
</table>
| Pick either the ENGR or the CSCI sequence:
| ECSE 2610 | Computer Components and Operations         | 4            |
| ECSE 2660 | Computer Architecture, Networks, and Operating Systems | 4            |
| or
| CSCI 2200 | Foundations of Computer Science            | 4            |
| CSCI 2300 | Introduction to Algorithms                 | 4            |
| CSCI 2500 | Computer Organization                      | 4            |
| ENGR 2350 | Embedded Control                           | 4            |
| Pick either:
| ITWS 4100 | Information Technology and Web Science Capstone (Professional track) | 4            |
| or
| ITWS 4990 | Senior Thesis (Research track)             | 6            |
| Pick either:
| ITWS 4100 | Information Technology and Web Science Capstone (Professional track) | 4            |
| or
| ITWS 1100 | Introduction to Information Technology and Web Science | 4            |
| ITWS 2110 | Web Systems Development                   | 4            |
| ITWS 4200 | Web Science                               | 4            |
| TWS 4310 | Managing IT Resources                      | 4            |

### ITWS Technology Elective (one of):

<table>
<thead>
<tr>
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<th>Title</th>
<th>Credit Hours</th>
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<tr>
<td>CSCI 4380</td>
<td>Database Systems</td>
<td>4</td>
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<tr>
<td>MGMT 4170</td>
<td>Data Resource Management</td>
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1 Students must select either the three-course CSCI or the three-course ENGR sequence.
Student-Selected Concentration: (32 credits)

<table>
<thead>
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<th>Concentration Course</th>
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<tr>
<td>Concentration Capstone Experience</td>
<td>4</td>
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</table>

Concentration Information

The Concentrations from which students may choose are as follows:

- Arts
- Civil Engineering
- Cognitive Science
- Communication
- Computer Networking
- Computer Hardware
- Data Science
- Economics
- Entrepreneurship
- Finance
- Information Security
- Machine and Computational Learning
- Management Information Systems
- Mechanical/Aeronautical Engineering
- Medicine
- Pre-law
- Psychology
- Science and Technology Studies: Information and Society
- Science Informatics
- Special Interest
- Web Technologies

The above list, and the associated required courses for each Concentration are available on the ITWS program Web page itws.rpi.edu. The list expands as new Concentrations are developed. Students wishing to design a special interest Concentration specific to individual interests should consult their faculty advisers.

Course Schedule

Below is a typical, but not required, eight-semester course schedule for obtaining the B.S. in ITWS.

**FIRST YEAR**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CSCI 1100</td>
<td>Computer Science I</td>
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<tr>
<td>ITWS 1100</td>
<td>Introduction to Information Technology and Web Science</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>CSCI 1200</td>
<td>Data Structures</td>
</tr>
<tr>
<td>ITWS 1220</td>
<td>IT and Society</td>
</tr>
<tr>
<td>Math Elective</td>
<td>4</td>
</tr>
<tr>
<td>Physical-Science Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**SECOND YEAR**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITWS 2110</td>
<td>Web Systems Development</td>
</tr>
<tr>
<td>One of: ECSE 2610</td>
<td>Computer Components and Operations</td>
</tr>
<tr>
<td>ENGR 2350</td>
<td>Embedded Control</td>
</tr>
<tr>
<td>One of: CSCI 2200</td>
<td>Foundations of Computer Science</td>
</tr>
<tr>
<td>Concentration Course</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective (CSCI track only)</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITWS 2210</td>
<td>Introduction to Human Computer Interaction</td>
</tr>
<tr>
<td>ITWS 4200</td>
<td>Web Science</td>
</tr>
<tr>
<td>One of: CSCI 2500</td>
<td>Computer Organization</td>
</tr>
<tr>
<td>ECSE 2660</td>
<td>Computer Architecture, Networks, and Operating Systems</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

---

1 Students must select either the three-course CSCI or the three-course ENGR sequence.

2 See HASS elective requirements in the HASS section of this catalog.
### THIRD YEAR

**Fall**  
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 2300</td>
<td>Introduction to Algorithms (CSCI track only)</td>
</tr>
<tr>
<td>ITWS 4310</td>
<td>Managing IT Resources</td>
</tr>
<tr>
<td></td>
<td>HASS Elective (ENGR track only)</td>
</tr>
<tr>
<td></td>
<td>Concentration Course</td>
</tr>
<tr>
<td></td>
<td>Life-Science Elective</td>
</tr>
</tbody>
</table>

**Spring**  
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITWS Technology Elective (one of):</td>
<td></td>
</tr>
<tr>
<td>CSCI 4380</td>
<td>Database Systems</td>
</tr>
<tr>
<td>MGMT 4170</td>
<td>Data Resource Management</td>
</tr>
<tr>
<td></td>
<td>Concentration Course</td>
</tr>
<tr>
<td></td>
<td>Concentration Course</td>
</tr>
<tr>
<td></td>
<td>Free Elective</td>
</tr>
</tbody>
</table>

### FOURTH YEAR

**Fall**  
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITWS 4100</td>
<td>Information Technology and Web Science Capstone (Professional track)</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>ITWS 4990</td>
<td>Senior Thesis (Research track)</td>
</tr>
<tr>
<td></td>
<td>Concentration Course</td>
</tr>
<tr>
<td></td>
<td>Concentration Course</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
</tr>
</tbody>
</table>

**Spring**  
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITWS 4990</td>
<td>Senior Thesis (Research track only)</td>
</tr>
<tr>
<td></td>
<td>Concentration Capstone Course/Experience</td>
</tr>
<tr>
<td></td>
<td>Concentration Course</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
</tr>
<tr>
<td></td>
<td>Free Elective</td>
</tr>
</tbody>
</table>

### Additional Information

Co-terminal students would replace ITWS 4100 Information Technology and Web Science Capstone with ITWS 4980 - Special Projects course which will be the culminating experience.

Only free electives and six credits of the HASS electives may be taken with the Pass/No Credit option.

If a student chooses to pursue a dual degree with Information Technology and Web Science as one of the degrees, the dual degree must be the area that is closest to the student’s Concentration. For example, if a student’s Concentration is Psychology, then the dual degree would need to be in Psychology.

### Minor Programs

The ITWS minor requires 16 credit hours that must be approved by the minor adviser in ITWS. The specific requirements are

<table>
<thead>
<tr>
<th>Program Requirements</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITWS 1100</td>
<td>Introduction to Information Technology and Web Science</td>
</tr>
<tr>
<td>ITWS 4310</td>
<td>Managing IT Resources</td>
</tr>
</tbody>
</table>
| Humanities elective (one of):
  | Credit Hours |
| COMM 4790            | Social Impact of Electronic Media | 4 |
| iHSS 1220            | IT and Society | 4 |
| ITWS 1220            | IT and Society | 4 |
| Technical Elective (one of):
  | Credit Hours |
| CSCI 2300            | Introduction to Algorithms | 4 |
| CSCI 4380            | Database Systems | 4 |
| ITWS 2110            | Web Systems Development | 4 |
| MGMT 4170            | Data Resource Management | 4 |

1 Other courses as approved by the minor adviser in ITWS.  
2 See HASS elective requirements in the HASS section of this catalog.
Graduate Programs

Rensselaer’s Master of Science in Information Technology balances the study of management strategies and technology leadership with advanced course work in an IT concentration. Students complete a suite of Core and Capstone courses and also select three to five additional courses to complete their Concentrations. Both a professional and research track are offered for the M.S. in IT degree.


Programs are individually tailored to accommodate students with a variety of entering backgrounds and career goals. Most students complete the program in three semesters and have the option to select two concentrations for a total of 12 courses, four courses each semester. These students will generally complete a significant salaried internship/co-op over the summer/summer-fall. Students can also choose to complete the program in two semesters. They will select one concentration and need to complete a total 10 classes, five classes per semester.

The IT master’s is also available at the Hartford campus in Hartford, Connecticut. Students enrolling at Hartford should consult the following Web site for concentrations, course offerings, and degree requirements: www.ewp.rpi.edu.

Applicants are expected to have prior academic records that indicate their ability to excel in advanced coursework. Prospective students should also have completed the equivalent to the following three Rensselaer courses prior to enrollment:

- CSCI 1100 Computer Science I (number systems, basic computer architecture, stepwise refinement of algorithms, functions and parameter passing, basic programming concepts through two-dimensional arrays, and pointer basics using C++)
- CSCI 1200 Data Structures (pointers, classes, operator overloading, deep vs. shallow copy constructors, inheritance, file I/O, templates in C++, introductory algorithm analysis, and data structures)
- CSCI 2300 Introduction to Algorithms (advanced topics including mathematical induction and its application to algorithm design, linear structures, trees and balanced trees, heaps and priority queues, graphs and graph algorithms, backtracking, divide-and-conquer, and greedy algorithms.)

The Graduate Record Examination (GRE) is required of all full and part-time applicants in Troy. Substitution of the Graduate Management Admissions Test (GMAT) is possible. Applicants to the Hartford campus will be notified in writing if results of the Graduate Record Examination are required.

Master’s Programs

Both a professional and research track are offered for the M.S. in IT degree.

Students admitted to the M.S. in IT develop an approved Plan of Study.

- Ten courses (a minimum of 30 credits)
- A minimum of six courses (18 credit hours or more) at the graduate level (6xxx-level courses)
- Five core courses; one from each of the five core areas. For the research track, replace the “Management of Technology” core course requirement with one of the two-semester ITWS 6990 Master’s Thesis or ITWS 6980 Master’s Project
- A minimum of three courses (nine credit hours or more) in an approved Concentration
- One elective approved by the adviser to add further depth to the degree
- One of: ITWS 6800 Information Technology Master’s Capstone, ITWS 6990 Master’s Thesis, or ITWS 6980 Master’s Project

The Financial Engineering Concentration requires completion of an upper level finance course prior to enrollment.

The core and concentration courses are designed to accommodate a wide range of backgrounds. If students have previously completed the basic required Core course, they must then complete the next level required course to add depth in that core area. For example, if an equivalent course to Database Systems was completed in a prior degree, the Core area requirement could be satisfied by taking Database Mining. Students may request transfer credit only for the elective, subject to adviser approval. Additionally, no more than half of all credits used towards the M.S. in IT degree may be taken from courses offered by the Lally School of Management and Technology. These courses are coded MGMT.
The M.S. in IT Master’s Capstone course integrates the knowledge and professional practice of IT core and concentration courses. The Capstone utilizes an Information Technology Team Project with a real organization to practice the major concepts of the IT master’s degree. The Team Project involves strategic and business planning, systems development, and technology implementation. Expertise in database systems, networking, software design, decision sciences, management of technology, human computer interaction, and ethics are applied within a framework of global e-business strategy.

Full-time students normally begin in the fall term and take four courses in the fall, four courses the following spring, participate in an internship/co-op over the summer and complete the final four courses in the fall. This option may allow a student to complete two concentrations. Students also have the option to take five courses in the fall and five in the spring to complete the program in two semesters with one concentration. Part-time students typically complete the program in two and one-half years of continuous study.

Rensselaer currently offers numerous Ph.D. degrees with significant information technology and web science related research, e.g. computational chemistry and physics, science and technology studies, decision sciences, applied mathematics, and human-computer interaction, among many others. Students who are planning doctoral study may choose to apply simultaneously for admission to the Ph.D. in the relevant Rensselaer department and also for the M.S. in IT.

**IT Core Requirements**

To acquire a breadth of IT experience, master’s degree students take the five Core courses listed below. Alternate courses are also listed for those who have previously completed the required Core course. Also noted is the usual term in which the required Troy campus Core course is offered. Course offerings change frequently to keep pace with rapid advancement in IT; some courses are delivered in alternate years. Please see the Troy ITWS Web site for the most current information: itws.rpi.edu.

<table>
<thead>
<tr>
<th>M.S. in IT Core Area</th>
<th>Course Name</th>
<th>Term(s) Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database Systems</td>
<td>CSCI 4380 Database Systems</td>
<td>fall/spring terms (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6900 Networking Laboratory I</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ECSE 4670 Computer Communication Networks</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td>Networking</td>
<td>CSCI 4440 Software Design and Documentation</td>
<td>fall/spring terms (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6400 X-Informatics</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td>Software Design</td>
<td>ITWS 6300 Business Issues for Engineers and Scientists (Professional track only)</td>
<td>fall/spring terms (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6990 Master’s Thesis</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6980 Master’s Project (Research track only)</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td>Management of Technology</td>
<td>human-computer interaction</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6960 Human Media Interaction</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6420 Foundations of Human-Computer Interaction Usability</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M.S. in IT Advanced Core</th>
<th>Course Name</th>
<th>Term(s) Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database Systems</td>
<td>ITWS 6960 Semantic e-Science</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 Data Science</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6390 Database Mining</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td>Networking</td>
<td>CSCI 6960 Cryptography and Network Security</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6500 Distributed Computing Over The Internet</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ECSE 6600 Internet Protocols</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td>Software Design</td>
<td>ITWS 6900 Semantic e-Science</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6500 Distributed Computing Over The Internet</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ECSE 6780 Software Engineering II</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td>Management of Technology</td>
<td>MGMT 6080 Networks, Innovation, and Value Creation</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6140 Information Systems for Management</td>
<td>fall term (3 credit hours)</td>
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<tr>
<td>Human Computer Interaction</td>
<td>COMM 6900 Interactive Media Design</td>
<td>summer term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6620 Information Architecture</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6770 User-Centered Design: 3</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td>One of:</td>
<td>ITWS 6800 Information Technology Master’s Capstone</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6980 Master’s Project</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6990 Master’s Thesis</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
</tbody>
</table>
**Concentration Requirements**

The ITWS faculty designed the concentrations to provide an in-depth, leading-edge experience in the application of information technology. Students often select areas that complement their prior backgrounds (e.g., students with strong computer backgrounds may select MIS or Information Systems Engineering). Alternately, some students select a Concentration related to their prior backgrounds and then expand on that background through higher-level course work. The course taken to complete a Core requirement does not count toward the Concentration.

Rensselaer’s course offerings are dynamic and new courses are developed each term, making course listings subject to change. Some courses are offered in alternate years. For current status, please visit itws.rpi.edu.

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Course Name</th>
<th>Term(s) Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Web Science</strong></td>
<td>Select two of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 Semantic e-Science</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 Data Science</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 X-informatics</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 Advanced Semantic Technology (Research Track Only)</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>Select one of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>COMM 6960 Interactive Media Design</td>
<td>summer term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6960 Internet Market</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 4580 Advertising and Culture</td>
<td>(4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 4690 Interface Design: Hypermedia Theory and Application</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6270 Digital Rhetoric</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6480 Theory and Research in Technical Communication and Human-Computer Interaction</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6510 Communication Theory</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6620 Information Architecture</td>
<td>(3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6770 User-Centered Design</td>
<td>(3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 4220 Network Programming</td>
<td>(4 credit hours)</td>
</tr>
<tr>
<td><strong>Database and Intelligent Systems</strong></td>
<td>Select three of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 Data Science</td>
<td>fall term spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 Semantic e-Science</td>
<td>fall term spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 Advanced Semantic Technologies (Research Track Only)</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 4150 Introduction to Artificial Intelligence</td>
<td>fall term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6390 Database Mining</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ISYE 6180 Knowledge Discovery with Data Mining</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td><strong>Information Security</strong></td>
<td>Select two or three of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSCI 6960 Cryptography &amp; Network Security</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 4210 Operating Systems</td>
<td>fall/spring terms (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 4370 Information System Security</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>If only two of the above were chosen, select one more from the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSCI 6390 Database Mining</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ISYE 6180 Knowledge Discovery with Data Mining</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MATH 4020 Introduction to Number Theory</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td><strong>Information Systems Engineering</strong></td>
<td>Select three of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSCI 6960 Computational Finance</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ISYE 6960 Agent Based Simulation Methods</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6960 Internet Marketing</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6390 Database Mining</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ECSE 6780 Software Engineering II</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ISYE 6180 Knowledge Discovery with Data Mining</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ISYE 6610 Systems Modeling in Decision Sciences</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ISYE 6620 Discrete-Event Simulation</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ISYE 6870 Introduction to Neural Networks</td>
<td>(3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6170 Advanced Systems Analysis and Design</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td><strong>Networking</strong></td>
<td>Select three of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSCI 6960 Networking Laboratory I</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6960 Cryptography and Network Security I</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 4220 Network Programming</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 4320 Parallel Programming</td>
<td>(4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6360 Parallel Computing</td>
<td>(3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 4660 Networking Laboratory II</td>
<td>fall/spring terms (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6500 Distributed Computing Over The Internet</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ECSE 6660 Internet Protocols</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ECSE 6660 Broadband &amp; Optical Networking</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td>Concentration</td>
<td>Course Name</td>
<td>Term(s) Offered</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td><strong>Software Design</strong></td>
<td>Select three of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSCI 4960 Open Source Software</td>
<td>fall term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 Semantic e-Science</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 X-informatics</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ITWS 6960 Advanced Semantic Technologies (Research track only)</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6810 Studio Design in Human-Computer Interaction</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 4220 Network Programming</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 4430 Programming Languages</td>
<td>fall/spring terms (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 4440 Software Design and Documentation</td>
<td>fall/spring terms (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6500 Distributed Computing Over The Internet</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ECSE 6780 Software Engineering II</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6170 Advanced Systems Analysis and Design</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td><strong>Management Information Systems</strong></td>
<td>Select three of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MGMT 4960 International Project Management</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6960 Internet Marketing</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>CSCI 6390 Database Mining</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ISYE 6180 Knowledge Discovery with Data Mining</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 4130 Enterprise IT Integration</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 4150 T Project Management</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6060 Business Implications of Emerging Technologies</td>
<td>fall/spring terms (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6080 Networks, Innovation, and Value Creation</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6140 Information Systems for Management</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6170 Advanced Systems Analysis and Design</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6180 Strategic Information Systems Management</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6620 Principles of Technological Entrepreneurship</td>
<td>(3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6630 Starting Up A New Venture</td>
<td>(3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6810 Management of Technical Projects</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td><strong>Financial Engineering</strong></td>
<td>MATH 4740 Introduction to Financial Mathematics and Engineering</td>
<td>fall term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 7760 Risk Management</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>With adviser approval, choose three additional courses for a total of five courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSCI 6960 Computational Finance</td>
<td>Offered fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ECON 4120 Quantitative Analysis</td>
<td>fall term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ECON 6570 Advanced Econometrics</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>ISYE 6100 Time Series Analysis</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MATH 4800 Numerical Computing</td>
<td>fall/spring terms (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MATH 4820 Introduction to Numerical Methods for Differential Equation</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MATH 6740 Financial Mathematics and Simulation</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MATP 4620 Mathematical Statistics</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MATP 4700 Mathematical Models of Operations Research</td>
<td>fall term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MATP 4820 Computational Optimization</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MATP 6640 Linear Programming</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6240 Financial Trading and Investing</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6370 Options, Futures, and Derivatives Markets</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6400 Financial Econometrics Modeling</td>
<td>(3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6410 Investments I</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6510 Financial Computation</td>
<td>(3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>MGMT 6520 Financial Modeling</td>
<td>(3 credit hours)</td>
</tr>
<tr>
<td><strong>Human-Computer Interaction</strong></td>
<td>Select three of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>COMM 6960 HCI Prototype Production</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6960 Human-Media Interaction</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6960 Interaction Design for the 21st Century</td>
<td>summer term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6960 Interactive Media Design</td>
<td>summer term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 4690 Interface Design: Hypermedia Theory and Application</td>
<td>spring term (4 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6480 Theory and Research in Technical Communication and Human-Computer Interaction</td>
<td>fall term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6620 Information Architecture</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6770 User-Centered Design</td>
<td>spring term (3 credit hours)</td>
</tr>
<tr>
<td></td>
<td>COMM 6810 Studio Design in Human-Computer Interaction</td>
<td>spring term (3 credit hours)</td>
</tr>
</tbody>
</table>

1 A maximum of five management courses (code: MGMT) may be taken towards the IT degree.
Lally School of Management and Technology

Dean: Thomas M. Begley

Associate Dean for Academic Affairs: Jeffrey F. Durgee

Director, Undergraduate Programs: Frank X. Wright

Director, MBA/M.S. Programs: Vacant

Director, Career Resources: Thomas Whalen

Co-Directors, Ph.D. Program: Bill B. Francis and Iftekhar Hasan

Lally School Home Page: www.lallyschool.rpi.edu

Rensselaer’s Lally School is focused on developing aspiring business leaders who have a passion for technology with the ability to work across business functions. Our programs are built around the themes of innovation and technology entrepreneurship in the global economy.

Lally School students will:

- Develop the skills to integrate technology across business functions for commercial results.
- Acquire “real-world” experience through study that emphasizes hands-on projects and teamwork from day one.
- Leverage Rensselaer’s resources to network, learn, and prepare to capitalize on the business opportunities of tomorrow.

Tapping into Rensselaer’s interdisciplinary advantage, Lally students have access to the management school’s highly respected international faculty as well as to students and faculty from Architecture, Engineering, Humanities, Arts, and Social Sciences, Information Technology, Science, the Rensselaer Incubator, the Rensselaer Technology Park, and the Severino Center for Technological Entrepreneurship.

The Lally School offers five areas of educational specialization and research for students:

- Technological entrepreneurship
- Management of information systems
- Finance
- New product development
- Production and operations management

In conjunction with the Information Technology (IT) program, the Lally School provides three concentrations (MIS, Finance, and Technological Entrepreneurship) for IT majors. Dual-degrees are available with the Schools of Engineering, Humanities, Arts, and Social Sciences, and Science.

The Lally School is fully accredited by the Association to Advance Collegiate Schools of Business (AACSB International), the premier accrediting agency for bachelor’s, master’s, and doctoral degree programs in business.

The Lally School and its faculty are organized into two departments, with a residential program based in Troy, N.Y., and a primarily nonresidential campus focused on executive cohort Master’s programs and education for working professionals in Hartford, Conn.
Degrees Offered

<table>
<thead>
<tr>
<th>Program</th>
<th>Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Analytics</td>
<td>M.S.</td>
</tr>
<tr>
<td>Business in Management</td>
<td>B.S.</td>
</tr>
<tr>
<td>Financial Engineering and Risk Analytics</td>
<td>M.S.</td>
</tr>
<tr>
<td>Management</td>
<td>M.S., MBA, Ph.D.</td>
</tr>
<tr>
<td>Supply Chain Management</td>
<td>M.S.</td>
</tr>
<tr>
<td>Technology Commercialization and Entrepreneurship</td>
<td>M.S.</td>
</tr>
</tbody>
</table>

Research Innovations and Initiatives

Research at the Lally School is characterized by its cross-disciplinary, multiplatform, and international nature. Faculty at the Lally School conduct research in Argentina, Australia, Canada, Chile, China, Denmark, Finland, France, Germany, Italy, Mexico, Spain, Sweden, Tunisia, the United Kingdom, and the United States. While the issues investigated cut across functional areas in a business setting, are longitudinal in scope, and involve a variety of academic disciplines, the objective is to produce rigorously developed theories and empirical studies that are at the frontiers of new management knowledge and that pass the stringent tests of academic peer review.

Research conducted by the Lally School is often featured at conferences sponsored by the Academy of Management, INFORMS, PICMET, Academy of International Business, the IEEE, and ASSA. In addition, the Lally School regularly sponsors international conferences and seminars designed to bring together the best academics globally to focus on emerging areas of new research in order to establish intellectual leadership in a domain of broad interest to the academic community.

The Lally School has five intersecting research categories that are recognized for their leadership position in the academic community. They seek to create new frontiers of managerial thought in the area of technology and entrepreneurial management. The five Lally research categories are as follows:

**Technological Entrepreneurship**
At Rensselaer, technological entrepreneurship is the process of converting technical ideas into new businesses in startup ventures and established firms. This is the primary research focus for more than 15 faculty engaged in collaborative, multidisciplinary projects. These faculty members examine technological entrepreneurship from many perspectives, including psychology, economics, and sociology. They focus on such problems as opportunity identification, accelerating new-venture creation, intellectual property and governance in high-technology startups, and managing hyper-growth firms. The Severino Center for Technological Entrepreneurship is the focal point for scholarship in entrepreneurship and serves as a bridge to the Rensselaer Incubator and Rensselaer Technology Park.

**Innovation Management and New Product Development**
In this area, researchers concentrate on understanding the management processes leading to the development of successful new products, technologies, or services. Research topics include managing technological innovation, technology strategy, new product development, distributed innovation, strategic innovation alliances, innovation networks, management of radical innovation, and intellectual property management. Related research focuses on organizational strategies to successfully pursue product or service innovation, those that occur within the boundaries of the organization as well as those that involve other organizations. Given the emergence of global networks of innovation, issues related to inter-organizational alliances and collaboration form a primary focus of research at Lally.

**Management Information Systems**
This area focuses on the role and use of information technology in organizations and how it transforms the theories and practice of management. The research incorporates theories and concepts from such fields as computer science, economics, psychology, communications, and organization theory. Of particular interest are topics that relate to supply-chain management, business and consumer marketing, virtual collaboration, distributed innovation, and internal organizational capabilities. The Lally School adopts an interdisciplinary approach to researching new business models and the issues that present challenges and opportunities for managers in IT, entrepreneurship, finance, marketing, and innovation.

**Financial Technology**
This emerging field of scholarship and practice combines the traditionally distinct disciplines of finance, information technology, and modeling. Formed within this field are three relatively distinct applications. The first application is the impact of technology on the financial management of corporations, financial institutions and markets. This area specifically focuses on the interface between technological shifts and practices in the financial services industry and the overall functioning and productivity of these institutions in the capital markets. The
second application pertains to the alternative financing and exit strategies of new technological ventures and business initiatives. This area focuses on the economics and governance of private equity, venture capital funds, traditional bank debts and going public process of individual companies along with the financial implications for regulatory, macroeconomic, and firm specific influences on respective industries and markets. The above two areas of research are further explicated by a third research specialty in computational accounting and finance involving emerging financial products and derivatives.

**International Business and Global Management of Technology**
Driven by the rapid onset of globalization, the processes of technological discovery, innovation, and commercialization have become transnational in nature. On-going research in this area at the Lally School focuses on two specific issues. First, it seeks to better understand how the emergence of new centers of technological capability outside of the United States, Europe, and Japan affects decisions regarding the location of R&D and high-value-added manufacturing processes by global managers. Secondly, this research seeks to learn more about the specific strategic and operational challenges associated with managing the creation and application of new knowledge in a multinational firm with critical facilities in several different regions around the world. By gaining a deeper appreciation of the impact of globalization on innovation and R&D, it is hoped that managers can develop an international perspective on where and how to access technical resources for enhancing their competitive advantage.

**Troy Campus Faculty***

**Professors**
Francis, B.B.—Ph.D. (University of Toronto); corporate and international finance.
Hasan, I.—Ph.D. (University of Houston); finance. (Cary L. Wellington Chaired Professor).
Nambisan, S.—Ph.D. (Syracuse University); information systems.
Paulson, A.S.—Ph.D. (Virginia Polytechnic Institute); operations research and statistics, risk management and investment analysis (Frank and Lillian Gilbreth Professor in the Technologies of Management).
Ravichandran, T.—Ph.D. (Southern Illinois University, Carbondale); management information systems.

**Clinical Professor**
Abetti, P.A.—P.E., Ph.D. (Illinois Institute of Technology); management of technology, international business development and strategic planning, entrepreneurship.

**Associate Professors**
Corbett, A.—Ph.D. (University of Colorado, Boulder); strategic management and entrepreneurship.
Durgee, J.F.—Ph.D. (University of Pittsburgh); marketing research and advertising (Associate Dean for Academic Affairs).
Golden, T.—Ph.D. (University of Connecticut); organizational behavior, human resource management.
Goldenberg, D.H.—Ph.D. (University of Florida); investments, derivatives markets, mathematical and computational finance.
McDermott, C.—Ph.D. (University of North Carolina, Chapel Hill); manufacturing strategy, operations management.
O'Connor, G.—Ph.D. (New York University); marketing, product management.
Peters, L.S.—Ph.D. (New York University); science and technology policy, innovation and R&D management, entrepreneurship, organization theory, international business.
Sanderson, S.—Ph.D. (University of Pittsburgh); international business, manufacturing policy, new product development.

*Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.*
Assistant Professors

Chi, L.—Ph.D. (University of Kentucky); information systems.

Gupta, A.—Ph.D. (Stanford University); quantitative finance, risk management financial decision support, optimization, and simulation.

Ha, C.—Ph.D. (Columbia University); asset pricing, international finance, information economics, market microstructure.

Huang, D.—Ph.D. (University of Texas at Dallas); marketing.

Jiao, Y.—Ph.D. (Boston College); finance.

Kumar, S.—Ph.D. (University of Illinois at Urbana-Champaign); joint ventures and alliances, diversification, theories of the firm.

Kuruzovich, J.—Ph.D. (University of Maryland); information systems.

Markovitch, D.—Ph.D. (New York University); marketing.

Nam, S.—Ph.D. (New York University); finance.

O’Brien, J.—Ph.D. (Purdue University); strategic management and organization.

Tracy, W.—Ph.D. (UCLA); strategic management and organization.

Yayla-Kullu, H.M.—Ph.D. (University of North Carolina at Chapel Hill); operations management.

Zhao, H.—Ph.D. (University of Illinois, Chicago); organizational behaviors, entrepreneurship, human resource management.

Zhang, Y.—Ph.D. (Temple University); finance.

Clinical Assistant Professors

Demertzoglou, P.—Ph.D (State University of New York); transaction processing systems, decision support systems, e-business applications, commercial open source databases.

Wright, E.—M.S. (Naval Postgraduate School); general management, business policy and strategy, entrepreneurship, R&D management.

The Lally Undergraduate Program

The undergraduate program at Rensselaer’s Lally School draws heavily on Rensselaer’s strengths in engineering, science, technology, and entrepreneurship. Within these programs, the Lally School provides a balance between theory and practice while insuring rigor and relevance. There is a strong emphasis on the application of knowledge through team-based projects and a focus on the intersection of entrepreneurship and innovation.

Goals for the baccalaureate program in Management include:

- Preparing students for professional careers in technology-driven organizations.
- Core management practices and an in-depth understanding in a specialized area.
- Theories, concepts, and techniques to solve problems and make effective decisions.
- Critical-thinking skills and the ability to adapt to a rapidly changing technological world.
- A high standard of ethics and responsibility in personal affairs and professional life.
- Competencies in utilizing information technology.
- Global thinking and working in a multi-cultural setting.

Course work integrates business concepts with technological knowledge and prepares students for careers in the fields of information systems, management of R&D, technical sales, risk assessment, new product development, and marketing. Analytic and quantitative methodologies are introduced in specialized technical courses that build on cases and examples introduced in other classes. Students learn to associate the development of technology with increases in organizational effectiveness and efficiency.

The management core sequence emphasizes basic skills in the traditional business areas of finance, marketing, human behavior, computing, and organizational analysis and development. The math and science sequence provides a strong background in quantitative skills, while
humanities and social sciences course work heightens the student’s appreciation for significant societal issues. Throughout the program, the topics introduced in the various courses are integrated.

This four-year B.S. in Business and Management program requires a minimum of 124 credit hours. A typical program is described below.

<table>
<thead>
<tr>
<th>FIRST YEAR</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
</tr>
<tr>
<td>MATH 1500</td>
<td>Calculus for Architecture, Management, and HASS 4</td>
</tr>
<tr>
<td>MGMT 1100</td>
<td>Introduction to Management 4</td>
</tr>
<tr>
<td>MGMT 2510</td>
<td>Microcomputers and Applications 4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective 4</td>
</tr>
<tr>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>CSCI 1010</td>
<td>Introduction to Computer Programming 4</td>
</tr>
<tr>
<td>MATH 1520</td>
<td>Mathematical Methods in Management and Economics 4</td>
</tr>
<tr>
<td>MGMT 1260</td>
<td>Business Law and Ethics 4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECOND YEAR</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
</tr>
<tr>
<td>ECON 1200</td>
<td>Introductory Economics 4</td>
</tr>
<tr>
<td>MGMT 1240</td>
<td>Management Leadership I 2</td>
</tr>
<tr>
<td>MGMT 2100</td>
<td>Statistical Methods 4</td>
</tr>
<tr>
<td>MGMT 2300</td>
<td>Fundamentals of Accounting for Decision Making 4</td>
</tr>
<tr>
<td></td>
<td>Science Elective 4</td>
</tr>
<tr>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>MGMT 1250</td>
<td>Management Leadership II 2</td>
</tr>
<tr>
<td>MGMT 2320</td>
<td>Managerial Finance 4</td>
</tr>
<tr>
<td>MGMT 4110</td>
<td>Operations Management 4</td>
</tr>
<tr>
<td>MGMT 4140</td>
<td>Computer Information Systems 4</td>
</tr>
<tr>
<td></td>
<td>Communications Requirement 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>THIRD YEAR</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
</tr>
<tr>
<td>MGMT 4100</td>
<td>Quantitative Methods for Business 4</td>
</tr>
<tr>
<td>MGMT 4430</td>
<td>Marketing Principles 4</td>
</tr>
<tr>
<td></td>
<td>Elective 4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective 4</td>
</tr>
<tr>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>MGMT 4850</td>
<td>Organizational Behavior in High Performance Organizations 4</td>
</tr>
<tr>
<td></td>
<td>Science Elective 4</td>
</tr>
<tr>
<td></td>
<td>Elective 4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective (4000 level) 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FOURTH YEAR</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
</tr>
<tr>
<td>MGMT 4860</td>
<td>Human Resources in High Performance Organizations 4</td>
</tr>
<tr>
<td></td>
<td>Elective 4</td>
</tr>
<tr>
<td></td>
<td>Elective 4</td>
</tr>
<tr>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>MGMT 4870</td>
<td>Strategy and Policy 4</td>
</tr>
<tr>
<td></td>
<td>Elective 4</td>
</tr>
<tr>
<td></td>
<td>Elective 4</td>
</tr>
</tbody>
</table>
Concentrations
Students are encouraged to select one or more concentrations in order to provide further depth in an area of student interest. A concentration consists of three or four courses from each of the elective areas below, dependent upon the concentration. Students may choose to gain more extensive knowledge of the field by selecting additional courses in the area of concentration.

### Accounting
All four courses are required for the concentration.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 4230</td>
<td>Cost Accounting</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4250</td>
<td>Managerial Accounting</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4270</td>
<td>Intermediate Accounting I</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4280</td>
<td>Intermediate Accounting II</td>
<td>4</td>
</tr>
</tbody>
</table>

### Business Analytics
ISYE 4810, MGMT 4170, and MGMT 4470 are required for the concentration.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISYE 4810</td>
<td>Computational Intelligence</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 4170</td>
<td>Data Resource Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4470</td>
<td>Marketing Research</td>
<td>4</td>
</tr>
</tbody>
</table>

### Entrepreneurship
MGMT 4510, MGMT 4520, and MGMT 4530 are required for the concentration.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 4510</td>
<td>Invention, Innovation, and Entrepreneur</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4520</td>
<td>Introduction to Technological Entrepreneur</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4530</td>
<td>Starting Up a New Venture</td>
<td>4</td>
</tr>
</tbody>
</table>

### Finance
MGMT 4320, MGMT 4340 and MGMT 4360 are required for the concentration.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 4320</td>
<td>Investments I</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4340</td>
<td>Advanced Corporate Finance</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4360</td>
<td>International Financial Management</td>
<td>4</td>
</tr>
</tbody>
</table>

### International Management
ECON 4190, MGMT 4360, and STSS 1330 are required for the concentration.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 4190</td>
<td>International Economics and Globalization</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4360</td>
<td>International Financial Management</td>
<td>4</td>
</tr>
<tr>
<td>STSS 1330</td>
<td>International Relations</td>
<td>4</td>
</tr>
</tbody>
</table>

### Management Information Systems
MGMT 4150, MGMT 4170, and MGMT 4240 are required for the concentration.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 4150</td>
<td>IT Project Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4170</td>
<td>Data Resource Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4240</td>
<td>Systems Analysis and Design</td>
<td>4</td>
</tr>
</tbody>
</table>

### Marketing
MGMT 4450, MGMT 4470, and MGMT 4490 are required for the concentration.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 4450</td>
<td>Internet Marketing</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4470</td>
<td>Marketing Research</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4490</td>
<td>Advertising Strategy and Promotions</td>
<td>4</td>
</tr>
</tbody>
</table>

### Supply Chain Management
ISYE 4210, MGMT 4130 and MGMT 6080 are required for the concentration.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISYE 4210</td>
<td>Design and Analysis of Supply Chains</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 4130</td>
<td>Enterprise IT Integration</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 6080</td>
<td>Networks, Innovation, and Value Creation</td>
<td>3</td>
</tr>
</tbody>
</table>
Minor Programs

The Lally School also offers undergraduate minor programs for Management students and Rensselaer students majoring in other fields. Lally students may pursue a minor outside of the management school. Management majors typically use electives in their program for minor course work in complementary fields such as communications, computer science, economics, industrial and management engineering, or psychology. Students can elect to pursue interests in any Rensselaer school.

The minors offered by the Lally School are detailed in the Programs section of this catalog and require a minimum of 16 credit hours. Each student's designated minor adviser can approve course substitutions to meet individual student needs.

### Entrepreneurship Minor

<table>
<thead>
<tr>
<th>Program Requirements</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 1100 Introduction to Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4510 Invention, Innovation, and Entrepreneurship</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4520 Introduction to Technological Entrepreneurship</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4530 Starting Up a New Venture</td>
<td>4</td>
</tr>
</tbody>
</table>

### Finance Minor

<table>
<thead>
<tr>
<th>Program Requirements</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 2300 Fundamentals of Accounting for Decision Making</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 2320 Managerial Finance</td>
<td>4</td>
</tr>
<tr>
<td>Plus any two of these:</td>
<td></td>
</tr>
<tr>
<td>MGMT 4260 Financial Statement Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 4310 Financial Trading and Investing</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4320 Investments</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4340 Advanced Corporate Finance</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4350 Financial Markets and Institutions</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4370 Risk Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4380 Derivatives Markets</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4540 Venture Capital Finance</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4540 Venture Capital Finance</td>
<td>4</td>
</tr>
</tbody>
</table>

### Management Minor

<table>
<thead>
<tr>
<th>Program Requirements</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 1100 Introduction to Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 2300 Fundamentals of Accounting for Decision Making</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 2320 Managerial Finance</td>
<td>4</td>
</tr>
</tbody>
</table>

### Marketing Minor

<table>
<thead>
<tr>
<th>Program Requirements</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 1100 Introduction to Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4470 Marketing Research</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4430 Marketing Principles</td>
<td>4</td>
</tr>
<tr>
<td>Prerequisite:</td>
<td></td>
</tr>
<tr>
<td>MGMT 2100 Statistical Methods</td>
<td>4</td>
</tr>
<tr>
<td>In addition to one of the following:</td>
<td></td>
</tr>
<tr>
<td>MGMT 4450 Internet Marketing</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4460 Consumer Behavior and Product Design</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4490 Advertising Strategy and Promotions</td>
<td>4</td>
</tr>
</tbody>
</table>

### Dual or Double Major Programs

To develop skills in other areas of interest or in preparation for careers related to specialized topics, students may pursue a dual or double major with other non-management curricula.

Such options can be arranged with the Schools of Engineering, Science, Architecture, or Humanities, Arts, and Social Sciences.
Special Undergraduate Opportunities

The Lally School offers four additional programs to meet undergraduate needs in the areas of research, law, international business, and cooperative education.

Undergraduate Research Program (URP)
Through the URP, students have the opportunity to work with a faculty adviser on tangible research projects. Students are eligible for a Summer Research Fellowship stipend under a program sponsored by the Office of Undergraduate Education. The stipend is intended to cover 10 weeks of full-time research.

Accelerated Management-Law Program
In cooperation with Albany Law School of Union University and Columbia University Law School, Rensselaer offers a unique program leading to a B.S. and a Juris Doctor (J.D.) in six years rather than seven. Admission to this program is restricted, with most students admitted as incoming freshmen. Selected applicants must also meet the admission requirements of Albany Law School of Union University. Thus, a prospective management-law student may be able to assure admission to law school prior to beginning an undergraduate career at Rensselaer. Transfer into the management-law program from other Rensselaer curricula is limited to students who have demonstrated academic excellence.

Although guaranteed admission to Albany Law School is available to selected incoming freshmen, conditional admission also is available to students accepted by Rensselaer who meet specified achievement levels in their undergraduate program. In addition, Rensselaer has established a working relationship with Columbia University Law School that allows a gifted management-law student to become a candidate for admission after his or her third year at Rensselaer, if a committee within the Lally School nominates the student. Rensselaer’s inclusion in Columbia’s Accelerated Interdisciplinary Legal Education Program (AILE) has made this opportunity possible.

International Management Exchange Program
Rensselaer’s Lally School has agreements with more than 12 schools in nine countries for the exchange of qualified students from and to the Rensselaer campus. This exchange occurs for one semester in the third or fourth year of undergraduate studies and/or in the fall semester in the second year of graduate studies. The foreign schools chosen for the exchange program are renowned in the field of management education. Students interested must demonstrate superior academic records, maturity, and in some cases, the necessary language capabilities to be selected for the exchange program. This program is strongly recommended for all Management students.

For more information about this program, contact the International Exchange Program Coordinator at (518) 276-2388 or e-mail maceyb2@rpi.edu.

Cooperative Education
Rensselaer’s Cooperative Education Program and the Lally School offer pre-professional work experience for undergraduates. As part of the co-op program, students work one semester and one summer in industry, business, and government positions. The co-op assignment usually occurs during the junior or senior year and can sometimes be scheduled to permit the student to graduate with the class in which he or she matriculated. Typical job opportunities are in the fields of accounting, finance, management systems, and information systems. The co-op program is described in detail in the Student Life section of this catalog.

For more information on any aspect of the undergraduate management and technology program, contact wrighf@rpi.edu.

The Lally Graduate Programs
Rensselaer’s Lally School offers five graduate programs: a Master of Science in Management, a Master of Science in Technology, Commercialization, and Entrepreneurship, a Master of Science in Financial Engineering and Risk Analytics, a Master of Business Administration, and a doctoral program in Management and Technology.

The M.S. in Management builds around a specific focal area and is best suited for students with a clearly defined career goal. The degree allows students with technical expertise to develop broader career options that include project management and the ability to apply business methods in a specialized area.

The Lally MBA is a degree in general management with a focus on the themes of innovation and entrepreneurship. This program develops leaders who combine a passion for technology with the ability to apply it across business functions and to leverage it for competitive advantage. In addition to the full-time MBA program, the Lally School offers two additional tracks. The Executive MBA is a two-year, weekend-based, intensive study for working professionals with significant work history and management experience. The evening program offers the regular MBA curriculum to working professionals who prefer the evening schedule.
The M.S. in Technology Commercialization and Entrepreneurship takes specially selected undergraduates from RPI’s Schools of Science (including ITWS), Architecture, Engineering, Humanities, Arts, and Social Sciences and Management, then blends them together in a special Master’s level cohort to learn how to bring new technologies from lab to market. This focus fits with Rensselaer Plan — to be part of “changing the world”.

The M.S. in Financial Engineering and Risk Analytics trains students for careers in analyzing and assessing risk. These careers are expected to be in high demand given the current economic climate and corporate history of insufficient risk analysis.

The Lally Ph.D. in Management and Technology is a research-oriented academic program. Students develop a scholarly specialization in one of six core areas and graduates generally pursue a career path in either academia or research.

The Lally School also provides an array of support services to students throughout their studies. The Graduate Student Services staff assists with orientation, academic advising, and career development. In particular, the office of MBA Career Resources provides a comprehensive series of career workshops throughout the academic year. These services include employer information sessions, career panels, and an online resource directory made available to employers globally. Other resources include the Severino Center for Technological Entrepreneurship and the Graduate Management Student Association. These organizations provide activities throughout the year, such as the Tech Valley Collegiate Business Plan Competition, the Distinguished Speaker Series, the Rensselaer Entrepreneurship Interns Program, the Biotech Club, and alumni networking programs on and off campus. Additional information on these activities may be found at www.lallyschool.rpi.edu.

All Lally graduate students are encouraged to work during the summer months in summer internship experiences that add value to their degree program and career goals. Part-time internships during the academic year are also an option for some students. Lally MBA Career Resources and Rensselaer’s Career and Professional Development Center (CDPC) support students in finding these internships. The academic adviser is also typically consulted to prevent academic or immigration issues. The Lally Graduate Student Services, the CDC, and the International Student Services office must approve internships for international students working on a visa prior to the student accepting the offer.

Master of Science in Management

The M.S. in Management is a 30-credit program designed for students who wish to gain an exposure to the fundamentals of business and some depth in one of its specific disciplines, or, develop a much deeper expertise in a specific discipline.

<table>
<thead>
<tr>
<th>Course Sequence</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6040</td>
<td>Talent Management .................................................... 3</td>
</tr>
<tr>
<td>MGMT 6100</td>
<td>Statistics and Operations Management I ..................................... 3</td>
</tr>
<tr>
<td>MGMT 6140</td>
<td>Information Systems for Management ....................................... 3</td>
</tr>
<tr>
<td>MGMT 6190</td>
<td>Introduction to Accounting and Financial Management .................... 3</td>
</tr>
<tr>
<td>MGMT 6490</td>
<td>Competitive Advantage and Operations Strategy ........................... 3</td>
</tr>
<tr>
<td>MGMT 6580</td>
<td>Marketing High-Tech Products ............................................. 3</td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
</tr>
</tbody>
</table>
| Concentrations in the Master of Science Program

A concentration consists of a 12-credit group of related courses. Concentrations aid students in marketing themselves to employers for internship opportunities or for employment opportunities upon graduation.

<table>
<thead>
<tr>
<th>Business Analytics</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Course: MGMT 69XX</td>
<td>Technology Fundamentals for Business Analytics .................. 3</td>
</tr>
<tr>
<td>Choose three (3) from the following: ISYE 4220</td>
<td>Optimization Algorithms and Applications ........................... 3</td>
</tr>
<tr>
<td>ISYE 6180</td>
<td>Knowledge Discovery with Data Mining ........................... 3</td>
</tr>
<tr>
<td>ISYE 6870</td>
<td>Introduction to Neural Networks ........................... 3</td>
</tr>
<tr>
<td>MGMT 6720</td>
<td>Internet Marketing .................................................... 3</td>
</tr>
</tbody>
</table>
Students can elect one of two options: Investments or Corporate Finance. All students must take MGMT 6430 and then elect three courses from one of the options below.

**Finance**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6430</td>
<td>Financial Statement Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

**Corporate Finance Option**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6030</td>
<td>Financial Management II</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6300</td>
<td>International Finance</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6370</td>
<td>Options, Futures, and Derivatives Markets</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6380</td>
<td>Advanced Corporate Finance</td>
<td>3</td>
</tr>
</tbody>
</table>

**Investments Option**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6240</td>
<td>Financial Trading and Investing</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6370</td>
<td>Options, Futures, and Derivatives Markets</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6410</td>
<td>Investments I</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6961</td>
<td>Investments II</td>
<td>3</td>
</tr>
</tbody>
</table>

**Management Information Systems**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 4460</td>
<td>Consumer Behavior and Product Design</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 6540</td>
<td>Marketing Communication and Branding Strategies</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6550</td>
<td>Marketing Research</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6580</td>
<td>Marketing High-Tech Products</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6590</td>
<td>Commercializing Advanced Technologies</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6600</td>
<td>Research and Development Management</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6690</td>
<td>Negotiations</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6720</td>
<td>Internet Marketing</td>
<td>3</td>
</tr>
</tbody>
</table>

**Marketing – New Product Development**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6530</td>
<td>Making Business Happen</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6540</td>
<td>Marketing Communication and Branding Strategies</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6550</td>
<td>Marketing Research</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6580</td>
<td>Marketing High-Tech Products</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6590</td>
<td>Commercializing Advanced Technologies</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6720</td>
<td>Internet Marketing</td>
<td>3</td>
</tr>
</tbody>
</table>

**Supply Chain Management**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 4100</td>
<td>Quantitative Methods for Business</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4130</td>
<td>Enterprise IT Integration</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 4220</td>
<td>Optimization Algorithms and Applications</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6080</td>
<td>Networks, Innovation, and Value Creation</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6490</td>
<td>Competitive Advantage and Operations Strategy</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6600</td>
<td>Design of Manufacturing System Supply Chains</td>
<td>3</td>
</tr>
</tbody>
</table>

**Technological Entrepreneurship**

Students following the technological entrepreneurship concentration may elect two paths: entrepreneurship for start ups or corporate entrepreneurship. The former focuses on founding a brand new business entity, whereas the latter focuses on creating new growth platforms based on technological innovation within established companies. Both require entrepreneurial behavior.

**All students in the Technological Entrepreneurship concentration should take:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6620</td>
<td>Principles of Technological Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6640</td>
<td>Invention, Innovation, and Entrepreneurship</td>
<td>3</td>
</tr>
</tbody>
</table>

**Corporate Entrepreneurship Option**

Students wishing to pursue the corporate entrepreneurship option can elect two courses from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6580</td>
<td>Marketing High-Tech Products</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6590</td>
<td>Commercializing Advanced Technologies</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6600</td>
<td>Research and Development Management</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6700</td>
<td>Corporate Entrepreneur</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6810</td>
<td>Management of Technical Projects</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 69XX</td>
<td>Social Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 7070</td>
<td>Managing on the Edge: Corporate Innovation for the Coming Years</td>
<td>3</td>
</tr>
</tbody>
</table>

**Start-Up Option**

Then, students wishing to pursue the start up path can elect two courses from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6260</td>
<td>Entrepreneurial Finance</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6590</td>
<td>Commercializing Advanced</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6630</td>
<td>Starting Up A New Venture</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6670</td>
<td>Practicum in Technological Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6810</td>
<td>Management of Technical Projects</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 69XX</td>
<td>Social Entrepreneurship</td>
<td>3</td>
</tr>
</tbody>
</table>
Master of Business Administration

The MBA is the Lally School’s premier program and offers students both depth and breadth in management education with an emphasis on innovation and entrepreneurship. The focus on “innovation” is concerned with organizational, financial, and technological innovation, while the emphasis on “entrepreneurship” involves both individually-driven new start-ups and the launch of new businesses within larger corporations.

The curriculum provides a strong grounding in managerial fundamentals while highlighting the strategic role that technology plays in enhancing business performance and creating sustainable competitive advantage.

In addition, it includes a non-pay community service (Practicum) course in the final semester in which students use training in service and process innovation to help solve local community problems. Individual faculty supervise teams of students who work with local agencies and small business start-ups. Projects come from faculty in conjunction with local organizations, agencies, and businesses.

If they choose, students can complete the 45-credit hour MBA in one year from September to August. The MBA includes 11 required courses (33 credits) and four electives (12 credits) for a total of 45 credits. Students who would like more depth in a concentration have the option to stay for a fourth semester (60 credits).

The infusion of innovation and the entrepreneurial spirit begins prior to the start of official classes with an orientation program called, “Heroes, Leaders, and Innovators.” This session exposes new students to the key characteristics, experience, and behaviors of successful business leaders.

Throughout the remainder of the MBA curriculum, students are exposed to the cutting-edge methods and strategies that corporations deploy to create and capture value in today’s global economy. The program also provides ample opportunity for professional development by developing such skills in business communication, negotiation, conflict resolution, and team building.

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6010</td>
<td>Heroes, Leaders, and Innovators ........................................... 0</td>
</tr>
<tr>
<td>MGMT 6040</td>
<td>Talent Management .................................................... 3</td>
</tr>
<tr>
<td>MGMT 6100</td>
<td>Statistics and Operations Management I ..................................... 3</td>
</tr>
<tr>
<td>MGMT 7050</td>
<td>Design, Manufacturing, and Marketing I ..................................... 3</td>
</tr>
<tr>
<td>MGMT 7230</td>
<td>Professional Development Workshop I ..................................... 0</td>
</tr>
<tr>
<td>MGMT 7250</td>
<td>Professional Development Workshop II .................................... 0</td>
</tr>
<tr>
<td>MGMT 7730</td>
<td>Economics and Institutions ............................................. 3</td>
</tr>
<tr>
<td>MGMT 7740</td>
<td>Accounting for Reporting and Control .................................... 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6020</td>
<td>Financial Management I ............................................. 3</td>
</tr>
<tr>
<td>MGMT 7060</td>
<td>Design, Manufacturing, and Marketing II .................................. 3</td>
</tr>
<tr>
<td>MGMT 7240</td>
<td>Professional Development Workshop II ................................... 0</td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Summer</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6060</td>
<td>Business Implications of Emerging Technologies ........................................... 3</td>
</tr>
<tr>
<td>MGMT 6140</td>
<td>Information Systems for Management ............................................. 3</td>
</tr>
<tr>
<td>MGMT 6840</td>
<td>Practicum in Management .................................................... 3</td>
</tr>
<tr>
<td>MGMT 7030</td>
<td>Strategy, Technology, &amp; Competition I ........................................... 3</td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
</tr>
</tbody>
</table>

Concentrations

Below are concentrations and relevant courses. A concentration consists of four elective courses. The concentrations and courses are suggested for students who are interested in these areas:

<table>
<thead>
<tr>
<th>Business Analytics</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Course:</td>
<td></td>
</tr>
<tr>
<td>MGMT 69XX</td>
<td>Technology Fundamentals for Business Analytics ........................................... 3</td>
</tr>
<tr>
<td>Choose three (3) from the following:</td>
<td></td>
</tr>
<tr>
<td>ISYE 4220</td>
<td>Optimization Algorithms and Applications ........................................... 3</td>
</tr>
<tr>
<td>ISYE 6180</td>
<td>Knowledge Discovery with Data Mining ............................................. 3</td>
</tr>
<tr>
<td>ISYE 6870</td>
<td>Introduction to Neural Networks ............................................... 3</td>
</tr>
<tr>
<td>MGMT 6720</td>
<td>Internet Marketing .................................................... 3</td>
</tr>
</tbody>
</table>
### Finance Credit Hours

Students can elect one of two options: Investments or Corporate Finance. All students must take MGMT 6430 and then elect three courses from one of the options below.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6430</td>
<td>Financial Statement Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Corporate Finance Option

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6030</td>
<td>Financial Management II</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6360</td>
<td>International Finance</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6370</td>
<td>Options, Futures, and Derivatives Markets</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6380</td>
<td>Advanced Corporate Finance</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Investments Option

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6240</td>
<td>Financial Trading and Investing</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6370</td>
<td>Options, Futures, and Derivatives Markets</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6410</td>
<td>Investments I</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6961</td>
<td>Investments II</td>
<td>3</td>
</tr>
</tbody>
</table>

### Global Enterprise Management — ISP Credit Hours

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6390</td>
<td>International Operations</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6620</td>
<td>Principles of Technological Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6840</td>
<td>Practicum in Management</td>
<td>3 to 6</td>
</tr>
<tr>
<td>MGMT 7750</td>
<td>Global Business and Social Responsibility</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Management Information Systems Credit Hours

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 4130</td>
<td>Enterprise IT Integration</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4150</td>
<td>IT Project Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4170</td>
<td>Data Resource Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 6080</td>
<td>Networks, Innovation, and Value Creation</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6170</td>
<td>Advanced Systems Analysis and Design</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6720</td>
<td>Internet Marketing</td>
<td>3</td>
</tr>
</tbody>
</table>

### Marketing — New Product Development Credit Hours

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 4460</td>
<td>Consumer Behavior and Product Design</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 6530</td>
<td>Making Business Happen</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6540</td>
<td>Marketing Communication and Branding Strategies</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6550</td>
<td>Marketing Research</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6580</td>
<td>Marketing High-Tech Products</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6590</td>
<td>Commercializing Advanced Technologies</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6600</td>
<td>Research and Development Management</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6690</td>
<td>Negotiations</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6720</td>
<td>Internet Marketing</td>
<td>3</td>
</tr>
</tbody>
</table>

### Supply Chain Management Credit Hours

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISYE 4220</td>
<td>Optimization Algorithms and Applications</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6600</td>
<td>Design of Manufacturing System Supply Chains</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 4100</td>
<td>Quantitative Methods for Business</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4130</td>
<td>Enterprise IT Integration</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 6080</td>
<td>Networks, Innovation, and Value Creation</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6490</td>
<td>Competitive Advantage and Operations Strategy</td>
<td>3</td>
</tr>
</tbody>
</table>

### Technological Entrepreneurship Credit Hours

Students following the technological entrepreneurship concentration may elect two paths: entrepreneurship for startups or corporate entrepreneurship. The former focuses on founding a brand new business entity, whereas the latter focuses on creating new growth platforms based on technological innovation within established companies. Both require entrepreneurial behavior.

All students in the Technological Entrepreneurship concentration should take:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6620</td>
<td>Principles of Technological Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6640</td>
<td>Invention, Innovation, and Entrepreneurship</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Start-Up Option

Then, students wishing to pursue the start up path can elect 2 courses from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6260</td>
<td>Entrepreneurial Finance</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6590</td>
<td>Commercializing Advanced Technologies</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6630</td>
<td>Starting Up A New Venture</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6670</td>
<td>Practicum in Technological Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6810</td>
<td>Management of Technical Projects</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 69XX</td>
<td>Social Entrepreneurship</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Corporate Entrepreneurship Option

Then, students wishing to pursue the start up path can elect 2 courses from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6260</td>
<td>Entrepreneurial Finance</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6590</td>
<td>Commercializing Advanced Technologies</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6630</td>
<td>Starting Up A New Venture</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6670</td>
<td>Practicum in Technological Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6810</td>
<td>Management of Technical Projects</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 69XX</td>
<td>Social Entrepreneurship</td>
<td>3</td>
</tr>
</tbody>
</table>
Master of Science in Financial Engineering and Risk Analytics

The purpose of this degree is to provide students with the knowledge and essential skills to respond to the changes and new challenges that characterize the fast changing world of Financial Engineering and Risk Analysis. The goal of the program is for students to master cutting-edge financial theory as well as advanced analytical and quantitative techniques that have become key to the success of the new breed of financial experts. Students will be exposed to emerging concepts, practices, and techniques in the finance industry through rigorous training in empirical research and modeling, using a variety of professional databases and computer software packages.

The degree offers three tracks - a general track and tracks in quantitative finance and financial analysis. Within these three tracks students will be able to develop expertise in areas such as quantitative financial analysis and financial risk assessment and management.

The program requires four basic foundation courses and six courses in the area of concentration. The FERA Program is designed to allow for maximum flexibility for students from a variety of backgrounds wishing to pursue rigorous study in financial engineering and risk analytics. Thirty credit hours for students with Finance or Technical undergraduate background.

Prerequisites: Basic foundation of mathematics and statistics. Students may take a suitable prerequisite course within Lally if such a course is offered and is approved by the FERA Program Director. Students with college-level calculus and statistics courses (the equivalent of 6 credit hours) will normally have fulfilled this prerequisite, as will students with undergraduate backgrounds in finance, management, business, economics, and technical fields. Mathematical and Statistical Foundations (or substitute) courses will not count towards the 30-credit-hour FERA degree requirement. Courses fulfilling this Math and Statistics foundation course requirement include MATH 1520, MATH 4100, ISYE 4140.

Foundation Courses (Four) Required

Foundation courses are basic courses in finance and quantitative methods that contain concepts that are prerequisite to understanding the principles of Financial Engineering and Risk Analytics. These foundation courses are required for all students without undergraduate business degrees and for students whose backgrounds did not include coverage of comparable material. Students in Financial Engineering and Risk Analytics with business undergraduate degrees may waive the Financial Management I course with the consent of the Program Adviser(s) if they have sufficient relevant undergraduate work. A student can waive this foundation course if he or she got a B or better in an introductory finance course as well as a B or better in one higher level finance course. If this or any other course is waived, it must be replaced with some other course from the courses listed below. Therefore, waivers of any of these Foundation Courses will require substitutions from the Track Courses lists.

<table>
<thead>
<tr>
<th>Foundation Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Foundation Course 1</strong></td>
<td></td>
</tr>
<tr>
<td>MGMT 6020 Financial Management I</td>
<td>3</td>
</tr>
<tr>
<td>Or one of the following:</td>
<td></td>
</tr>
<tr>
<td>MGMT 6190 Introduction to Accounting and Financial Management</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6240 Financial Trading and Investing</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6410 Investments I</td>
<td></td>
</tr>
<tr>
<td><strong>Foundation Course 2</strong></td>
<td></td>
</tr>
<tr>
<td>MGMT 6520 Financial Modeling</td>
<td>3</td>
</tr>
<tr>
<td>Or the following:</td>
<td></td>
</tr>
<tr>
<td>MATH 4740 Introduction to Financial Mathematics and Engineering</td>
<td>4</td>
</tr>
<tr>
<td><strong>Foundation Course 3</strong></td>
<td></td>
</tr>
<tr>
<td>MGMT 6510 Financial Computation</td>
<td>3</td>
</tr>
<tr>
<td>Or one of the following:</td>
<td></td>
</tr>
<tr>
<td>CSCI 4800 Numerical Computing</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4800 Numerical Computing</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 4820 Introduction to Numerical Methods for Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4820 Introduction to Numerical Methods for Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td><strong>Foundation Course 4</strong></td>
<td></td>
</tr>
<tr>
<td>MGMT 6370 Options, Futures, and Derivatives Markets</td>
<td>3</td>
</tr>
</tbody>
</table>
Concentration Courses (Six) Required

FERA students are permitted to declare a Concentration in either the General Track, Quantitative Finance, or Financial Analysis. Students should select six (6) courses from the following lists to fulfill their concentration requirements.

<table>
<thead>
<tr>
<th>General Track: Choose Six</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 4820 Numerical Computing</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 4820 Introduction to Numerical Methods for Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>ECON 4570 Economometrics*</td>
<td>4</td>
</tr>
<tr>
<td>ECON 6570 Advanced Econometrics</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6550 Stochastic Processes in Communication and Control</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4760 Mathematical Statistics</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 6010 Applied Regression Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6100 Time Series Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6770 Linear Programming</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 6780 Nonlinear Programming</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 6870 Introduction to Neural Networks</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4800 Numerical Computing</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4820 Introduction to Numerical Methods for Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>MATH 6740 Financial Mathematics and Simulation</td>
<td>4</td>
</tr>
<tr>
<td>MATP 4600 Probability Theory and Applications</td>
<td>4</td>
</tr>
<tr>
<td>MATP 4620 Mathematical Statistics</td>
<td>4</td>
</tr>
<tr>
<td>MATP 4640 Nonlinear Programming</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4260 Financial Statement Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 4330 Investments II</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4370 Risk Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4440 Financial Simulation</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 6440 Financial Simulation</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6460 Financial Management II</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6480 Financial Trading and Investing</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6340 Financial Markets and Institutions</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6360 International Finance</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6380 Advanced Corporate Finance</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6400 Financial Econometrics Modeling</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6410 Investments I</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6430 Financial Statement Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6940 Independent Study</td>
<td>1 to 6</td>
</tr>
<tr>
<td>MGMT 7740 Accounting for Reporting and Control</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 7760 Risk Management</td>
<td>3</td>
</tr>
<tr>
<td>MATP 6610 Computational Optimization</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quantitative Finance Track: Choose Six</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 4820 Introduction to Numerical Methods for Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>ECON 4570 Economometrics*</td>
<td>4</td>
</tr>
<tr>
<td>ECON 6570 Advanced Econometrics</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6550 Stochastic Processes in Communication and Control</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 4760 Mathematical Statistics</td>
<td>4</td>
</tr>
<tr>
<td>MATP 4620 Mathematical Statistics</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 6010 Applied Regression Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6100 Time Series Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6780 Nonlinear Programming</td>
<td>4</td>
</tr>
<tr>
<td>MATP 6600 Nonlinear Programming</td>
<td>4</td>
</tr>
<tr>
<td>MATH 6740 Financial Mathematics and Simulation</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4740 Introduction to Financial Mathematics and Engineering</td>
<td>4</td>
</tr>
<tr>
<td>MATP 4820 Introduction to Numerical Methods for Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>MATP 4600 Probability Theory and Applications</td>
<td>4</td>
</tr>
<tr>
<td>MATP 6610 Computational Optimization</td>
<td>4</td>
</tr>
<tr>
<td>MATP 6640 Linear Programming</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 4440 Financial Simulation</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 6440 Financial Simulation</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6460 Financial Management II</td>
<td>3</td>
</tr>
<tr>
<td>MATP 6640 Financial Econometrics Modeling</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6410 Investments I</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6940 Independent Study</td>
<td>1 to 6</td>
</tr>
<tr>
<td>MGMT 7760 Risk Management</td>
<td>3</td>
</tr>
</tbody>
</table>
Master of Science in Technology Commercialization and Entrepreneurship

This degree is designed to prepare students to create businesses or products based on their own intellectual property or facilitate the commercialization of technology enabled products, services, or businesses. Students with one of the following profiles should consider this degree: 1) Scientists and engineers who envision themselves running a laboratory, 2) Scientists and engineers who have developed intellectual property that they wish to see commercialized, 3) Those who wish to leverage their science and engineering education to facilitate new product development and new business creation, 4) Those who have studied management and wish to work in technology intensive environments.

The program consists of a set of advanced management courses, a set of upper level science or technology courses and a series of law courses. The approved plan of study includes Talent Management, Business Implications of Emerging Technologies, and Commercializing Advanced Technologies. The capstone course is Organizational Design and Change. It is highly recommended that students admitted into this program need to take preparatory courses in Accounting and Finance. Four elective courses are taken from science and engineering departments at the Institute, and the remaining credits consist of legal study courses, which can be taken from a menu of those delivered by the Albany Law School.

Examples of Law Courses include:
- Contracts 2 credits
- Introduction to Intellectual Property 2 credits
- Law of Technology Transfer 2 credits

Elective Course Combinations:

The following are examples of elective science and engineering course combinations. However, as long as students have the prerequisite science and engineering courses they can take any combination of science and engineering courses to meet the technology requirement of this program.

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH 4840</td>
<td>Architectural Acoustics 1</td>
</tr>
<tr>
<td>ARCH 4850</td>
<td>Architectural Acoustics 2</td>
</tr>
<tr>
<td>ARCH 4860</td>
<td>Applied Psychoacoustics</td>
</tr>
<tr>
<td>LGHT 4230</td>
<td>Lighting Design</td>
</tr>
<tr>
<td>LGHT 4770</td>
<td>Lighting Technologies and Applications</td>
</tr>
<tr>
<td>LGHT 4840</td>
<td>Human Factors in Lighting</td>
</tr>
<tr>
<td>LGHT 6760</td>
<td>Lighting Workshop</td>
</tr>
<tr>
<td>LGHT 6830</td>
<td>The Physics of Light</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biology</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4620</td>
<td>Molecular Biology</td>
</tr>
<tr>
<td>BIOL 4630</td>
<td>Molecular Biology II</td>
</tr>
<tr>
<td>BIOL 4640</td>
<td>Proteomics</td>
</tr>
<tr>
<td>BIOL 4760</td>
<td>Molecular Biochemistry I</td>
</tr>
</tbody>
</table>
### Biomedical Engineering

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED 4410</td>
<td>BioMEMs</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6410</td>
<td>BioMEMs</td>
<td>3</td>
</tr>
<tr>
<td>BMED 4420</td>
<td>Clinical Orthopaedics and Contemporary Research</td>
<td>4</td>
</tr>
<tr>
<td>BMED 6420</td>
<td>Clinical Orthopaedics and Contemporary Research</td>
<td>4</td>
</tr>
<tr>
<td>BMED 4650</td>
<td>Intro to Cell and Tissue Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BMED 6500</td>
<td>Mechatronics</td>
<td>3</td>
</tr>
</tbody>
</table>

### Cognitive Science

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoGS 6100</td>
<td>Seminar in Cognitive Engineering</td>
<td>4</td>
</tr>
<tr>
<td>CoGS 6200</td>
<td>Cognition</td>
<td>4</td>
</tr>
<tr>
<td>CoGS 6210</td>
<td>Cognitive Modeling I</td>
<td>4</td>
</tr>
<tr>
<td>CoGS 6240</td>
<td>Logic and Artificial Intelligence</td>
<td>4</td>
</tr>
<tr>
<td>CoGS 6570</td>
<td>Advanced Behavioral Statistics</td>
<td>4</td>
</tr>
</tbody>
</table>

### Computer Science

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 4020</td>
<td>Computer Algorithms</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 6140</td>
<td>Computer Operating Systems</td>
<td>3</td>
</tr>
<tr>
<td>CSCI 6390</td>
<td>Database Mining</td>
<td>3</td>
</tr>
<tr>
<td>CSCI 6xxx</td>
<td>(Any course at this level with adviser approval)</td>
<td></td>
</tr>
</tbody>
</table>

### IT

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM 6770</td>
<td>User-Centered Design</td>
<td>3</td>
</tr>
<tr>
<td>COMM 6820</td>
<td>Usability Testing</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6180</td>
<td>Knowledge Discovery with Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6520</td>
<td>Enterprise Database Systems</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 6530</td>
<td>Decision Support and Expert Systems</td>
<td>3</td>
</tr>
</tbody>
</table>

### Materials Science

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTLE 6030</td>
<td>Advanced Thermodynamics</td>
<td>4</td>
</tr>
<tr>
<td>MTLE 6060</td>
<td>Advanced Kinetics of Materials Reactions</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 6250</td>
<td>Advanced Mechanical Properties of Materials</td>
<td>4</td>
</tr>
<tr>
<td>MTLE 6460</td>
<td>Advanced Structure and Bonding in Materials</td>
<td>4</td>
</tr>
</tbody>
</table>

### Product Design and Innovation

**Required Courses:**

See program director for information.

Then choose two (2) from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS 6040</td>
<td>Technology Studies</td>
<td>3</td>
</tr>
<tr>
<td>STSS 6100</td>
<td>Policy Studies</td>
<td>3</td>
</tr>
<tr>
<td>STSS 6400</td>
<td>Environment and Health</td>
<td>3</td>
</tr>
<tr>
<td>STSS 6540</td>
<td>Advanced Environment, Law, and Culture</td>
<td>3</td>
</tr>
<tr>
<td>STSS 6600</td>
<td>Seminar in Ecological Economics, Values, and Policy</td>
<td>3</td>
</tr>
</tbody>
</table>

### Sustainability

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4270</td>
<td>Human Physiology</td>
<td>4</td>
</tr>
<tr>
<td>ECON 4250</td>
<td>Ecological Economics</td>
<td>4</td>
</tr>
<tr>
<td>ENVE 4340</td>
<td>Physicochemical Processes in Environmental Engineering</td>
<td>4</td>
</tr>
<tr>
<td>ENVE 4350</td>
<td>Biological Processes in Environmental Engineering</td>
<td>4</td>
</tr>
<tr>
<td>STSS 2300</td>
<td>Environment and Society</td>
<td>4</td>
</tr>
<tr>
<td>STSS 4270</td>
<td>Sustainability Problems</td>
<td>4</td>
</tr>
</tbody>
</table>

### Dual Master’s Program

#### J.D.-MBA Program

In collaboration with Albany Law School of Union University, a student may simultaneously pursue an MBA and a J.D. degree. By integrating the programs, some courses at one institution are applied toward the degree requirements at the other. This arrangement reduces the total time required for both degrees by at least one semester. Interested candidates must apply to and be accepted at both institutions. Additional information concerning the MBA requirements can be obtained from the Lally School. This program is separate and distinct from the undergraduate management-law program.
Doctoral Programs

The Ph.D. in Management and Technology is a research-based program concentrating on scholarship in the following core areas:

- Entrepreneurship
- Innovation management and new product development
- Information technology
- Financial technology
- International business and global management of technology

Students are expected to develop scholarship in one of Lally’s areas of interdisciplinary focus and be conversant in a traditional business discipline. The Ph.D. program emphasizes research methods and an appreciation of relevant theoretical and empirical literature in the student’s area of concentration. The program strives to balance theoretical approaches with empirical studies that can be applied to real-world challenges. Graduates of the doctoral program typically pursue academic and research positions at well-respected institutions in the United States and abroad.

Core Requirements

Through courses taken prior to admission or courses within the doctoral program, management Ph.D. students must demonstrate knowledge that covers basic management areas, such as marketing, finance, and organizational behavior. In addition to area content courses, students are expected to take courses related to Lally’s thematic focus areas. The doctoral adviser and committee evaluate each student and specify any courses needed to fulfill the breadth and depth requirements. Each semester, the student is expected to take a selected number of doctoral-level seminars offered by the Lally School.

In addition, all doctoral students must take a three-course research methodology sequence. Because the doctoral degree is research oriented, the student must complete a research paper as part of the research-methods course sequence. In consultation with their faculty adviser, students normally submit an outline of their goals and a Plan of Study by the second year. The plan indicates courses the student intends to use, including thesis credits, to meet the 90-credit graduation requirement. By the third year, the student is expected to complete all coursework, a comprehensive examination on economics fundamentals and quantitative methods, and a field exam in their area of concentration. This is followed by a candidacy exam and a final defense.

Concentrations

Research programs and concentrations are developed through consultation with faculty. They include traditional disciplines such as finance, marketing, strategic management, organizational behavior, and information systems, as well as interdisciplinary programs such as international business, financial technology, entrepreneurship, environmental management, and new product development. Candidates are encouraged to combine fields; for example, entrepreneurship and management of information systems or the strategic uses of technology.

Students choose specific courses in consultation with the Ph.D. director and concentration area adviser. They also may petition the doctoral committee for a program of advanced studies and research not included in the above. Faculty in the student’s area of desired expertise will prepare the field examination, which includes a written and, when deemed necessary, an oral examination. For information concerning the requirements for a typical program of study, applicants should contact the director of the Ph.D. programs.

The appropriate faculty evaluate a student’s progress yearly. Depending on the candidate’s stage of development in the program, criteria of evaluation include:

- Performance in the doctoral research seminars and the required methodology courses.
- Appropriate Plan of Study.
- Coursework/thesis registration.
- Successful completion of the field exam.
- Formation of doctoral committee.
- Completion of candidacy exam.
- Identified goals, expectations, accomplishments, and career path.
- Successful completion of the qualifying exam.

Students failing to satisfy the requirements of the annual evaluations will be terminated from the management doctoral program.

Once a student chooses a dissertation topic, the student adviser recommends a doctoral committee for that student to the Office of Graduate Education. This recommendation is based on the student’s desires and objectives within the Plan of Study. Before completing 75 credit hours of graduate study, each student will prepare a dissertation proposal consisting of a problem statement, supporting literature, proposed research methodology, and anticipated results. The presentation of this research topic to the academic community, followed by an examining session conducted by and limited to the student’s doctoral committee, will comprise the candidacy examination. A student will be admitted to candidacy upon satisfactory performance of the candidacy examination and by meeting the requirements in designated core disciplines (through their study in the concentration or program area and through the preparation of a research paper).
The culmination of doctoral studies is the dissertation, which represents the results of an original investigation and demonstrates capacity for independent research. The candidate’s studies lead to the dissertation and include participation with faculty in research activities. This participation may form the basis of the dissertation topic. Participation in these projects should enable the student to structure, engage in, and report on a research endeavor consistent with his/her area of study. This is a requirement that must be satisfied prior to the admission to candidacy. Students will present the results of their dissertation research to the Rensselaer community and be examined by their doctoral committees. Upon satisfactory completion of this examination (and university requirements), students will be awarded the doctoral degree in management.

Graduate Programs at Hartford

The program offered by the Lally School for the Education of Working Professionals at Rensselaer is the Master of Business Administration (MBA). In its program, the Lally School strives for a balance between theory and practice, and between rigor and relevance. The programs place heavy emphasis on the application of knowledge through team-based projects.

Hartford Campus Faculty*

Professors of Practice

Albright, R.—Ph.D. (University of Pittsburgh); organization behavior, strategy.
Maleyeff, J.—Ph.D. (University of Massachusetts); operations management (Associate Dean for Academic Affairs).
Rainey, D.L.—Ph.D. (Rensselaer Polytechnic Institute); technology, innovation, and environment.
Stodder, J.P.—Ph.D. (Yale University); economics, analytics.
Triscari, T.—Ph.D. (Rensselaer Polytechnic Institute); information systems.

Lecturers

Gingerella, L.W., Jr.—MBA (Rensselaer Polytechnic Institute); finance, accounting.
Peteros, R.G.—J.D. (Western New England College School of Law); finance, business law.

Adjunct Faculty

Araujo, R.J.—M.S., MBA (Rensselaer Polytechnic Institute; University of New Haven).
Bialecki, D.M.—MBA (Rensselaer Polytechnic Institute).
Chippenfield, L.—J.D. (Washington University, St. Louis).
Mayer, P.—MBA (Rensselaer Polytechnic Institute).
Mutchler, J.—J.D. (Quinnipiac University, School of Law).
Nigro, L.—MBA, J.D. (University of Connecticut; University of Connecticut, School of Law).
Young, V.J.—M.S. (Rensselaer Polytechnic Institute).

Evening MBA Cohort (Hartford)

The Rensselaer Hartford campus offers an evening MBA which focuses on innovation, globalization, and entrepreneurship. Details on the structure of and coursework for this program is available at the following Web site: http://www.ewp.rpi.edu.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
**Accelerated Weekend MBA Program**

In the Accelerated Weekend MBA Program, students can earn an MBA degree in a 33-month period of accelerated instruction. Classes are conducted primarily on Friday evenings and essentially every other Saturday designed to enhance cumulative skill building and learning. The schedule is designed to appeal to students with significant work experience who are interested in joining a group of mature students attending classes and working and studying together and who desire an opportunity to earn the MBA degree in less than three years.

**Executive Master’s of Business Administration (EMBA) - Hartford**

The Lally School offers an Executive Master’s of Business Administration degree for those individuals with at least six or more years of work experience in a management capacity. The typical EMBA student is one who is both motivated to assume senior management responsibility and willing to make a strong commitment to the program of study.

Executive MBA classes are scheduled all day Friday and Saturday on alternating weekends over two academic years. Participants are expected to continue in their full-time employment and are encouraged to apply, in their work environments, techniques and theories they learn as they progress through the program. Upon successful completion of the program, the participant receives the Master’s of Business Administration degree from Rensselaer.

The program curriculum has been carefully designed to achieve a logical sequencing and integration of subjects. Students proceed through the program in a cohort and are assigned to small study groups. The faculty team is experienced in executive education, as both tenured and practice faculty collaborate in delivering the program in a highly interactive mode.

Considering the growing importance of the global marketplace, the program features an international residency. The residency entails an intensive eight-day module in a European or Asian Pacific venue where students visit companies, meet government officials, and receive instruction on global political economy topics that cultivate appreciation of doing business on a global scale.

**Master of Science in Management**

The M.S. in Management is designed to provide students with the knowledge, skills, and capabilities to be professional contributors and technical managers in a functional area of organizations. It is intended for students who want to acquire more expertise in a specialized area before they seek general management skills and capabilities later in their careers.

The Master of Science in Management is a specialized program requiring a minimum of 30 credit hours of graduate work and must:

- Focus on enterprise management or innovation and entrepreneurship. It must not be of a general business nature. See below for a list of areas of concentrations.
- Include the four core courses as defined below, four courses in an approved area of concentration, one elective, and a culminating experience (CAPSTONE course). The program must meet the requirements of the Office of Graduate Education. A Plan of Study must be approved by the Assistant Dean for Academic Programs.
- Include a three-credit Capstone course ordinarily completed in the final term, which is satisfied by either: 1) MGMT 6680 Strategy, Technology, and Global Competitive Advantage; or 2) MGMT 7980, Capstone Project Course with the approval of a full-time faculty member. See below for additional details.

The following is a typical 10-course M.S. program sequence. The four core courses are normally offered every term.

<table>
<thead>
<tr>
<th>Management Core: Background in Key Areas of Management</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6020 Financial Management I (formerly MGMT 6310 Financial Management and Valuation of Firms)</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6040 Talent Management (formerly MGMT 6710 Designing, Developing, and Staffing High-Performance Organizations I)</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6050 Organizational Design and Change</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 7740 Accounting for Reporting and Control (formerly MGMT 6190 Financial and Managerial Accounting)</td>
<td>3</td>
</tr>
</tbody>
</table>
Management and Entrepreneurship Concentration

A Concentration is a 12-credit-hour (four-course) sequence of related course work that is required for the M.S. in Management program (see above) but not required for the MBA. Neither the diploma nor the transcript will specify a concentration. There are two main concentrations: Innovation and Entrepreneurship; and Enterprise Management. Specific requirements for each concentration are described below.

Innovation and Technology Concentrations

This concentration has been designed for students who have an interest in technological innovation, new product development, technological entrepreneurship, and new venture creation in established firms and start-up companies. It prepares professionals in the strategic management of innovation and the integration of the technical function with other corporate functions and goals.

Students must select four concentration courses pertaining to Innovation and Entrepreneurship: 

<table>
<thead>
<tr>
<th>Credit Hours</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>MGMT 7003 Sustainable Business Development</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6060 Business Implications of Emerging Technologies</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6600 Research and Development Management</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6620 Principles of Technological Entrepreneurship</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6630 Starting Up A New Venture</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6730 Technological Change and International Competitiveness</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6810 Management of Technical Projects</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6750 Design, Manufacturing, and Marketing I (formerly MGMT 6560 Managing New Product Development)</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 7060 Design, Manufacturing, and Marketing II</td>
</tr>
</tbody>
</table>

Enterprise Management

This concentration has been designed for students who are interested in the integration of supply networks, operations, marketing, finance, and management of information systems. It prepares students for management careers at several different levels of the product and service organization by developing the knowledge necessary to support and add value to the underlying strategic focus of a management system.

Students must select four concentration courses from one of the following areas of specialization:

Operations Management

Executives in every kind of organization—large and small, private and public, for-profit and not-for-profit—can utilize the tools delivered in this specialization to form high-level strategy and improve day-to-day operations; to unlock the value of their data; to model complex systems; and to make better decisions with less risk. The courses will help improve processes, productivity, and performance across the entire business enterprise, whether its focus is service or production.

Select four courses from the following: 

<table>
<thead>
<tr>
<th>Credit Hours</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>MGMT 6100 Statistics and Operations Management I</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6110 Statistics and Operations Management II</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6450 Manufacturing Systems Management</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6470 Management of Quality, Processes, and Reliability</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6480 Service Operations Management</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6490 Competitive Advantage and Operations Strategy</td>
</tr>
<tr>
<td>3</td>
<td>MGMT 6080 Networks, Innovation, and Value Creation</td>
</tr>
</tbody>
</table>

* See The Capstone Course Requirement for more information.
Finance
This specialization prepares students for a career path in corporate finance functions and for careers in the financial services industries. The special finance problems in high-tech industries are explored as well as the impact of technology on financial markets and the financial manager in modern corporations. To provide students with a broad finance background, students take four courses beyond the core financial management courses which are prerequisites for the courses listed below: MGMT 7740 Accounting for Reporting and Control — formerly MGMT 6190 Financial and Managerial Accounting — and MGMT 6020 Financial Management I — formerly MGMT 6310 Financial Management and Valuation of Firms.

Select four courses from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6030</td>
<td>Financial Management II</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6320</td>
<td>Investment Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6330</td>
<td>Investment Analysis II</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6340</td>
<td>Financial Markets and Institutions</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6350</td>
<td>International Finance</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6400</td>
<td>Financial Economics</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6960</td>
<td>Topics in Management (Taxation for Business Investment)</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 7210</td>
<td>Acquisition and Venture Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

Global Enterprise Management
This specialization explores the rapidly evolving managerial and technological environments which students will encounter as professionals in a competitive global marketplace. Special emphasis is placed on the following areas: multinational business environments, varying levels of technology, finance, trade issues, politics, and cross-cultural dynamics.

Select four courses from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6290</td>
<td>Macroeconomics and International Environments of Business</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6080</td>
<td>Networks, Innovation, and Value Creation</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6390</td>
<td>International Operations</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6550</td>
<td>Marketing Research</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6730</td>
<td>Technological Change and International Competitiveness</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 7500</td>
<td>Managing Supply Networks</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 7700</td>
<td>International Negotiations</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 7710</td>
<td>Cultural Environment of International Business</td>
<td>3</td>
</tr>
</tbody>
</table>

Management Information Systems
This specialization is designed for professionals responsible for achieving competitive advantage through the integration of information technology into organizations. The specialization courses use an interdisciplinary approach to the practices and methodologies of systems analysis, design, development, and integration and evaluation of information technology into business functions and processes.

Select four courses from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 6140</td>
<td>Information Systems for Management</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6170</td>
<td>Advanced Systems Analysis and Design</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6180</td>
<td>Strategic Information Systems Management</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6750</td>
<td>Legal Aspects of E-Business and Information Technology</td>
<td>3</td>
</tr>
<tr>
<td>MGMT 6810</td>
<td>Management of Technical Projects</td>
<td>3</td>
</tr>
</tbody>
</table>

Dual Master's Programs
The dual degree option offers students the opportunity to receive two master’s degrees in a shorter period of time than if the degrees were pursued independently. The objective is to combine technical expertise in information technology, engineering, or computer science by obtaining an M.S. degree in one of these disciplines with an M.S. in Management or an MBA degree.

The dual MBA/M.S. option allows the student to concurrently complete both degrees by taking a total of 72 credit hours (the MBA alone is 51 credits). The dual M.S./M.S. option allows the student to complete both degrees by taking a total of 54 credit hours (the M.S. in Management alone is 30 credits).

Upon acceptance to both programs, students confer with academic advisers in both disciplines to determine their Plans of Study. The Plans of Study are submitted for both degree programs and separate diplomas reflect a degree in each discipline.

Students should contact their adviser for the name of the dual degree faculty coordinator.

The Capstone Course Requirement
The Capstone course requirement for the MBA program is satisfied by students taking the required course MGMT 6840 Practicum Management.
Special Graduate Opportunities

International Scholars Program
The International Scholars Program (ISP) is a 10-week intensive educational experience at the graduate level that includes four-week-long visits to Rome, Italy, and Shanghai, China, for a total of eight weeks abroad. It is offered during summer term. The 12- or 15-credit-hour course load can be used as part of a number of degrees at the Master’s level, mainly in the Schools of Management and Engineering. It can be used as part of a co-terminal degree.

The ISP has two tracks to choose from: (1) Global Enterprise Management, and (2) Energy Systems Engineering. Each track includes nine credit hours of course work and a three-credit-hour project. Many projects have corporate sponsorship, and numerous site visits and local guest speakers are integrated with the curriculum. Rensselaer Professors travel with the students and interact often with them in both classroom and informal settings.

Some degrees that can incorporate the ISP are: Master of Business Administration, M.S. in Management, M.Eng. in Mechanical Engineering, the M.Eng. in Environmental Engineering, and the M.Eng in Systems Engineering & Technology Management. The department offering the targeted degree should be contacted for further information.

Course Descriptions
Courses directly related to all Management curricula are described in the Course Description section of this catalog under the department code MGMT.
The realm of science is a constantly growing and expanding field. Today, more and faster than ever before, new and exciting discoveries are augmenting human knowledge of this world and the vast reaches beyond it. As always, Rensselaer faculty and graduates are leading the way in making many of these important discoveries.

Science and mathematics have been at the heart of Rensselaer since its founding, and most important to maintaining this tradition has been the Institute’s commitment to anticipating and generating advancements in all aspects of these fields. Curricula are constantly reviewed and revised to incorporate new discoveries and knowledge. Emphasis is placed on undergraduate research.

Today, Rensselaer prepares students for a wide variety of careers in the firmly established areas of mathematics and the natural sciences while forging ahead to develop excellent new programs in the emerging field of information technology and Web science. Curricula in bioinformatics and molecular biology and information technology and Web science are meeting the high demand for scientists in these areas. The Center for Biotechnology and Interdisciplinary Studies is emphasizing additional research in these fields, as will Rensselaer’s dedication to attracting leaders in this field to its faculty.

Indeed, the School of Science faculty consists of some of the world's most highly educated and accomplished scientists. Included among them are a Nobel laureate and two National Academy members. In addition, many are fellows in their professional societies, and all have achieved the highest attainable degree in their fields.

At Rensselaer, this esteemed faculty works closely with undergraduates through both instructional and research programs. Rensselaer has a long-standing commitment to undergraduate teaching, and Rensselaer professors have authored some of the most widely used science and mathematics textbooks.

At the graduate level, Rensselaer’s School of Science offers opportunities to conduct research in a wide range of areas. These include applied mathematics; astrophysics; biocomputation; biophysics; the chemistry and physics of electronic, optical, and structural materials; bioorganic and biophysical chemistry; environmental science; earth science; mathematical modeling; parallel computation; networking; pervasive computing; computer imaging and vision; scientific computation; and data science.

Enhancing these research opportunities are the many Rensselaer facilities that expose students to highly advanced equipment and technology. Among the Institute’s state-of-the-art computational and laboratory equipment are supercomputers for high speed computation, experimental computer network facilities, an electron microprobe for surface analysis, molecular beam epitaxy for growing innovative electronic and optical materials, and automated X-ray facilities for studying the structure of crystals. Also impressive are Rensselaer’s terahertz imaging capabilities and computer vision and robotics laboratories. The Center for Biotechnology and Interdisciplinary Studies houses state-of-the-art instrumentation for biomedical research.

The research activities of many School of Science faculty members are conducted within Rensseler’s major interdisciplinary research centers, including the Center for Integrated Electronics (CIE), the Nanotechnology Center, the Scientific Computation Research Center (SCOREC), the Computational Center for Nanotechnology Innovations, and the Center for Social and Cognitive Networks.

Also providing unique opportunities for students are a number of School of Science administered research centers. These include the Margaret A. and David M. Darrin ’40 Fresh Water Institute, the New York State Center for Polymer Synthesis, the New York Center for Astrobiology, the Rensselaer Exploratory Center for Cheminformatics Research, the Center for Terahertz Research, the Center for Inverse Problems at RPI, and the Baruch ’60 Center for Biochemical Solar Energy Research. These centers engage graduate and undergraduate students alike in leading-edge research activities.
These centers complement the programs offered through the six departments within the School of Science. These departments are Biology, Chemistry and Chemical Biology, Computer Science, Earth and Environmental Sciences, Mathematical Sciences, and Physics, Applied Physics, and Astronomy. Additionally, the school administers the interdisciplinary Information Technology and Web Science Program and offers a full complement of interdisciplinary degree programs such as Biochemistry/Biophysics that are described in detail under Interdisciplinary Degree Programs later in this section and in the Information Technology and Web Science section of this catalog.

Degrees Offered and Associated Departments

- **Applied Mathematics**
- **Applied Physics**
- **Applied Science**
- **Astronomy**
- **Biology**
- **Biochemistry/Biophysics**
- **Bioinformatics and Molecular Biology**
- **Chemistry**
- **Computer Science**
- **Environmental Science**
- **Geology**
- **Hydrogeology**
- **Interdisciplinary Science**
- **Mathematics**
- **Multidisciplinary Science**
- **Natural Sciences**
- **Physics**

The School of Science prepares students for a broad range of careers in natural science, computer science, and mathematics, as well as in such diverse areas as management, technological communication, and industry or government agencies, or for graduate studies that may include medical, dental, or law school. The school’s educational goals for all of these students are to give them:

- a broad background in their particular field.
- working knowledge of modern research and technological tools.
- preparation for a lifetime of learning and discovery as both individuals and part of a team.

Students may attain these goals through a variety of majors offered within the six School of Science departments or through interdisciplinary degree programs offered in biochemistry/biophysics, bioinformatics and molecular biology, and environmental science. A major in interdisciplinary science is also available to students wishing more breadth in their program. Additionally, the Information Technology and Web Science program offers students the opportunity to explore computing and information system development in the context of a student chosen application domain. For more details on this program see the Information Technology and Web Science section of this catalog.

All programs offer a large number of electives so that students can emphasize their areas of interest, select a dual major or one or more minors, or study a wide range of topics in addition to obtaining a strong background in their major field of study.

Selection of a major within the School of Science may take place at any time during the first year of study or during the admissions process. Students who are uncertain of their major may enter as undeclared science and may defer their choice of major until the second year. With the exception of programs requiring joint admission outside the School of Science, the choice of any approved curriculum within the school is guaranteed.

Advanced placement credit or credit for courses taken in the higher level International Baccalaureate program is possible in those areas where examinations are given. Transfer students are welcome; formalized agreements exist with several community colleges so that students who have followed specified curricula in the community college will have all the standard freshman and sophomore requirements of the science departments at Rensselaer. Students transferring from other colleges will receive credit depending on the courses taken.
Core Program in Science for All Students

All Institute undergraduate students are required to complete a core program in science. As part of this program, students must take a minimum of 24 credit hours in physical, life, and engineering sciences, including at least eight credit hours of mathematics. No more than one course of the science core may be taken as Pass/No Credit. No courses graded S/U may be used to satisfy the science core.

Any of the courses with the following course codes meet the physical, life, and engineering sciences requirement: ASTR (Students majoring in the School of Science cannot combine two-credit Astronomy courses to satisfy a Science Elective), BCBP, BIOL, CHEM, CISH, CSCI, ERTH, MATH, MATP, PHYS. In addition, the following courses also meet these requirements:

- ENGR 1100 (as Science not Mathematics)
- ENGR 1600
- ENGR 2090
- ENGR 2250
- ESCE 2100
- IENV 4500 (cross-listed as ERTH 4500)
- IENV 4700
- ISCI 4500

Other courses may fulfill this requirement and will be reviewed by the science core curriculum adviser (currently the acting dean of science) on a case-by-case basis. A number of upper-level courses in several engineering disciplines satisfy the requirement, but generally students taking these courses have enough prerequisites that the science requirement would already have been satisfied.

Transferring Credit Towards the Science Core

Students entering Rensselaer as first-year students may transfer up to two science courses (up to eight credit hours) toward satisfying their science core requirement. Other science and mathematics courses may be transferred as free electives.

Students who have taken advanced placement or the International Baccalaureate higher level exams may be granted credit for all such mathematics and science courses depending on their scores.

Transfer students from an accredited collegiate program may qualify for transfer of additional credits toward satisfying their science core requirement at the discretion of the science core curriculum adviser (currently the associate dean of science).

Students enrolled at Rensselaer who wish to take a science course at another accredited institution must obtain prior approval for the course from the science core curriculum adviser. To apply for approval, a student must furnish a catalog description of the proposed course and a completed copy of Rensselaer’s transfer credit approval form to the science core curriculum adviser.

Baccalaureate Programs in Science

Students entering as freshmen may pursue Bachelor of Science degrees in applied physics, bioinformatics and molecular biology, biology, biophysics/biochemistry, chemistry, computer science, environmental science, geology, hydrogeology, interdisciplinary science, mathematics, and physics. A bachelor’s program that combines Information Technology and Web Science with a concentration in mathematics or science is also available.

Additional degree options are available in astronomy, biochemistry, biophysics, computing in chemistry, engineering chemistry, geophysics, operations research, polymer science, mathematics of computation, and many others. In these options, students choose courses from a list to make a coherent program of several courses in the same area.

A B.S. in any of these curricula requires between 124 and 128 credit hours.

A minimum of 46 credit hours in science is required for a B.S. degree in science. These must include BIOL 1010, Introduction to Biology (or an approved alternate life sciences course), MATH 1010, Calculus I, MATH xxxx, (a second four credit Mathematics course chosen from MATH xxxx or MATP xxxx), and PHYS 1100, Physics I. A course from at least one other science discipline is also required. Each curriculum also requires a three- or four-credit culminating experience taken in the senior year.

Each curriculum also offers an option that allows a student to receive up to four hours of course credit for an out-of-classroom experience. Students may exercise this option more than once. This out-of-classroom experience should have intellectual content relevant to the student’s educational or career goals. Appropriate experience might include an individual or group research project (on or off campus), an independent study project, a cooperative education assignment, a public service internship, or study abroad. A written proposal and a final written report must be submitted for evaluation to the faculty member designated by each curriculum. This course option may be included in the courses required for the major.
Additional opportunities for undergraduate science students are dual majors and minors. Flexible curricula make dual majors possible between all science majors. In addition, School of Science students may also arrange a dual major in science and humanities, arts, or social science or science and management. While the more structured architecture and engineering curricula make dual majors in these areas more difficult, students with advanced placement or advanced standing may be able to satisfy the requirements for dual degrees in these areas. Computer Science and Computer Engineering is a frequently selected dual major.

Students also frequently take minors in one of the science programs or in other Rensselaer programs ranging from philosophy to management to engineering. Minor programs are available in each of the sciences and mathematics, as well as in environmental science and biochemistry/biophysics. Consult the individual department or program descriptions for details of minor programs.

**Special Undergraduate Opportunities**

**Accelerated Programs**

**Accelerated Physician-Scientist** The School of Science offers an accelerated physician-scientist program in cooperation with Albany Medical College. Students in this program are recruited directly from high school.

**Accelerated Bachelor of Science–Doctor of Philosophy** An accelerated B.S./Ph.D. program leading to both degrees in six to seven years is possible in all departments and doctoral degree programs within the School of Science. Students apply by invitation to this program after their first year of study at Rensselaer. Selections are made after an interview with Deans of the School. Students participate in research rotations with faculty and select a prospective Ph.D. thesis adviser by the start of their third year of study. They have the opportunity for Darrin Undergraduate Research Fellowships during their undergraduate summers. Students maintain undergraduate status until completion of all requirements for an undergraduate degree. With satisfaction of all program requirements, including excellent overall GPA and initiation of thesis research with the adviser, they transition to graduate status.

**Accelerated Science-Law** In cooperation with Albany Law School, Rensselaer offers a unique program leading to the B.S. and Juris Doctor (J.D.) in six years rather than the usual seven. Admission to this program is restricted. For Albany Law School, most students are admitted as incoming first-year students. Selected applicants must meet the admission requirements of Albany Law School of Union University. Thus a prospective science-law student may be able to assure admission to law school prior to beginning an undergraduate career at Rensselaer. Transfer from other Rensselaer curricula to this program is limited to students who have demonstrated academic excellence. Although guaranteed admission to Albany Law School is only available to selected first-year students, conditional admission is available to accepted Rensselaer students who meet specified achievement levels in their undergraduate program. Students should notify the undergraduate science core curriculum adviser before the end of the sophomore year of a desire to be nominated.

**Undergraduate Research Experience**

At Rensselaer, involving undergraduates in real-world research is of paramount importance. Through the Undergraduate Research Program (URP), described in the Educational Programs and Resources section of this catalog, undergraduates work directly with faculty and/or graduate students on projects requiring critical inquiries. These studies involve exciting areas of leading-edge technological research and have the potential to result in groundbreaking discoveries. Involvement in URP's can be arranged strictly for the experience, for credit, or for pay. Students apply through direct contact with faculty seeking students via their Web site or campus advertisements.

**Cooperative Education**

Students may augment their academic course work with on-the-job experience through the Cooperative Education program. Studies and work assignments are scheduled after consultation with the curriculum adviser. Although many co-op students complete their academic program in four years, some delay graduation for a semester or year to obtain additional work experience. Additional information on Rensselaer’s cooperative education programs can be found in the Student Life section of this catalog under the Center for Career and Professional Development heading.

**Study Abroad/Exchange Programs**

Rensselaer offers a number of study abroad/exchange programs that are open to the student body as a whole. For more information on these Institute-wide programs, see the Educational Programs and Resources section of this catalog.
Overview of Graduate Programs

Rensselaer’s greatest strength—the interface between science and engineering—is a unique feature that particularly benefits graduate students by providing a wide and unique variety of research areas. Graduate students are key to the Rensselaer’s ability to remain in the forefront of research and education in the sciences and to apply its research findings to needs of society.

Graduate students are the focus of personal attention and professional mentoring as they enter and develop their programs of study. A graduate adviser guides each student by assisting in the formation of a suitable program to meet individual needs and interests. Courses may be pursued for special purposes, as well as be applied to programs leading to a Master of Science or a Doctor of Philosophy degree.

Recognizing that the divisions between basic science disciplines and specializations within particular sciences are not distinct, the School has developed many interdisciplinary programs. These programs allow for greater flexibility and situations in which research in one area may serve advanced degree requirements in another. This is especially evident in such areas as applied mathematics with an emphasis on modeling and analysis. Other examples include: bioinformatics that spans biology, chemistry, computer science, and mathematics; materials science stressing electronic, optical, polymeric, and structural materials; environmental research in the Margaret A. and David M. Darrin ’40 Fresh Water Institute; the New York Center for Astrobiology; advanced computation in the areas of software, databases, and parallel computation; research into terahertz radiation for innovative imaging and sensing; research at the Center for Inverse Problems to find objects and their properties that cannot be measured directly; and research at the Center for Social and Cognitive Networks to better understand how people exploit social computing networks to accomplish goals.

Many science students and faculty also participate in Institute-wide research activities including composite materials, integrated electronics, design, manufacturing productivity, robotics, etc. Still others participate in co-op programs with industry. For details on graduate cooperative education opportunities, contact the Center for Career and Professional Development.

Numerous School of Science graduate students hold teaching assistantships, research assistantships, and fellowships while pursuing their degrees. Upon leaving Rensselaer with an advanced degree in mathematics or science, graduates easily find positions with corporations and government facilities or obtain postdoctoral and faculty positions at the most prestigious universities.

Master’s Programs

The School of Science offers Master of Science (M.S.) degrees in all of its individual departments. In addition, it offers master’s programs in applied science and in multidisciplinary science. For more information and specific details on these degree programs, see the Interdisciplinary Programs and Research section within the School of Science section of this catalog.

Doctoral Programs

Each School of Science department offers programs of doctoral study, and the Ph.D. is awarded in biochemistry and biophysics, biology, chemistry, computer science, geology, mathematics, and physics. Additional doctoral degree options are also available in a variety of special programs including astrophysics, surface science, mathematical programming, operations research, polymer science, and multidisciplinary science. These programs are a testament to Rensselaer’s commitment to encouraging study programs that cross disciplines within departments and even Institute schools. Detailed information on such programs follow within the School of Science Interdisciplinary Programs and Research section of this catalog.
Biology

Head: Susan P. Gilbert

Graduate Admissions Coordinator: Jody Malm

Department Home Page: http://www.rpi.edu/dept/bio

Biology has been undergoing revolutionary changes in recent decades. Many problems once handled only descriptively are now analyzed at the molecular level using powerful combinations of biochemical, biophysical, genetic, molecular, structural, and computational tools. Rensselaer faculty have developed undergraduate and graduate programs to train students for the biological challenges of the future including new basic research paradigms, applied biomedical research, as well as challenges in healthcare, environmental sustainability, and resource management. The theory and practice of biological sciences today arises from a mechanistic understanding of life. Thus, biology is built on a foundation of chemistry, physics, and mathematics. The undergraduate biology curriculum, therefore, trains students in the fundamentals of the life sciences, as well as the chemistry and physics underlying life processes. Upper division students choose areas of interest for more specialized study. This curriculum can be used to prepare students for professional training in research or medicine, applied biology, or industry. Programs of study in biology may also be combined with specific options in biochemistry, biomedical engineering, bioinformatics, biophysics, biotechnology (genetic engineering), chemical engineering, computer science, environmental sciences, management, mathematics, microbiology, and technical communications.

Research and Innovation Initiatives

Biochemistry and Biophysics

The study of fundamental problems in modern biochemistry and molecular biochemistry employ a variety of advanced techniques. Faculty members work on many exciting problems that span the disciplines of cell biology, physiology, and structural biology. For example, research in these areas include investigations such as how muscle is organized to power locomotion and how variation between muscle fiber types is generated; structure/function relations of myosin and kinesin using molecular biology and genetic techniques; study of functional dynamics of proteins and protein design; the application of nuclear magnetic resonance (NMR) spectroscopy to study important problems in neuroscience and aging, e.g. Alzheimer’s disease, the most common senile dementia, plus theoretical and experimental approaches to the study of protein-protein interactions and rational protein design using fluorescence microscopy and x-ray crystallography.

Bioinformatics and Molecular Biology

Research in bioinformatics and molecular biology includes both computational work and applications using molecular genetic approaches. Algorithms are being developed for sequence alignment, structural bioinformatics, phylogenetic analysis and hypothesis driven molecular simulations. Massively parallel computer clusters are being used to carry out large scale molecular dynamics simulations, to mine large genomic data sets and to design novel proteins. Gene manipulations are used to engineer proteins for further biophysical characterization, leading to a better understanding of the forces that hold proteins together.

Microbiology and Ecology

In this program, faculty and their students are conducting ecological, molecular, and genetic studies. Both basic and applied research projects are available, sometimes within the same laboratory. Ecological studies include freshwater ecology and biotransformation of organic compounds. Molecular studies include work on nitrogen fixing symbiotic bacteria and bacteria living in the environment using recombinant DNA technology, and overlap in some cases with genetic studies of prokaryotes and eukaryotes. Vibrio cholerae the agent of the disease cholera, is indigenous in aquatic environments which serve as the reservoir for infection of humans. Studies are aimed at understanding the physiology and biochemistry that gives Vibrio cholerae the ability to propagate through the external environment. In addition, the Darrin Fresh Water Institute at Lake George is well-equipped for studies in microbial ecology. A semester of study at Lake George is offered as part of the curriculum.

Cell and Developmental Biology

Research in this area comprises in vivo studies in model organisms and studies on vertebrate cultured cells. Three undergraduate laboratory courses that teach basic research techniques in these areas are available, and students are encouraged to work in faculty research labs upon completion of one of these courses. These faculty labs utilize molecular and/or genetic approaches in their studies of many biological problems. Examples of research areas include the biochemical control of cytoskeletal organization, microtubule dynamics, cell polarity, and cell differentiation in epithelial and neuronal cells; signal transduction during normal development and during tumor cell migration; stem cell growth and regulation in the context of tissue engineering; the genetic control of tissue remodeling in normal developmental contexts; and the molecular mechanisms controlling aging.

Interdisciplinary Programs

See also Biochemistry/Biophysics, and Bioinformatics and Molecular Biology, under the Interdisciplinary Programs and Research section.
Faculty*

Professors

Boylan, C.W.—Ph.D. (University of Wisconsin); microbial ecology, physiological effects of starvation on microorganisms.

Dordick, J.—Ph.D. (Massachusetts Institute of Technology); biochemical engineering, enzyme technology, bioseparations.

Garcia, A.E.—Ph.D. (Cornell University); mathematical and computational analysis in cellular and molecular biology.

Gilbert, S.P.—Ph.D. (Dartmouth College); structure and mechanisms of microtubule-based molecular motors involved in cell motility and microtubule dynamics.

Lindhardt, R.—Ph.D. (John Hopkins University); medicinal chemistry and biocatalysis, carbohydrate chemistry.


Nierzwicki-Bauer, S.A.—Ph.D. (University of New Hampshire); plant molecular biology, subsurface microbiology.

Plopper, G.—Ph.D. (Harvard University); signal transduction in tumor cell biology and tissue engineering.

Roy, H.—Ph.D. (The Johns Hopkins University); plant molecular biology and biochemistry.

Royer, Catherine—Ph.D. (University of Illinois at U-C); protein interactions in vitro and in live cells, regulation of gene expression, advanced microscopy, protein folding, high pressure.

Research Professors

Bedard, D.—Ph.D. (University of Chicago); environmental microbiology and ecology, microbial molecular biodegradation of halogenated aromatics.

Lister, B.—Ph.D. (Princeton University); ecology, statistical methods, undergraduate education.

Associate Professors

Barquera, B.—Ph.D. (National Autonomous University of Mexico); bioenergetics of Vibrio cholerae.

Bystroff, C.—Ph.D. (University of California, San Diego); bioinformatics, computational biology and protein design.

Gorby, Y.—Ph.D. (University of New Hampshire); electromicrobiology, microbial physiology, bioprocess engineering and bioremediation.

Hanna, M.H.—Ph.D. (University of Illinois); directed evolution of proteins, scientific teaching.

Koffas, M.—Ph.D. (Massachusetts Institute of Technology) metabolic engineering, synthetic biology, industrial microbiology, natural products.

Ligon, L.A.—Ph.D. (University of Virginia); neurobiology, cytoskeleton and motor proteins, microtubule/cortex interaction.

Swank, D.—Ph.D. (University of Pennsylvania); muscle physiology and motor protein biophysics.


Assistant Professors

Collins, C.—Ph.D. (California Institute of Technology); synthetic biology, biochemical engineering, microbial communities, human microbiome, protein engineering directed evolution, biofilms.

Maxwell, P.M.—Ph.D. (Syracuse University); aging, mechanisms and consequences of genome instability, retrotransposons.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Professors Emeritus

Diwan, J.J.—Ph.D. (University of Illinois); cell physiology, bioenergetics.

Ehrlich, H.L.—Ph.D. (University of Wisconsin); microbial ecology, biotransformation and biodegradation of natural polymers and pesticides, biotechnology.

McDaniel, C.N.—Ph.D. (Wesleyan University); plant development and cell culture.

Parsons, R.H.—Ph.D. (Oregon State University); cellular physiology, epithelial transport.

Pfau, C.J.—Ph.D. (Indiana University); molecular biology of animal viruses, antiviral drugs.

Associate Professor Emeritus

Clersceri, L.S.—Ph.D. (University of Wisconsin); microbial ecology, biotransformation and biodegradation of natural polymers and pesticides, biotechnology.

Adjunct Faculty

Bawa, R.—Ph.D. (Rensselaer Polytechnic Institute); biochemistry, microbiology, biotechnology, nanotechnology and pharmaceutical patent law.

Belfort, M.—Ph.D. (University of California-Irvine); molecular genetics; biotechnology; infectious disease.

Khodajakov, A.—Ph.D. (Moscow State University); cell cycle, mitosis, centrosome assembly and function.

Rieder, C.—Ph.D. (University of Oregon, Eugene); mitosis, cell cycle regulation.

Undergraduate Programs

Undergraduate students may pursue either a baccalaureate program or an accelerated degree program. Both of these degree programs will receive further explanation within this catalog.

Baccalaureate Programs

The undergraduate curriculum in biology is designed to prepare students for admission to graduate or professional school or to enter the workplace. Recognizing that flexibility is essential for students with specific interests and goals other than those spelled out in the traditional curricula, it is designed to leave many options open to the student. The following is a sample biology curriculum, completion of which requires a minimum of 128 credit hours.
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<tr>
<th>FIRST YEAR</th>
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<tr>
<td><strong>Fall</strong></td>
<td><strong>Credit Hours</strong></td>
<td><strong>Spring</strong></td>
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<tr>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
<td>CHEM 2120</td>
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<tr>
<td>CHEM 1110</td>
<td>Chemistry I with Advanced Lab</td>
<td>Chemistry II</td>
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<td>MATH 1010</td>
<td>Calculus I</td>
<td>MATH 1020</td>
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<td><strong>Fall</strong></td>
<td><strong>Credit Hours</strong></td>
<td><strong>Spring</strong></td>
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<tr>
<td>BIOL 2500</td>
<td>Genetics and Evolution</td>
<td>CHEM 4620</td>
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<tr>
<td>CHEM 2230</td>
<td>Organic Chemistry Laboratory I</td>
<td>Organic Chemistry Laboratory II</td>
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<td>CHEM 2250</td>
<td>Organic Chemistry I</td>
<td>CHEM 2260</td>
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<td>PHYS 1100</td>
<td>Physics I</td>
<td>PHYS 1200</td>
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<td><strong>Credit Hours</strong></td>
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<tr>
<td>BIOL 4760</td>
<td>Molecular Biochemistry I</td>
<td>HASS Elective</td>
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<td>BIOL Biology Elective</td>
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<th>FOURTH YEAR</th>
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<td><strong>Fall</strong></td>
<td><strong>Credit Hours</strong></td>
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<tr>
<td>BIOL - Advanced Lab¹</td>
<td>4</td>
<td>BIOL - Culminating Experience²</td>
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<tr>
<td>BIOL - Biology Elective</td>
<td>4</td>
<td>BIOL - Biology Elective³</td>
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Electives

Required courses are indicated in the template. Careful selection of biology electives and technical electives in the third and fourth years may contribute significantly to preparation for various professional goals. Technical electives include any pertinent courses in biology, other sciences, or mathematics.

¹ Chosen from one of the following three courses: BIOL 4710, BIOL 4720, or BIOL 4740. All three courses are communication intensive.

² Chosen from one of the following BIOL courses: 4020, 4060, 4260, 4750, 4860, 4900, 4940, 4970, 4980, 4330, or one can fulfill this requirement by taking BCBP 4310. For BIOL 4060, 4940, 4970, see course descriptions for restrictions on CE credit.

³ One of the biology electives can be chosen from any of the following classes: CHEM 2440, CHEM 4300, CHEM 4350, any BCBP course except BCBP 4760, or any Biology course.

Note: Only four credits from the following courses are allowed as biology electives: BIOL 4940 - Readings in Biology, BIOL 4979 - Non-thesis Research and BIOL 4990 - Senior Research Thesis.
Students who anticipate working on a senior thesis are strongly urged to take one of the advanced laboratory courses (BIOL 4710, BIOL 4720, BIOL 4740) in their junior year, since these courses offer excellent preparation for independent laboratory work and meet the communication intensive requirement.

**Concentrations**

Technical and free electives may be chosen to provide a concentration in biochemistry, bioinformatics, biomedical engineering, biophysics, biotechnology (genetic engineering), chemical engineering, computer science, environmental science, management, mathematics, microbiology, psychology, or technical communication. Program advisers should be consulted.

**Accelerated Programs**

The Biology Department offers highly motivated students the opportunity to combine undergraduate and graduate study to reduce the number of years spent in academic study. The Accelerated Physician Scientist Program (B.S.-M.D., seven years) leads to a B.S. from Rensselaer and the M.D. degree from Albany Medical School. The Department also offers accelerated B.S.-Ph.D. and B.S.-M.S. Programs. The coterminal B.S.-M.S. Program requires application by the end of the Junior Year, and students must have completed 90 credits and have a GPA of 3.2 to apply. To receive the M.S., students must complete an additional 30 credit hours of course work beyond that required for the B.S. and must meet all the requirements for the M.S. in Biology.

**Physician-Scientist**

This accelerated biomedical program leads to the B.S. degree from Rensselaer and the M.D. degree from Albany Medical College (AMC). Through this program, both degrees can be obtained within seven calendar years, including some summers.

Admission to the biomedical program is limited to individuals who have not yet initiated full-time undergraduate study and who display the motivation, maturity, and intellectual capacity necessary to pursue this accelerated course of study. Rensselaer conducts initial reviews and then forwards applications of candidates meeting the Institute’s program standards to Albany Medical College for further review. Only those applicants with uniformly superior academic credentials and the highest test scores are invited to the required interview at Albany Medical College. Some experience or demonstrated interest in biological or biomedical research during high school is considered as a factor in admission. The interview process assesses the applicant’s motivation for medicine, level of maturity, and level of personal development.

The biomedical program seeks and admits students without discrimination based on race, religion, color, gender, age, or handicap as defined in the Rehabilitation Act of 1973, or national or ethnic origin. Ordinarily, admission to the program is limited to citizens of the United States. Candidates must complete secondary school with superior scholastic credentials. Course work must include four years of English, one year each of physics, chemistry, and biology, and mathematics through calculus. The SAT with writing and the SAT Subject Tests, or the ACT with writing will be accepted in fulfillment of test requirements for students applying for the seven-year accelerated physician-scientist program. These students must complete their tests by the December test date. The SAT Subject Tests are required in Mathematics (Level 1C or 2C) and science (biology, chemistry, or physics). Scores of tests taken thereafter will not be considered. Preferably, secondary school applicants will have taken these tests in the spring preceding application. Applications must be filed and completed prior to November 1, which is earlier than application for normal admission.

Provided that the student maintains satisfactory standards of academic achievement, admission leads automatically to entrance into Albany Medical College after three years of study at Rensselaer (six semesters). A minimum grade point average of 3.50 (overall GPA and science/math GPA) is required each semester at Rensselaer. At the completion of the third fall semester, a minimum grade point average of 3.50 is required both in overall course work and in science/math for promotion to the medical portion of the curriculum. For students with AP credit for both Calculus I and II, a third math course of your choosing must be taken. Having additional quantitative course work at the college level is important in this program. All course work at Rensselaer must be satisfactorily completed before beginning the fourth year of study at Albany Medical College. A grade of D or F in any science course generally requires immediate transfer out of this program. Grades of I (Incomplete) are not accepted without justification involving illness or specific course structure. When an Incomplete is granted, the course work must be completed no later than one month after the last day of the examination period of the semester in which the incomplete was received.

Promotion to the medical portion of the curriculum is based not only on academic achievement, but also on the fitness of the student to enter the profession of medicine. Students may transfer into Rensselaer’s regular four-year undergraduate program at any time during the premedical portion of the biomedical program. The three years of Rensselaer study include a sound basis in the physical sciences, an introduction to the major concepts and principles of biology and biological research, and ample opportunity to become acquainted with the humanitie, arts, and social sciences. Students in the biomedical program will take 24 courses at Rensselaer over the three years. During the third summer (the transition between Rensselaer and Albany Medical College), students continue with research projects begun while at Rensselaer. These research projects will be completed during the fourth summer while at Albany Medical College. Students should plan on spending eight weeks of full time study during the summers. Biology course credit will be given for the two courses taken during the third summer and five additional preclinical courses taken at Albany Medical College to complete the undergraduate requirements for the B.S. degree.
Since many biomedical students will enter Rensselaer with advanced placement credit, a large proportion will have undergraduate course work credit in excess of standard requirements. These advanced placement credits will allow them to take advanced or additional course work, but cannot be used to decrease the length of time allotted to their undergraduate experience or to decrease the number of courses prescribed in the curriculum. All courses specifically named in the curriculum must be taken at Rensselaer, or given AP credit, or transferred in from courses taken prior to admission at Rensselaer. After completing the fourth year of the program, students receive a B.S. degree from Rensselaer. The M.D. degree is received at the end of the seventh year and is dependent upon completing all requirements for the B.S. degree. Requests for further information and applications for admission to this program should be addressed to the Office of Undergraduate Admissions, Rensselaer Polytechnic Institute, 110 8th Street, Troy, New York 12180-3590.

SEVEN-YEAR ACCELERATED PHYSICIAN-SCIENTIST PROGRAM

### ACADEMIC YEAR I

<table>
<thead>
<tr>
<th>Fall - Credits: 16</th>
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<tbody>
<tr>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
</tr>
<tr>
<td>CHEM 1100</td>
<td>Chemistry I</td>
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<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
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<tr>
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<tbody>
<tr>
<td>BIOL 2120</td>
<td>Introduction to Cell and Molecular Biology</td>
</tr>
<tr>
<td>CHEM 1200</td>
<td>Chemistry II</td>
</tr>
<tr>
<td>MATH 1020</td>
<td>Calculus II</td>
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<tbody>
<tr>
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<tr>
<td>CHEM 2230</td>
<td>Organic Chemistry Laboratory I</td>
</tr>
<tr>
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<td>Organic Chemistry II</td>
</tr>
<tr>
<td>PHYS 1100</td>
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<tr>
<td>BIOL 4620</td>
<td>Molecular Biology</td>
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<tr>
<td>BIOL 4760</td>
<td>Molecular Biochemistry I</td>
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<tr>
<td>BIOL 4090</td>
<td>Seminal Developments in Biomedical Research</td>
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<td>BIOL 4100</td>
<td>From Neuron to Behavior</td>
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<tr>
<td>BIOL 4250</td>
<td>Developmental Biology</td>
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<tr>
<td>BIOL 4980</td>
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1 Culminating experience and curriculum specific communications intensive course.
COURSES TRANSFERRED FROM ALBANY MEDICAL COLLEGE

Summer III

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Academic Year IV

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<tr>
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<tr>
<td>Musculoskeletal System</td>
<td>6</td>
</tr>
<tr>
<td>Nervous System</td>
<td>6</td>
</tr>
<tr>
<td>Cardiovascular System</td>
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<tr>
<td>Gastrointestinal System</td>
<td>4</td>
</tr>
<tr>
<td>Acid/Base &amp; Renal System</td>
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</table>

Total Credit Hours: 30

Minor Programs

The Biology Department offers a minor in Biology. Biology and BCBP majors may elect to complete minors in other disciplines.

Biology Minor

Program Requirements

Students may complete a minor in biology by passing Biology 1010 or its equivalent and 16 additional credits in Biology. Only a total of four credits can come from the following list: Biology 2900, 2930, 4020, 4050, 4060, 4330, 4900, 4940, 4970, 4980, 4990.

Astrobiology Minor for Biology Majors

Program Requirements

This multidisciplinary minor is open to students majoring in Biology or in other disciplines. To complete this minor, students must take ASTR 4510 and ISCI 4500, four credits each, and two semesters of the one-credit course ISCI 4510. Two additional courses outside the major field of study must be selected from the following:

<table>
<thead>
<tr>
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<tbody>
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<td>CHEM 2250</td>
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</tr>
<tr>
<td>CHEM 4810</td>
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<tr>
<td>ENVE 2110</td>
<td>4</td>
</tr>
<tr>
<td>ENTH 4540</td>
<td>4</td>
</tr>
</tbody>
</table>

Additional Information

The requirement that the two selected courses must be outside the major field of study is reduced to one in the case of a double major, provided both majors are in primary relevant areas of study (i.e., biology, chemistry, geology, and physics).

Graduate Programs

The biology research laboratories at Rensselaer are equipped for graduate study and projects in Biochemistry & Biophysics, Bioinformatics & Computational Biology, Biotechnology, Cancer Biology, Cell Biology & Cell Signaling, Microbial Ecology, Yeast Genetics, Geomicrobiology & Environmental Biology, Stem Cell Biology and Structural Biology. In addition, cooperative programs with other organizations provide a wider range of research possibilities. Rensselaer's Darrin Fresh Water Institute at Lake George offers a program on lake ecosystem analysis involving field, laboratory, and computer analysis of biological, chemical, and physical data. An active program in biochemistry and biophysics is jointly sponsored with the Chemistry, Physics, Mathematics, and Chemical Engineering Departments. Students must complete a core curriculum and pass a qualifying exam. During the first year students must complete three laboratory rotations with different faculty as part of their research training. Qualified students are required to take a candidacy examination at the end of year two in their special area of interest and proceed to the Ph.D. under the guidance of the candidacy committee. The detailed curriculum is tailored to the student's background and special interests.

* Integral part of the program but not transferred back to Rensselaer for credit.
Master’s Programs

Thirty credit hours of course work are necessary to complete the M.S. program with at least half of the courses at the 6000 level, with the remainder at the 4000 level. Courses from other departments may be applied to the Plan of Study, but at least half of the courses must be listed in Biology (BIOL) or Biochemistry-Biophysics (BCBP). In order to graduate, the student must complete a four- to nine-credit M.S. thesis or project. An individual program of study must be designed in consultation with a faculty adviser and approved by the Office of Graduate Education.

Doctoral Programs

Candidates for the Ph.D. must satisfy the requirements of the Graduate Program Oversight Committee (GPOC), pass the qualifying exam, and pass a candidacy exam. The latter consists of a written and an oral portion, and should be taken by the end of the second year of full-time study. A degree candidate also must submit a dissertation based on an original research project. The program requires a high level of performance in selected courses and research, and the students report their findings each year of full-time study. Additionally, all doctoral candidates are required to participate in teaching for one academic year under the supervision of a faculty member. The student thus gains experience should he or she select an academic career. Seventy-two credit hours are required for the Ph.D.

Course Descriptions

Courses directly related to all Biology curricula are described in the Course Description section of this catalog under the department code BIOL or BCBP.

Chemistry and Chemical Biology

**Head:** Curt M. Breneman  
**Associate Head:** Ronald A. Bailey  
**Undergraduate Program Contact:** Gerald M. Korenowski  
**Graduate Program Contact:** Peter Dinolfo or Sharon Gardner  
**Department Home Page:** [http://www.rpi.edu/dept/chem/index.html](http://www.rpi.edu/dept/chem/index.html)

The Department of Chemistry and Chemical Biology provides courses and programs of study that reflect the central role of chemistry in the science and technology of tomorrow. In addition to a strong focus in the traditional areas of chemistry, including analytical, biological, inorganic, organic, and physical, the department offers courses and research programs in the rapidly developing frontiers of modern science. These areas include biochemistry, biophysics and biotechnology, materials and polymer chemistry, nanotechnology and medicinal chemistry. The department offers programs leading to the B.S., M.S., and Ph.D. degrees in chemistry, as well as a minor in chemistry.

Chemistry instruction is delivered in Walker Laboratory, which houses state-of-the-art classrooms and laboratories, and in Cogswell Laboratory, the site of the majority of the department’s research activities. Undergraduate laboratories provide students with hands-on experience with equipment similar to that found in industrial and research laboratories. Chemistry research laboratories are found in the Cogswell Laboratory, the New York State Center for Polymer Synthesis, the nearby Science Center, and the Center for Biotechnology and Interdisciplinary Studies.

Research Innovations and Initiatives

**Analytical Chemistry**

Research in the broadly defined area of analytical chemistry includes new approaches to chemical and biological separation, detection, and quantitation. Projects include: protein and DNA analysis that extends to genomics, proteomics, glycomics, metabolomics, biomarker discovery and abiotic routes to the molecules of early life on earth; chemical and chiral separations; characterization of novel materials for applications in biotechnology and nanotechnology; characterization of novel organized media formed by molecular self-assembly; molecular probe techniques for studying molecular conformation and interactions; non-traditional approaches to discovery of aptamers and related affinity reagents. Techniques employed in the various projects include mass spectrometry, spectroscopic techniques including fluorescence, absorption and circular dichroism, surface plasmon resonance, imaging techniques such as AFM, STM, SEM, TEM and confocal fluorescence microscopy, and separation techniques including HPLC and capillary electrophoresis.
Biochemistry, Biophysical Chemistry, and Biotechnology
Pathways on the primitive earth for the origin of RNA are under investigation as part of the activities of the New York Center for Astrobiology. The goal of this research is to determine if the RNA formed by proposed prebiotic pathways has catalytic activity, a requisite for the first life on earth. Photosynthetic electron transport and biological energy transduction are studied by electron spin resonance and time-resolved optical and electroabsorption spectrosopies. Biochemical and biophysical research also focuses on the mechanisms of protein folding and aggregation, protein folding defects related to human diseases, and the molecular structures of proteins, including amino acid sequence determination and identification of protein post-translational modifications. Carbohydrate biochemistry and glycomicrobiology are used to understand disease processes and to develop new therapeutic agents. The biochemical aspects of biotechnology including chemo-enzymatic synthesis, biocatalysis, and metabolic engineering are being explored. The methodologies used include kinetic and spectroscopic analysis (NMR, fluorescence, circular dichroism, surface plasmon resonance (SPR) and FTIR of protein conformational changes), molecular modeling, computational graphics, and molecular mechanics calculations on peptides and proteins. New methods for the separation of biopolymers are being developed. A new initiative in carbohydrate chemistry is centered on the computer design and organic synthesis of carbohydrates with novel functionalities and non-natural architectures.

Inorganic Chemistry and Solid-State Chemistry
Inorganic chemistry involves the preparation and investigation of substances that include coordination complexes, metalloenzymes, organometallic compounds and inorganic solids with extended network structures. Projects include synthesis and characterization of molecular catalysts for artificial photosynthesis, synthesis and growth of thin film materials for molecular based solar cells and nanochemistry involving the synthesis and study of metallic and ceramic nanoparticles.

Organic Chemistry and Medicinal Chemistry
Active areas of synthetic organic and medicinal chemistry research include the design and synthesis of novel agents to treat cocaine addiction, carbohydrate-based cardiovascular anti-infection and anti-cancer agents, and novel anticoagulant and antithrombotic drugs. The development of molecular modeling programs that evaluate intermolecular electrostatics may result in the deeper understanding of enzyme-substrate interactions.

Photochemistry
Studies of the systems involved in photosynthesis carried out as part of the activities of the Baruch '60 Center for Biochemical Solar Energy Research are providing exciting insights into possible bio-solar energy production mechanisms. The atmospheric chemistry of Jupiter and Titan (Saturn’s largest moon), and the role of photochemical reactions of purines and of possible prebiotic gases are being studied to elucidate the role of photochemistry in transformations that led to biological molecules on the primitive earth. Photochemical processes used for the generation of polymer thin films, for the photoimaging of lithographic resists, and for novel polymerization processes are also being developed.

Polymer Chemistry and Materials Chemistry
Synthetic and development efforts are under way in the field of sustainable polymers, high-performance thermally stable polymers, fuel cell polymer membranes, block copolymers, and photosensitive thermosets and thermoplastics. Novel synthetic and biorenewable-monomers and methods for their synthesis are being studied with an emphasis of green chemistry. New approaches to polymer preparation and modification, including photochemical, photo-electroinitiated, transition metal catalyzed, and vapor-deposition polymerization and recyclable catalysts are also under study. Other studies include electrospinning of nanofiber polymer composites as electrical components and for biomedical and controlled release applications and natural polymers including polysaccharides in materials applications. Polymers are characterized by means of gel permeation chromatography, visometry, differential scanning calorimetry, scanning and transmission electron microscopy, atomic force microscopy, and confocal Raman microscopy. Polymerization processes are being investigated from the aspect of mechanistic organic chemistry.

Surface Science
Topics of current research interest include the study of surface interfacial tensions of liquids and liquid-liquid systems with and without surface-active solutes present. Molecular structure and orientation of liquid and solid surfaces and surface films are being studied through state-of-the-art laser spectrographic techniques. Structure and composition of films with environmental importance on lake and ocean surfaces are also under investigation by direct and remote sensing methods.

Cheminformatics, Computational Chemistry, and Molecular Modeling
New methods of computational chemistry are being developed at Rensselaer to better elucidate the relationships between the structure of molecules and materials and their observable properties. Specialized methods such as the Transferable Atom Equivalent (TAE) and PESD techniques have allow predictive models to be created that are capable of making accurate predictions of the properties of new compounds or materials prior to their synthesis. These techniques have been developed using novel machine learning techniques (Multiple-Instance Ranking) as part of the Rensselaer Exploratory Center for Cheminformatics Research (RECCR), which is dedicated to advancing the field of Cheminformatics and increasing the availability of new methods to the Cheminformatics, Materials Informatics and Medicinal Chemistry user communities.
Research Facilities and Equipment
Department research facilities are housed in Cogswell Laboratory and the attached New York State Center for Polymer Synthesis, with other laboratories in the nearby Center for Biotechnology and Interdisciplinary Studies (CBIS) and the Science Center. A variety of modern instruments is available in individual laboratories and in the department’s Major Instrument Facility, which provides state-of-the-art equipment for nuclear magnetic resonance and other techniques. This equipment, serviced and operated by a professional staff, is available to all researchers in the department. Other instruments available for research include NIR, visible, UV, fluorescence, atomic absorption, surface plasmon resonance and FTIR spectrophotometers, GC and HPLC equipment, electrochemical equipment, ESR spectrometers, DSC, DTA, TGA, and TMA instruments for thermal studies, and X-ray fluorescence and diffractometer instruments. Researchers also may have access to the extensive CBIS instrument facilities.

Faculty*

Professors
Bae, C.—Ph.D (University of Southern California); organic and polymer chemistry.
Bailey, R.A.—Ph.D. (McGill University); coordination chemistry and chemistry of molten salts.
Breneman, C.M.—Ph.D. (University of California, Santa Barbara); physical organic chemistry.
Crivello, J.V.—Ph.D. (University of Notre Dame); polymer chemistry.
Korenowski, G.M.—Ph.D. (Cornell University); laser spectroscopy, surface science.
Linhardt, R.T.—Ph.D. (John Hopkins University); carbohydrate chemistry, medicinal chemistry and biocatalysis.
McGown, L.B.—Ph.D. (University of Washington); analytical and bioanalytical chemistry.
Moore, J.A.—Ph.D. (Polytechnic Institute of Brooklyn); synthesis and reactions of polymers.
Wentland, M.P.—Ph.D. (Rice University); medicinal chemistry.

Research Professors
Ferris, J.P.—Ph.D. (Indiana University); prebiotic chemistry, origins of life.
Wiedemeier, H.A.—D.Sc. (University of Munster); high-temperature and solid-state chemistry, computational analysis of defect structures in solids.

Associate Professors
Colon, W.—Ph.D. (Texas A&M University); biophysical chemistry.
Ryu, C.Y.—Ph.D. (University of Minnesota); polymer physical and materials chemistry.

Assistant Professors
Barquera, B.—Ph.D. (National Autonomous University of Mexico); (joint appointment with Biology); bioenergetics, sodium metabolism, biochemistry/biophysics.
Dinolfo, P.—Ph.D. (Northwestern University); inorganic chemistry, materials chemistry, physical chemistry.
Kempf, J.—Ph.D. (California Institute of Technology); biophysical chemistry, NMR spectroscopy, biodynamics.
Lakshmi, K.—Ph.D. (Massachusetts Institute of Technology); biophysical chemistry; energy and signal transduction, pulsed EPR and solids NMR spectroscopy.
Platt, M.—Ph.D. (University of Virginia) bioanalytical chemistry, mass spectrometry, proteomics.
Wang, C.—Ph.D. (Cornell University); (joint appointment with Biology) NMR spectroscopy, neuroscience and aging.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
**Adjunct Faculty**

Bello, S.C.—M.D. (SUNY Downstate Medical Center); general chemistry, biochemistry.

Ding, X.—Ph.D. (University of Michigan); molecular genetics.

Sprague, E.—Ph.D. (Rensselaer Polytechnic Institute); physical chemistry.

**Undergraduate Programs**

The Department of Chemistry and Chemical Biology offers a variety of opportunities to undergraduate students, ranging from four-year and accelerated degree programs to dual majors, minors, and specialization programs.

**Baccalaureate Programs**

The B.S. in Chemistry curriculum is designed to meet the recommendations of the American Chemical Society Committee on Professional Training. At the same time, it provides ample opportunity for students to select electives that permit them to specialize in particular fields, to explore areas of potential interest, or to take unusual combinations of courses that will suit nontypical career goals. The program emphasizes hands-on laboratory experience in the second and third years, and provides extensive opportunities to participate in research. Besides allowing students to prepare for careers that demand a good background in science and mathematics, the curriculum also offers a sound basis for careers in fields such as law, the health professions, management, and technical communication.

For students transferring from other universities, two-year colleges, or from other curricula at Rensselaer, previous chemistry courses will be evaluated on an individual basis. Normally, these courses will count toward the Rensselaer program. The content of laboratory courses can be adjusted to allow for prior experience. The department makes every attempt to accommodate transfer students whose backgrounds do not permit them to follow the normal course sequence.

**FIRST YEAR**

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<tr>
<td>MATH 1010 Calculus I</td>
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<tr>
<td>PHYS 1100 Physics I</td>
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<tr>
<td>CHEM 1200 Chemistry II</td>
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<td>MATH 1020 Calculus II</td>
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<td>PHYS 1200 Physics II</td>
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**SECOND YEAR**

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<tbody>
<tr>
<td>CHEM 2110 Equilibrium Chemistry and Quantitative Analysis</td>
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<tr>
<td>CHEM 2120 Experimental Chemistry I: Analytical Techniques</td>
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<td>CHEM 2250 Organic Chemistry I</td>
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<tr>
<td>MATH 2400 Introduction to Differential Equations</td>
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<table>
<thead>
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<tbody>
<tr>
<td>BIOL 1010 Introduction to Biology</td>
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<tr>
<td>CHEM 2030 Inorganic Chemistry I</td>
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<td>CHEM 2260 Organic Chemistry II</td>
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1 ENGR 1600 may be substituted for CHEM 1200 by students transferring into Chemistry.
### THIRD YEAR

**Fall**

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<td>CHEM 4020</td>
<td>Experimental Chemistry III: Inorganic and Physical Methods</td>
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<tr>
<td>CHEM 4410</td>
<td>Macroscopic Physical Chemistry</td>
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<tr>
<td>CHEM 4760</td>
<td>Molecular Biochemistry 12</td>
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**Spring**

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<td>CHEM 4120</td>
<td>Experimental Chemistry IV: Physical and Instrumental Methods</td>
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<td>Microscopic Physical Chemistry</td>
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<td>Microscopic Physical Chemistry</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### FOURTH YEAR

**Fall**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 4950</td>
<td>Senior Experience</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Senior Experience</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Electives</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Professional Development Seminar</td>
<td>1</td>
</tr>
</tbody>
</table>

**Spring**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 4620</td>
<td>Introduction to Polymer Chemistry</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Electives</td>
<td>13</td>
</tr>
</tbody>
</table>

### Additional Information

Twenty-eight of these total 128 credit hours required for graduation are completely free electives. Students should select electives in consultation with the adviser to give a balanced program. Some HASS courses can be deferred until the senior year to allow for earlier electives.

Students planning to pursue graduate studies in Chemistry are recommended to take at least 12 credits in Chemistry courses beyond those required. Research experience such as through CHEM 2950 or URP activities is particularly valuable.

### Electives

Combinations of electives that can provide appropriate depth in specific areas such as environmental chemistry, medicinal chemistry, polymer chemistry, chemical engineering, management, pre-law, and others can be provided by the adviser. Students interested in medicine as a career should include the following courses among their elective choices. They are recommended before the senior year as preparation for the qualifying exams required for admission to medical school. In addition, two communications courses should be included among Humanities, Arts, and Social Sciences elective options.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 2120</td>
<td>Introduction to Cell and Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4270</td>
<td>Human Physiology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4620</td>
<td>Molecular Biology</td>
<td>4</td>
</tr>
</tbody>
</table>

### Dual Major Programs

Students interested in both chemistry and another field may use the elective course options in one program to take the required courses from another discipline to qualify for a dual degree. Examples are a B.S. in chemistry and biology, or chemistry and physics, or chemistry and economics. Combinations with any other science or HASS discipline are usually easy to arrange, but students should seek counsel from their advisers.

### Minor Programs

The department offers a number of minor options for both chemistry and nonchemistry majors. In addition to the science minors detailed in this catalog, chemistry majors may minor in other disciplines through programs offered within other departments.

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2 CHEM 4310 may be substituted for this course.
Chemistry Minor
Students must pass 20 credits of courses bearing the CHEM prefix, at least 16 of which must be at or above the 2000 level, and two of which must be laboratory.

In all Chemistry minor programs, independent study, project, or research courses will be acceptable only with special permission.

In addition to CHEM courses required in their major, students must take:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2030</td>
<td>Inorganic Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 2110</td>
<td>Equilibrium Chemistry and Quantitative Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

Astrobiology Minor for Chemistry Majors
The Biology, Biochemistry and Biophysics, Chemistry and Chemical Biology, Earth and Environmental Sciences, and Physics Departments participate in a multidisciplinary minor in Astrobiology for students majoring in these or other disciplines. To be eligible for the minor, students must pass the three-credit course ASTR 4510 Origins of Life - A Cosmic Perspective and at least two semesters of the one-credit seminar course ISCI 4510; they must also undertake a four-credit research project on a topic related to Astrobiology under the supervision of a faculty member engaged in Astrobiology research in one of the above departments; finally, they must complete a further two courses outside the major field of study selected from the following:

Program Requirements
This multidisciplinary minor is open to students majoring in Chemistry or in other disciplines. To complete this minor, students must take ASTR 4510 and ISCI 4500, four credits each, and two semesters of the one-credit course ISCI 4510. Two additional courses outside the major field of study must be selected from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR 2050</td>
<td>Introductory Astronomy and Astrophysics</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4620</td>
<td>Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4760</td>
<td>Molecular Biochemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 2250</td>
<td>Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 4810</td>
<td>Chemistry of the Environment</td>
<td>4</td>
</tr>
<tr>
<td>ENVE 2110</td>
<td>Introduction to Environmental Engineering</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 4540</td>
<td>Organic Geochemistry</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Any course in BCBP</td>
<td>4</td>
</tr>
</tbody>
</table>

Additional Information
The requirement that the two selected courses must be outside the major field of study is reduced to one in the case of a double major, provided both majors are in primary relevant areas of study (i.e., biology, chemistry, geology, and physics).

Chemistry Minor for Non-Chemistry Majors

Chemistry Minor for BCBP Majors:
In addition to CHEM courses required in their major, students must take one three- or four-credit CHEM course, plus:

<table>
<thead>
<tr>
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<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2030</td>
<td>Inorganic Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 2110</td>
<td>Equilibrium Chemistry and Quantitative Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

Chemistry Minor For Biology Majors:
In addition to CHEM courses required in their major, students must take:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2030</td>
<td>Inorganic Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 2110</td>
<td>Equilibrium Chemistry and Quantitative Analysis</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 2440</td>
<td>Physical Chemistry for Life Sciences</td>
<td>4</td>
</tr>
</tbody>
</table>

Chemistry Minor For Chemical Engineering Majors:
In addition to CHEM courses required in their major, students must take:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2030</td>
<td>Inorganic Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 4620</td>
<td>Introduction to Polymer Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 4760</td>
<td>Molecular Biochemistry I</td>
<td>4</td>
</tr>
</tbody>
</table>
Chemistry Minor for Majors in Other Disciplines
Students must pass 20 credits of courses bearing the CHEM prefix, at least 16 of which must be at or above the 2000 level, and two of which must be laboratory.

In all Chemistry minor programs, independent study, project or research courses will be acceptable only with special permission.

Special Undergraduate Opportunities

Accelerated Programs
Students may elect to complete their B.S. degree in three years instead of four. To achieve this, they must take courses during the summer semesters and additional electives. Students with advanced placement standing in some courses are especially well situated for such arrangements. It is also possible for those not wishing to remain in Troy over the summer to take equivalent courses elsewhere and receive transfer credit.

An additional option is completion of the requirements in three and a half years. With advanced placement credit and additional courses during some academic semesters, summer work may be minimal.

B.S.-M.S. and B.S.-Ph.D. Programs
The co-terminal B.S.-M.S. program allows students in the spring of the junior or fall of the senior year to apply for admission into a program that continues undergraduate support for a fifth year, at the end of which they can receive both the B.S. and M.S. degrees. Because the M.S. degree in Chemistry requires a research thesis, this is most practical for students who already have a strong undergraduate research background.

The accelerated B.S.-Ph.D. program of the School of Science allows highly motivated students who carry out significant research as undergraduates to apply this toward their graduation thesis in a mentored program that can lead to the Ph.D. degree three years after the B.S. degree.

Students contemplating an accelerated program must consult with their adviser early in their careers.

Undergraduate Research Programs
Chemistry majors at all levels are encouraged to participate in the research program of the department. Research may be taken for credit or supported financially through the Institute URP program and from faculty research funds. Participation may be during academic semesters or in the summer. A senior research experience is required of all majors.

Graduate Programs
The Department of Chemistry and Chemical Biology offers two graduate degrees—the Master of Science, and the Doctor of Philosophy. The M.S. and the Ph.D. require research and a thesis.

Graduate students are expected to show basic knowledge in the areas of analytical, inorganic, organic, physical, and bio-chemistry through placement examinations or courses. Each student's course requirements are determined individually by the results of the placement examinations, background, and area of interest. Common course requirements for all students in the first year are Perspectives in Chemistry, Introduction to Mass Spectrometry, Nuclear Magnetic Resonance Spectroscopy, and, if supported by a teaching assistantship, Chemistry Teaching Seminar. In consultation with the adviser, students may select a number of specialized advanced-level courses in chemistry as well as offerings that meet their needs in other departments as they plan a program to meet individual professional goals.

The department has well-developed research programs not only in the traditional areas of chemistry, but also in interdisciplinary areas that transcend traditional boundaries and that foster collaborative work with other departments. There are extensive collaborations among Chemistry, Chemical Engineering, and Materials Science and Engineering in the areas of polymers/bio/nano/materials, and collaborative programs with Biology, Computer Science, Physics, and Mathematical Sciences Departments, and the School of Engineering and the Center for Integrated Electronics. These, and off-campus collaborations which include Albany Medical College, the University at Albany, and the New York State Wadsworth Laboratories provide essential connections between Chemistry and other areas vital to modern society. Cooperative programs with industry, national laboratories, and other universities are also part of the department's research activities. Faculty members, visiting scholars, postdoctoral associates, graduate students, and undergraduates all participate in the research efforts of the department.

Supplementing courses and research projects are weekly seminars and colloquia in the various areas of chemistry. Scientists of national and international renown participate in these seminars.

Most first-year graduate students receive support as teaching assistants, usually participating in undergraduate chemistry courses under the direction of a faculty member. After they have chosen a research adviser graduate students are eligible for support as research assistants.
Master’s Programs

Master of Science
Students must complete 30 credit hours of research and course work, 15 of which must be at the 6000–9990 level. In addition, these students must submit a research thesis.

Doctoral Programs
To complete the Ph.D., students must meet institutional and departmental requirements including an oral candidacy examination and a final defense of the doctoral thesis and accumulate 72 credit hours beyond the B.S. degree (of which 48 credits must be taken while in residence at Rensselaer) of research and course work. For any Ph.D. degree, the courses required will be specified based on the student’s background and research needs.

Course Descriptions
Courses directly related to all Chemistry curricula are described in the Course Description section of this catalog under the department code CHEM.

Computer Science

Head: Jim Hendler
Home Page: http://www.cs.rpi.edu/

Computer science is the study of the design, analysis, communication, implementation, and application of computational processes. The core subjects of this discipline include software systems (such as operating systems and networks) and programming languages (including design and other language translation tools). They also include computer hardware systems, the design and analysis of data structures and algorithms, and the theoretical basis of computation, in particular the complexity of computation. In addition to these core subjects, various application areas are open to students, including artificial intelligence, computer graphics, databases, semantic web, knowledge representation and reasoning, scientific and numeric computation, computer vision, cyberinfrastructure, data mining, robotics, computational finance, parallel and distributed systems, and social networking.

At Rensselaer, education in computer science prepares students for solving applied real-world problems and for conducting research in computer science. The program provides students with a solid grounding in both theory and practice. The undergraduate program also provides a rigorous background in mathematics and science.

Rensselaer's Computer Science Department has its own well-equipped laboratories for instruction and research. The general use lab in Amos Eaton consists of 20 PCs running Unix. The Cisco Academy program has a lab with over 200 Cisco networking devices, enabling students to experiment with networking in an environment similar to real-world conditions.

The department has a number of labs with specialized computer architectures to support the department’s research. Computationally intensive applications benefit from our computing clusters, consisting of more than 300 CPUs. Data intensive research efforts can make use of high-speed interconnects utilizing technologies such as Myrinet, Infiniband, or 10Gb Ethernet, as well as file servers with many petabytes of storage. Combined with numerous specialized equipment for computer vision, robotics, and tetherless computing research, the Computer Science Department at Rensselaer offers an ideal environment for students to participate in a variety of research activities.

Students involved in research can also use specialized computers in other departments, such as high-speed graphics workstations, computers for image processing, and massively parallel computers for large-scale computation. One of the most prevalent of these is an IBM Blue Gene supercomputer, which provides more than 70 TeraFLOPS of computing power and is among the fastest supercomputers in the world.
Research Innovations and Initiatives

Bioinformatics
Bioinformatics is the science of managing, retrieving, analyzing, and interpreting biological data. Research is being carried out on such topics as multiple sequence alignment, sequence assembly, protein and RNA structure prediction, and regulatory networks. Research also spans emerging areas, including microarray data analysis, high-dimensional indexing, database support, information integration, and data mining.

Computational Geometry
Current research in computational geometry concentrates on algorithms for the reconstruction of smooth geometric objects from their samples. Problems of interest include characterizing the conditions on sampling density, which allows a curve to be reconstructed from its samples. The reconstruction is homeomorphic and sufficiently close to the original and the algorithms developed to achieve the reconstruction. Also involved are the dependence of such algorithms on the dimension of the embedding space, related algorithms for the reconstruction of surfaces and manifolds, and finding the most concise representation of a manifold in terms of its samples. A second research track focuses on applications of computational geometry, particularly in robotic motion planning.

Computer Graphics
The faculty and students in the Computer Graphics Research Group are interested in a wide variety of rendering, geometry, simulation, and visualization problems motivated by computer games, special effects in movies, architectural design and pre-visualization, and many other exciting applications. Research topics include physically-based digital sculpting, efficient high-quality photo-realistic rendering, new data representations and algorithms, and the use of modern graphics hardware for interactive applications.

Computational Finance
The Computational Finance group applies its research to diverse areas, including computational finance, bioinformatics, networks of social and selfish agents, and design of multi-agent systems.

Computational Science and Engineering
Students and faculty work on computational approaches and algorithms to solve large-scale problems that arise in natural science and engineering. Current research includes adaptive methods for solving partial differential equations, scientific software libraries, algorithms for medical imaging and tomography, high-performance matrix algorithms, computational biology, and algorithms for high-performance, parallel, and distributed computation.

Computer Vision
Computer vision research in the Computer Science Department focuses on developing and applying computer vision techniques to address problems in image-based environmental monitoring. Applications include determining the distribution of species and individual animals, identifying the presence of invasive species, and monitoring ecosystem health. Within the context of this important application domain, a range methods is studied, including illumination modeling, segmentation, tracking, and, most importantly, recognition.

Data Mining; Machine and Computational Learning; Algorithms for Massive Data Sets
This research area focuses on the theoretical and applied aspects of automated information extraction (knowledge discovery) from data. For large data sets, emphasis is placed on developing efficient, scalable, and parallel algorithms for various data mining techniques in addition to the data management itself. Examples include association rules, classification, clustering, and sequence mining. For small data sets, the emphasis is on robust computational learning systems (supervised, unsupervised, and reinforcement) and their theoretical properties. Application areas include combinatorial optimization, computational biology (bioinformatics, computational genomics), web mining, geographic information systems, and computational finance.

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Database Systems
This research area focuses on efficient and effective methods for storing, querying, analyzing, mining, and maintaining data from possibly disparate and heterogeneous resources. Data is used in many different applications, from scientific data sets, sensor data, images, video, and audio to hypertext documents, biological data, and data on stock market behavior. Research focuses on methods for caching data, querying large and distributed databases, database mining, and supporting such applications as computer-aided design and manufacturing, bioinformatics, and collaborative engineering.
Pervasive and Network Computing
Pervasive computing foresees a world in the not-so-distant future in which computer systems are embedded in everything, from personal digital assistants to implanted biological devices, to bridge-monitoring systems, and to teams of robots deployed into a collapsed building to locate survivors. Untethered—wireless—communication is constant and, in many cases, so automated that human intervention is not needed. Wireless broadband community systems inexpensively bring people together for virtual town meetings, video doctor-patient conferences, and online business transactions. Computers in automobiles share information on congestion, quickly computing alternate routes. The promises are immense, but the challenges are formidable. Computer science faculty cover the broad area of pervasive and network computing. This research includes investigation of computer networks and their protocols, security of computers and networks, and distributed and parallel system optimization and simulations.

Programming Languages and Software Engineering
The Programming Languages and Software Engineering research group investigates programming models, languages, concepts, methodologies, and tools to enable the development of correct, efficient, reliable, and maintainable software.

Robotics
The primary goal in the field of robotics is to create machines that are physically capable, either alone or in groups, of performing useful tasks, such as the assembly of a car or the picking and washing of fruit. To build such robots, robotics research focuses on robot mobility, environmental sensing and perception, the mechanics of manipulation, motion planning and control, and both physical and social aspects of human-robot interaction. The robotics research group studies these problems from theoretical and computational perspectives, and also experimentally in the Computer Science Robotics Lab that is fully equipped with state-of-the-art equipment.

Semantic Web
As semantic technologies have been gaining momentum in various e-Science areas (for example, W3C's interest group for semantic web health care and life science), it is important to offer semantic-based methodologies, tools, and middleware to facilitate scientific knowledge modeling, logical-based hypothesis checking, semantic data integration and application composition, integrated knowledge discovery and data analyzing for different e-Science applications. Partially influenced by the Artificial Intelligence community, Semantic Web researchers have largely focused on formal aspects of semantic representation languages or general-purpose semantic application development, with inadequate consideration of requirements from specific science areas. What is required is the development of a multi-disciplinary field to foster the growth and development of e-Science applications based on the semantic technologies and related knowledge-based approaches.

Social and Cognitive Networks
In studying social and cognitive networks, in which people interact over a variety of means, research is focused on identifying fundamental properties of networks, the processes underlying their evolution, and the paradigms for network engineering to enhance their efficiency, reliability, robustness, and other desirable properties. In particular, the research concentrates on models and algorithms of community creation and evolution, building and measuring trust in social networks, impact of mobility on network formation, dependencies between social, information, and communication networks, spread of opinions and ideologies among network nodes, and cognitive models of net-centric interactions.

Theory
Theory of computation provides the foundation needed for effective applications in computer science. The theory group brings together researchers in many different areas to develop novel approaches and solutions to problems in information technology. The theory group research is characterized by close collaboration with researchers in diverse application areas, including networking, bioinformatics, visualization, pattern recognition in physics and astronomy, digital library, data mining, distributed computing, and experimental algorithmics.

Web Science
Since its inception, the World Wide Web has fundamentally changed the ways in which people work, play, communicate, collaborate, and educate. There is, however, a growing realization among researchers across a number of disciplines that without new research aimed at understanding the current evolving and potential Web, we may be missing or delaying opportunities for new and revolutionary capabilities. To model the Web, it is necessary to understand the architectural principles that have provided for its growth. Looking into the future, to be sure that it supports the basic social values of trustworthiness, personal control over information, and respect for social boundaries, a research agenda must be pursued that targets the Web and its use as a primary focus of attention. This research requires powerful scientific and mathematical techniques from many disciplines to explore the modeling of the Web from network- and information-centric views.
Faculty*

Professors

Berman, E.—Ph.D. (University of Washington); cyberinfrastructure, data preservation and access, e-science, and high performance and grid computing.

Carothers, C.—Ph.D. (Georgia Institute of Technology); parallel and distributed systems; simulation; networking and real-time systems.

Goldberg, M.K.—Ph.D (Institute of Mathematics, Novosibirsk, Russia); experimental analysis of optimization algorithms; combinatorics and graph theory; applications to social networks.

Hardwick, M.—Ph.D. (Bristol University, U.K.); database systems for engineering and manufacturing applications.

Hendler, J.—Ph.D. (Brown University); artificial intelligence, semantic web, agent based computing, high performance processing.

Magdon-Ismail, M.—Ph.D. (California Institute of Technology); theory, algorithms and applications of machine learning; computational finance; learning from networked data (social networks, hyperlinked networks, etc.).

McGuinness, D.L.—Ph.D (Rutgers University); knowledge representation and reasoning, explanation, proof, trust, ontologies, semantic web, semantic eScience, linked data.

Spooner, D.—Ph.D. (Pennsylvania State University); database systems, database security, computer science and information technology education.

Stewart, C.—Ph.D. (University of Wisconsin); computer vision with applications in ecology, medicine, and zoology.

Szymanski, B.K.—Ph.D. (National Academy of Sciences, Warsaw, Poland); network science, computer and sensor networks; distributed and parallel computing.

Trinkle, J.C.—Ph.D. (University of Pennsylvania); robotics, manufacturing automation, game physics engines, multibody dynamics.

Yener, B.—Ph.D. (Columbia University); complex networks, bioinformatics, medical informatics, security and privacy, computer networks, combinatorial optimization.

Zaki, M.—Ph.D. (University of Rochester); data mining and knowledge discovery; bioinformatics; graph mining; high performance computing.

Clinical Professor

Myers, J.D.—Ph.D. (University of California, Berkeley); high performance computing, data intensive computing, cyberinfrastructure, semantic e-science, community-scale research coordination, e-learning, industrial competitiveness.

Associate Professors

Adali, S.—Ph.D. (University of Maryland); trust, social network analysis, information integration, information retrieval, database systems.

Anshelevich, E.—Ph.D. (Cornell University); theory and algorithms, especially for large decentralized networks; strategic agents in networks and algorithmic game theory; approximation algorithms.

Cutler, B.—Ph.D. (Massachusetts Institute of Technology); computer graphics, geometry processing algorithms; design tools for architecture.

Drineas, P.—Ph.D. (Yale University); design and analysis of algorithms, in particular randomized and approximation algorithms; linear algebra algorithms and their applications in data mining.

Krishnamoorthy, M.S.—Ph.D. (Indian Institute of Technology); programming environments; design and analysis of combinatorial algorithms; performance issues in Internet; analysis of Web documents; network visualization.

Milanova, A.—Ph.D. (Rutgers University) software engineering, programming languages, compilers, program analysis, software testing, verification, reliable software systems.

Varela, C.A.—Ph.D. (University of Illinois at Urbana-Champaign); concurrent programming models and languages, adaptive scalable distributed computing, computational science applications, data science.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Research Associate Professors

Luciano, J. — Ph.D. (Boston University); knowledge representation, semantic web, semantic e-science, translational medicine, collaborative science, ontology evaluation, semantic and computational applications to health care and life science, bio-ontologies, computational medicine, computational biology, and systems biology.

Newberg, L. — Ph.D. (University of California, Berkeley); algorithmic, statistical, and mathematical combinatorics approaches to computational molecular biology; currently using cross-species DNA multiple alignments for phylogeny and the detection of conserved regions.

Clinical Assistant Professor

Kotfila, D.A. — M.Div. (Yale University); advanced routing and switching protocols; network security.

Executive Officer

Goldschmidt, D.E. — Ph.D. (Rensselaer Polytechnic Institute); operating systems; systems programming; algorithms; network programming; software engineering; database systems; computer science education.

Professors Emeritus

Flaherty, J.E. — Ph.D. (Polytechnic University of Brooklyn); scientific computation; adaptive and parallel solution techniques; numerical analysis.

Glinert, E. — Ph.D. (University of Washington); assistive technology; universal access; human-computer interaction; multimedia information visualization.

McNaughton, R. — Ph.D. (Harvard University); automata theory, formal languages, combinatorics of words.

Musser, D. — Ph.D. (University of Wisconsin); programming methodology; generic software libraries; formal methods of specification and verification; mechanized logic and proof methodology, applied to correctness and optimization of abstract algorithms.

Rogers, E. H. — Ph.D. (Carnegie Mellon University); collaborative computing; group operating systems; modeling paradigm; software engineering.

Joint Appointments with Earth and Environmental Sciences—Professor

Fox, P. — Ph.D. (Monash University, AU); semantic web, semantic e-science, data intensive science, virtual observatories, virtual organizations, data grids, high performance computing, visualization, collaborative science, sensor web, environmental informatics, solar-terrestrial physics, solar variability.

Joint Appointments with Mathematical Sciences—Professors

Bennett, K. — Ph.D. (University of Wisconsin-Madison); mathematical programming, optimization, machine learning, data mining, support vector machines, and application of data mining to bioinformatics, cheminformatics, finance, science and engineering.

Isaacson, D. — Ph.D. (New York University); mathematical computational problems arising in the diagnosis and treatment of heart disease and breast cancer in medical imaging and physics.

McLaughlin, H.W., II — Ph.D. (University of Maryland); applied geometry; computational geometry; complex systems.

Joint Appointments with Electrical, Computer, and Systems Engineering—Professors

Franklin, W.R. — Ph.D. (Harvard University); computational cartography; computational geometry; computer graphics; geographic information science; computer security.

Gerhardt, L.A. — Ph.D. (State University of New York at Buffalo); digital signal processing (voice and image processing); communication systems; brain computer interfacing; integrated inspection; personnel verification and identification using biometrics.

Wozny, M.J. — Ph.D. (University of Arizona); computer graphics; computer-aided geometric design; information systems in engineering design and manufacturing.

Joint Appointment with Mechanical, Aerospace, and Nuclear Engineering—Professor

Shephard, M. — (Cornell University); scientific computation, mesh generation, adaptive and parallel finite element methods.
Joint Appointment with Cognitive Science—Professors

Bringsjord, S.—Ph.D. (Brown University); artificial intelligence, specifically including: logical, mathematical, and philosophical foundations of AI; AI and creativity; reasoning-based systems for homeland defense/intelligence analysis; automated reasoning; automatic story generation and narrative control; intelligent tutoring systems (for teaching logic and logic-based programming).

Gray, W.—Ph.D. (University of California – Berkeley); integrated cognitive systems, computational cognitive modeling, cognitive social science, cognitive engineering; interested in basic and applied research that leads to understanding the interplay of natural interaction in routine human-human, human-machine, and human-information interactive behavior.

Joint Appointment with Science and Technology Studies – Professor

Eglash, R.—Ph.D. (University of California, Santa Cruz); HCI; Simulation of cultural designs; fractals and complexity; IT for STEM education.

Joint Appointment with Biology—Associate Professor

Bystroff, C.—Ph.D. (University of California, San Diego); bioinformatics, protein design, biosensors, crystallography.

Undergraduate Programs

The undergraduate degree program in computer science provides an excellent background for students entering the work force directly upon graduation and for those pursuing graduate studies. Students majoring in computer science study such topics as artificial intelligence, computer graphics, theory of computation, operating systems, robotics, data mining, databases, network programming, parallel computing, and scientific numerical computing. A graduating computer science major will:

• be an expert software developer, with knowledge of several programming languages and paradigms;
• have a solid understanding of the mathematical and theoretical underpinnings of computer science;
• be able to express himself or herself well both orally and in written form;
• understand current computing technologies and be prepared to quickly adapt to new technological developments.

Computer Science

All computer science students are assigned a faculty adviser to assist them with their interests and career goals throughout their academic career. As the typical 128-credit-hour B.S. curriculum leading to the B.S. in computer science shown below exhibits, flexibility is a hallmark of the Rensselaer computer science program. Students may explore related areas and pursue minors and/or dual or double majors in such fields as mathematics, electrical engineering, computer engineering, games and simulation arts and sciences, management, psychology, and electronic media, arts, and communication.

FIRST YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>CSCI 1100</td>
<td>Computer Science I</td>
<td></td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
<td></td>
</tr>
<tr>
<td>PHYS 1100</td>
<td>Physics I</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td></td>
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<td></td>
<td></td>
<td>4</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
<td></td>
</tr>
<tr>
<td>CSCI 1200</td>
<td>Data Structures</td>
<td></td>
</tr>
<tr>
<td>MATH 1020</td>
<td>Calculus II</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

1 Students with sufficient background in computer science may skip CSCI 1100 and replace it with at least three credits of other CSCI courses at the 200 level or above.
## SECOND YEAR

**Fall**
- CSCI 2200 Foundations of Computer Science ........................................ 4
- CSCI 2500 Computer Organization ..................................................... 4
- HASS Elective ........................................................ 4
- Mathematics/Logic Option ......................................................... 4

**Spring**
- CSCI 2300 Introduction to Algorithms ................................................ 4
- Mathematics/Logic Option ......................................................... 4
- HASS Elective ........................................................ 4
- Free Elective ............................................................. 4

## THIRD YEAR

**Fall**
- CSCI 4430 Programming Languages .................................................... 4
- Computer Science Option ......................................................... 4
- HASS Elective ........................................................ 4
- Science Option .......................................................... 4

**Spring**
- CSCI 4210 Operating Systems ......................................................... 4
- Free Elective ............................................................. 4
- Free Elective ............................................................. 4

## FOURTH YEAR

**Fall**
- CSCI 4440 Software Design and Documentation .................................... 4
- Computer Science Option ......................................................... 4
- Free Elective ............................................................. 4
- Free Elective ............................................................. 4

**Spring**
- Computer Science Option ......................................................... 4
- Free Elective ............................................................. 4
- Free Elective ............................................................. 4
- Free Elective ............................................................. 4

### Options

#### Science
A four-credit course chosen from the following: astronomy, biology, chemistry, earth and environmental science, and physics. The Pass/No Credit option cannot be used for this course. The course ERTH 1030 cannot be used to satisfy this requirement.

#### Computer Science
Three additional computing courses of three or four credits at the 4000 or 6000 level. For this purpose, courses in the series CSCI 4xxx, CSCI 6xxx, ECSE 46xx, and ECSE 47xx may be used, excluding ECSE 4630, ECSE 4640, ECSE 4720, and reading and independent study courses. The Pass/No Credit option cannot be used for these courses.

#### Mathematics
Two additional courses chosen from PHIL 2140, PHIL 4140, PHIL 4420, and/or any course in MATH and MATP at the 2000 level or above. Independent study courses cannot be used to satisfy this option. The Pass/No Credit option cannot be used for these courses.

#### Dual Major Programs
Computer science students can obtain a dual major with any other major offered at Rensselaer. In many cases, students can obtain a dual major within the 128 credits of a single degree, since many courses can be counted twice. Popular majors often combined with computer science include mathematics, physics, management, games and simulation arts and sciences, engineering (which requires additional credits hours), and electronic media, arts, and communication.

#### Accelerated Program
Students may be admitted to the graduate program in Computer Science when they are within 18 credits of completing their B.S. degree. Students may be able to complete the B.S. and M.S. in a shorter than usual time by using advanced placement credit, taking courses during the summer, or taking extra courses during the academic year. A variety of joint degree programs can be arranged, depending on the student's background, interests, and desired rate of progress. Any joint degree program requires that the student apply to and be accepted to the graduate program.
Special Undergraduate Opportunities

The Computer Science Department strongly encourages students to take part in the following special programs.

Co-operative Education and Internships
Numerous employment opportunities exist for computer science majors during their course of study. Students are urged to pursue at least one internship and/or co-op experience during their academic career. More detailed information on the co-op program is available in the School of Science introduction section and the Educational Programs and Resources section of this catalog. Internships are typically available over the summer, even after a student’s freshman year.

Undergraduate Research Program (URP)
This program allows students to participate in faculty research activities. The department urges students to take advantage of these opportunities, through which students can earn either pay or course credit. Additional benefits may include being named co-authors on journal papers or the opportunity to make presentations at professional conferences. Additional information is available in the School of Science introduction section and the Educational Programs and Resources section of this catalog.

Rensselaer Center for Open Source Software (RCOS)
The program provides a creative, intellectual, and entrepreneurial outlet for students to use open-source software platforms to develop open-source applications that solve societal problems. RCOS team members participate in a collaborative environment for sharing and practicing programming and project management skills, including code reviews and project presentations. Students can participate in RCOS for course credit or for a stipend. At the beginning of each semester, including the full summer sessions, an Internal Advisory Board reviews project proposals and decides which should receive financial support or course credit.

Cisco Networking Academy
The Cisco Networking Academy at Rensselaer provides extensive hands-on learning in networking. A state-of-the-art lab of over 300 routers, switches, and wireless devices is one of the largest educational lab environments in the world exclusively reserved for student use. Undergraduates have written labs that have been published and are used in over 160 countries. Through an escalating series of challenges, students learn both a sound theoretical foundation and the knowledge necessary to obtain industry certifications.

Graduate Programs
The Department of Computer Science offers M.S. and Ph.D. degrees in computer science. The department also offers computer science M.S. degrees with specializations in robotics and in computational science and engineering.

Applications for the M.S. or Ph.D. in computer science should be sent to the Graduate Admissions Office to be received no later than January 1 for fall admission; August 15 for spring admission. Applicants must provide transcripts, two letters of recommendation, a statement of goals, and GRE scores. Each student’s background is expected to include courses in discrete mathematics, calculus, data structures, computer organization, and computing languages, none of which can be counted toward the graduate degree. Admission is extremely competitive, and meeting the minimum requirements does not assure admission.

Master’s Programs
M.S. in Computer Science
In addition to meeting the degree requirements of the Office of Graduate Education, a candidate must plan a degree program and complete the Plan of Study form in consultation with a faculty adviser. A degree program must include at least 30 credits, at least 18 of which must be at the 6000 level. It must include the following two required courses: CSCI 6050 Computability and Complexity and CSCI 6140 Computer Operating Systems. Students who have not had an operating systems course prior to joining the program may replace CSCI 6140 with CSCI 4210 with the permission of their adviser. At least one course must be taken from the computer systems area, and at least one course must be taken from the computer theory area. Finally, it must include a master’s thesis and regular attendance at department colloquia.

M.S. in Computer Science Specializing in Computational Science and Engineering
Applicants apply to this program in the usual manner. However, student backgrounds are expected to include courses in calculus, elementary linear algebra, elementary differential equations, discrete mathematics, data structures, and numerical computing. Courses in computer organization and computing languages are recommended. Students lacking some of this material may be admitted but will be expected to acquire this knowledge during their studies. This may require taking courses beyond the normal degree requirements.

Students must complete a Plan of Study that includes 30 credits at the 4000 and 6000 levels with: (1) at least six credits in numerical analysis and/or scientific computation; (2) at least six credits in an area of natural science or engineering; (3) at least one course in each of software and hardware systems; and (4) a six-credit master’s thesis. At least 18 credits must be at the 6000 level, and students should attend the computer science colloquia and scientific computation seminars.
Students interested in further study within this area should refer to the Ph.D. in Computer Science Specializing in Computational Science and Engineering.

**M.S. in Computer Science Specializing in Robotics**

Applicants apply to this program in the usual manner. Students must complete a Plan of Study that includes 30 credits at the 4000 and 6000 levels. At least 18 of these credits must be at the 6000 level.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 4480</td>
<td>Robotics I</td>
<td>3</td>
</tr>
<tr>
<td>CSCI 6050</td>
<td>Computability and Complexity</td>
<td>3</td>
</tr>
<tr>
<td>CSCI 6140</td>
<td>Computer Operating Systems</td>
<td>3</td>
</tr>
<tr>
<td>CSCI 6490</td>
<td>Robotics II</td>
<td>3</td>
</tr>
<tr>
<td>CSCI 6990</td>
<td>Master’s Thesis</td>
<td>1 to 9</td>
</tr>
</tbody>
</table>

There are five required courses. In addition, students must take three additional courses related to robotics.

**Doctoral Programs**

**Ph.D. in Computer Science**

During the first few semesters, the student focuses on obtaining a breadth of knowledge in computer science. Full-time students must complete all requirements for the core qualifying examination by the end of their third semester. Part-time students may take up to six semesters to complete the core qualifying exam requirements. The timing is measured from the student’s semester of Ph.D. program entry, regardless of whether the student is concurrently enrolled in another degree program. The only exception is that students in the accelerated B.S.-Ph.D. program may begin the timing when they complete 128 credits.

To pass the core qualifying exam, students must meet the grading criteria in a course in each of five areas. The grading criteria are that the student must earn a grade of A in a course in at least two of the areas, and that no more than one of the five courses may have a grade of B+. No course with a grade lower than B+ will count. The student may earn A- grades in the remaining courses. Students who do not meet the grading criteria in an area may take additional courses in that area until the required grade is achieved.

A list of courses that may be used for each area is available on the Computer Science Department Web site. All students must pass Area 1, Area 2, and Area 3. Students may, in consultation with their advisers, choose any two additional areas from Areas 4-8. In general, when courses are offered at both the 4000 level and 6000 level, only the 6000-level course is included on the list of eligible courses. In some cases, students who were enrolled at Rensselaer prior to joining the Ph.D. program may have already taken 4000-level versions of courses whose 6000-level counterparts are qualifying exam courses. In these circumstances, up to two of the 4000-level versions of core qualifying exam courses may be counted toward the core qualifying exam.

The second year is devoted to research exploration and selection of a doctoral committee. By the end of the second year, students must pass a research qualifying exam demonstrating breadth of knowledge in their research area. The research qualifying exam is supervised by three faculty members and may take the form of coursework, a survey paper, and/or an oral presentation. If courses are used for the research qualifying exam, they may not also be counted for the core qualifying exam.

The third year, the student develops a detailed understanding of the chosen research area and prepares a research proposal. The student must pass an oral candidacy exam by the end of the third year. The candidacy exam is an oral exam focusing on a thesis proposal and administered by the student’s doctoral committee. The student begins by presenting the thesis proposal and is then questioned by the committee.

In the third year, the student develops a detailed understanding of the chosen research area and prepares a research proposal. The student must pass an oral candidacy exam by the end of the third year. The candidacy exam is an oral exam focusing on a thesis proposal and administered by the student’s doctoral committee. The student begins by presenting the thesis proposal and is then questioned by the committee.

In addition to the above requirements, the student must earn a total of 72 credits beyond the bachelor’s level, with at least 36 course credits and at least 24 dissertation research credits. Students entering the program with an M.S. degree must earn a total of 48 credits, at least 12 of which must be course credits and at least 24 dissertation research credits. All doctoral students are expected to have presented at least one public lecture (such as a conference presentation) on their research prior to their defense.

**Course Descriptions**

Courses directly related to all Computer Science curricula are described in the Course Description section of this catalog under the department code CSCI.
Computer Science at Hartford

CS/IT Programs Coordinator: Houman Younessi

Faculty

Younessi, H.—Ph.D. (Swinburne University of Technology, Australia); software engineering, research methods (Assistant Dean for Academic Programs), Professor of Practice and Assistant Dean for Programs.

Eberbach, E.—Ph.D. (Warsaw University of Technology); computer science, artificial intelligence, and distributed and concurrent computing, Professor of Practice.

Master of Science in Computer Science

Program Requirements

Applicants are assumed to have knowledge of computer concepts and programming in a high-level language (e.g., C, Pascal). To receive the Master of Science degree in Computer Science, students must earn a minimum of 30 credit hours in Computer Science or Engineering courses and satisfy the following requirements:

Plan of Study

Each student completes a Plan of Study in consultation with his or her adviser. This Plan will include required immigration courses (if any), five core courses, Research Methods course, the Culminating Experience (Computer Science Project), and three elective courses. At least two of the elective courses should pertain to a specific area that reflects the student’s professional or academic interest.

Immigration Courses

Depending on academic background and professional experience, some students may be required to begin their studies with one or more prerequisite “immigration” course(s) in addition to the standard 30 credit hours for the degree. The immigration courses are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 4010</td>
<td>Discrete Mathematics and Computer Theory*</td>
</tr>
<tr>
<td>CISH 4020</td>
<td>Object Structures*</td>
</tr>
<tr>
<td>CISH 4030</td>
<td>Structured Computer Architecture</td>
</tr>
</tbody>
</table>

Additional Program Information

Students with two or more immigration courses as prerequisites may be admitted conditionally. Since these are the equivalent of undergraduate courses, students are expected to achieve a grade of “B” or better in each course. Achievement below this level is cause for re-examination of admission. In addition, these immigration courses will not enter into the calculation of a student’s GPA for graduation.

Core Courses (15 credits)

Each Plan of Study will contain the following five courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 4210</td>
<td>Operating Systems</td>
</tr>
<tr>
<td>CSCI 4380</td>
<td>Database Systems</td>
</tr>
<tr>
<td>CSCI 6050</td>
<td>Computability and Complexity</td>
</tr>
<tr>
<td>ECSE 4670</td>
<td>Computer Communication Networks</td>
</tr>
<tr>
<td>ECSE 6770</td>
<td>Software Engineering I</td>
</tr>
</tbody>
</table>

Research Methods Course (3 credits):

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 6960H09</td>
<td>Research Methods (H09) in Computer Science</td>
</tr>
</tbody>
</table>

Culminating Experience (3 credits):

(For students admitted after Summer 2004, an approved Project Proposal is required before registering. Contact the department for further guidance.)

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 6970</td>
<td>Professional Project</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>CISH 6980</td>
<td>Master’s Project</td>
</tr>
</tbody>
</table>
Computer Science and Other Electives (9 credits):
With the exception of the immigration courses, all courses with the designation CISH or CSCI and most designated ECSE may be used as electives for the degree.

Advanced Courses
At least 18 credit hours must be at the “advanced” level. All courses with suffix numbers 6000-6990 fall into this category. These courses may include special topics courses which are offered under CISH or CSCI 6960 Topics in Computer and Information Sciences or ECSE 6960 Topics in Electrical Engineering.

After completing course work in a particular area, students may elect to complete a three-or six-credit Master’s Project (CISH 6970 or CSCI 6980) or six-credit Thesis (CISH or CSCI 6990) in that area.

Program Completion
Students will complete their program of study via one of two paths:

Applied Path

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 6960H09</td>
<td>Research Methods</td>
</tr>
<tr>
<td>CHME 6970</td>
<td>Professional Project</td>
</tr>
<tr>
<td>CISH 6980</td>
<td>Master’s Project</td>
</tr>
<tr>
<td>CISH 6990</td>
<td>Master’s Thesis</td>
</tr>
</tbody>
</table>

Or

Theory Path

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Theory Course</td>
<td>One CISH or CSCI Theory Course (3 credits)</td>
</tr>
<tr>
<td>CSCI 6990</td>
<td>Master’s Thesis (6 credits)</td>
</tr>
</tbody>
</table>

For More Information
Information concerning the Computer Science programs may be obtained by contacting Dr. Houman Younassi at (860) 548-7880, (800) 290-7637, ext. 7880; e-mail: youneh@rpi.edu; or by visiting: www.ewp.rpi.edu/does.

Graduate Certificate Programs in Computer Science
(Minimum of 12 Credit Hours)
The Computer Science Graduate Certificate Programs are designed with a selective focus and require that a student successfully complete four graduate courses (12 credit hours of which nine credit hours must be in residence), with an average grade of “B” or better in a specific area of Computer Science. Credits earned in Graduate Certificates may be subsequently applied toward an M.S. degree as electives with adviser’s approval. Additional technical information about the Graduate Certificates can be obtained from the Certificate Program Coordinators listed below. Graduate Certificates are offered in the following four areas:

Computer Network Communications Certificate (Hartford)
Program coordinator: Roger Brown, rhb@rh.edu, 860/548-2462

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 4670</td>
<td>Computer Communication Networks.</td>
</tr>
</tbody>
</table>

Select any three of the following courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 6960</td>
<td>Cryptography and Network Security</td>
</tr>
<tr>
<td>CISH 6220</td>
<td>LANs, MANs, and Internetworking.</td>
</tr>
<tr>
<td>CISH 6230</td>
<td>Network Management</td>
</tr>
<tr>
<td>ECSE 6660</td>
<td>Broadband &amp; Optical Networking</td>
</tr>
</tbody>
</table>
Database Systems

Program coordinator: Houman Younessi, houman@rh.edu, 860/548-7880

<table>
<thead>
<tr>
<th>Program Requirements</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 4380 Database Systems</td>
<td>3</td>
</tr>
</tbody>
</table>

Select any three of the following courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 6110 Object Oriented Database Systems</td>
<td>3</td>
</tr>
<tr>
<td>CISH 6120 Distributed Database Systems</td>
<td>3</td>
</tr>
<tr>
<td>CISH or CSCI 6960 Topics in Computer and Information Sciences</td>
<td>1 to 3</td>
</tr>
<tr>
<td>Data Warehouse Systems</td>
<td></td>
</tr>
</tbody>
</table>

Information Systems

Program coordinator: Roger Brown, rhb@rh.edu, 860/548-2462

<table>
<thead>
<tr>
<th>Required</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM 6420 Foundations of Human-Computer Interaction Usability</td>
<td>3</td>
</tr>
<tr>
<td>CSCI 4380 Database Systems</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 4670 Computer Communication Networks</td>
<td>3</td>
</tr>
</tbody>
</table>

Elective

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 6010 Object Oriented Programming and Design</td>
<td>3</td>
</tr>
<tr>
<td>or ECSE 6770 Software Engineering I</td>
<td>3</td>
</tr>
</tbody>
</table>

Software Engineering

Program coordinator: Houman Younessi, houman@rh.edu, 860/548-7880

<table>
<thead>
<tr>
<th>Required</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 6050 Software Engineering Management</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6770 Software Engineering I</td>
<td>3</td>
</tr>
</tbody>
</table>

Select any two of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH 6010 Object Oriented Programming and Design</td>
<td>3</td>
</tr>
<tr>
<td>CISH 6510 Web Application Design and Development</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 6780 Software Engineering II</td>
<td>3</td>
</tr>
</tbody>
</table>

Earth and Environmental Sciences

Head: Frank Spear

Department Home Page: http://www.rpi.edu/dept/ees

In recent decades, the Earth Sciences have undergone major changes, stimulated in part by the reinterpretation of Earth history and processes within the context of plate tectonics. The past 15 years have been especially exciting, as new understanding of the interconnectedness among all Earth systems – air, water, and solid Earth – has come into sharper focus. Cognizant of these changes (and leading some of them), Rensselaer’s E&ES faculty provide instruction in modern Earth Sciences that is both far-reaching and relevant, addressing key topics ranging from environmental contaminants in local waterways to the evolution of our planet.

At Rensselaer, students learn about Earth using techniques ranging from seismological and satellite-tracking investigations of crustal motions to state-of-the-art geochemical instruments. The latest techniques for simulating Earth processes include high-pressure experimentation and computer modeling. A broad choice of courses is available, ranging from quantitative, computer-oriented aspects of the geosphere to field experience and geochemical approaches. The program includes the study of Earth’s component materials, the development of its structures and surface features, the processes by which these change with time, and the origin, discovery, and protection of its resources water, fuels, and minerals.

The Troy area is well situated for field-based study of problems in hard-rock and surficial geology, as well as ground and surface water science. The department enjoys fruitful relationships with nearby university, industrial, and government geoscience groups within 10 miles of the campus. All students have access to these resources, as well as to the laboratory and computer facilities of the Institute, which has a strong commitment to education and research in science and engineering.
There are numerous opportunities for students to engage in field-oriented projects, both domestic and international. In addition, students may obtain summer employment with oil, geological engineering, or environmental consulting companies, or they may participate in a faculty member’s field-oriented research project.

**Research Innovations and Initiatives**

The diverse interests of the Earth and Environmental Science faculty lead to a wide variety of projects that stimulate educational programs at both the graduate and undergraduate levels. Undergraduate students are encouraged to enroll in the Undergraduate Research Program (URP), which involves them in front-line research for credit or pay. Graduate students pursue specialized study in consultation with their faculty advisers, whose research interests are matched on an individual basis.

**Geochemistry and Petrology**

Ongoing studies in geochemistry include the distribution of trace elements between minerals in metamorphic and igneous systems, the physics and chemistry of fluids transport in the crust and mantle, experimental studies of chemical reactions and transport deep in the Earth, and accessory minerals as geochronometers. The tectonic evolution of mountain belts is being investigated through the examination of metamorphic rocks in diverse regions such as New England, the Adirondacks, the Alps, and British Columbia.

**Geophysics**

Research in geophysics includes field studies of the seismology and tectonics of Asia, Indonesia, the western U.S., and the southwestern Pacific. Using the Global Positioning System (GPS), plate motions and earthquake strains are monitored and computer models of plate motions and faulting are developed. Seismic tomography is used to reveal deep structures of the lithosphere and mountain belts. Seismic, magnetic, geodetic, and gravity methods are used to probe local structures, including ancient faults and hydrologic conduits.

**Environmental Geochemistry**

Ongoing research includes investigations of organic and heavy-metal pollutant transport, dispersion, and degradation in natural water systems. Also underway are studies of sediment contamination histories of rivers, lakes, and reservoirs focused on the development of multi-tracer approaches to dating and source characterizations.

**Paleoceanography and Micropaleontology**

Ongoing research of past ocean and climate conditions utilize micropaleontological, sedimentological, and geochemical techniques. Studies focus on reconstructions of normal climate variability, rapid climate perturbations, mean shifts in global climate state, and sea-level change recorded in the geological record.

**Research Facilities**

Students have access to the department’s electron microprobe, gamma spectrometer, gas chromatographs, spectrophotometers, differential thermal apparatus, gravimeter, magnetometer, 12-channel seismograph, electrical resistivity equipment, GPS receivers, LA-ICP-MS, mercury analyzer, and seismograph stations. Also available are X-ray diffraction and fluorescence equipment, atomic absorption and optical emission spectrometers, and scanning electron microscopes, as well as two isotope ratio mass spectrometers.

**Faculty**

**Institute Professor**

Watson, E.B.—Ph.D. (Massachusetts Institute of Technology); experimental geochemistry and petrology.

**Chaired Professors**

Spear, F.S.—Ph.D. (University of California, Los Angeles); petrology, geochemistry.

Fox, Peter—Ph.D. (Monash University); applied mathematics (Computer Science, Theoretical Physics).

**Professor**

Roecker, S.—Ph.D. (Massachusetts Institute of Technology); geophysics, seismology, and geodesy.

**Associate Professor**

Bopp, R.E.—Ph.D. (Columbia University); environmental geochemistry.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Assistant Professor

Katz, M.E.—Ph.D. (Rutgers University); paleoceanography and micropaleontology.

Professors Emeriti

Bayly, M.B.—Ph.D. (University of Chicago); structural geology, rheological properties of earth materials.

Friedman, G.M.—Ph.D. (Columbia University); D.Sc. (University of London); sedimentology.

Gaffey, M.J.—Ph.D. (Massachusetts Institute of Technology); planetary science.

Katz, S.—Ph.D. (Columbia University); seismology, geophysics.

LaFleur, R.G.—Ph.D. (Rensselaer Polytechnic Institute); geomorphology, glacial geology, water resources.

Miller, D.S.—Ph.D. (Columbia University); geochemistry, isotope geology, fission track research.

Research Associate Professor

Cherniak, D.—Ph.D. (University at Albany); geochemical kinetics.

Research Scientists

Tailby, Nicholas—Ph.D. (Australian National University); geochemistry, petrology, astrobiology.

Thomas, J.—Ph.D. (Virginia Tech); geochemistry.

Traill, D.—Ph.D. (Rensselaer Polytechnic Institute); geology.

Undergraduate Programs

The undergraduate curricula are flexible so that students may work in interdisciplinary areas while maintaining emphasis in earth and environmental sciences. Students are encouraged to take electives in their field of interest, including some outside the department. These should form a coherent group and be approved by the adviser. The department adviser will consult with each student individually to arrange an optimal program in geology, hydrogeology, geochemistry, geophysics, or environmental geoscience.

Students transferring from other curricula can graduate with their class provided that they enter the department by the beginning of the junior year and that they have maintained satisfactory grades in their first two years.

Baccalaureate Programs

Geology Curriculum

The program shown below requires a total of 124 credit hours. The program leads to a B.S. in Geology.

**FIRST YEAR**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1100</td>
<td>Chemistry I</td>
</tr>
<tr>
<td>ERTH 1100</td>
<td>Geology I: Earth's Interior</td>
</tr>
<tr>
<td>MATH 1010</td>
<td>Calculus I</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1200</td>
<td>Chemistry II</td>
</tr>
<tr>
<td>ERTH 1200</td>
<td>Geology II: Earth's Surface</td>
</tr>
<tr>
<td>MATH 1020</td>
<td>Calculus II</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
</tr>
</tbody>
</table>
### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH 2330</td>
<td>Earth Materials</td>
</tr>
<tr>
<td>MATH 2010</td>
<td>Multivariable Calculus and Matrix Algebra</td>
</tr>
<tr>
<td>PHYS 1100</td>
<td>Physics I</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH 2140</td>
<td>Introduction to Geochemistry</td>
</tr>
<tr>
<td>PHYS 1200</td>
<td>Physics II</td>
</tr>
<tr>
<td>Biology Requirement</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH 2120</td>
<td>Structural Geology</td>
</tr>
<tr>
<td>ERTH 2210</td>
<td>Field Methods</td>
</tr>
<tr>
<td>ERTH 4070</td>
<td>Sedimentology/Stratigraphy</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>2-4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH 2100</td>
<td>Introduction to Geophysics</td>
</tr>
<tr>
<td>ERTH 4xxx</td>
<td>Electives</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Electives</td>
<td>8</td>
</tr>
<tr>
<td>ERTH Electives</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH 4970</td>
<td>Out-of-Classroom Experience in Earth Sciences</td>
</tr>
<tr>
<td>or ERTH 4980</td>
<td>Undergraduate Research Thesis</td>
</tr>
<tr>
<td>Culminating Experience</td>
<td>3-4</td>
</tr>
<tr>
<td>Electives</td>
<td>10-11</td>
</tr>
</tbody>
</table>

#### Geology Group Options (Two courses from the following group)

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH 4070</td>
</tr>
<tr>
<td>ERTH 4190</td>
</tr>
<tr>
<td>ERTH 4340</td>
</tr>
<tr>
<td>ERTH 4500</td>
</tr>
<tr>
<td>ERTH 4540</td>
</tr>
<tr>
<td>ERTH 4650</td>
</tr>
<tr>
<td>ERTH 4690</td>
</tr>
<tr>
<td>ERTH 4710</td>
</tr>
<tr>
<td>ERTH 4750</td>
</tr>
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</table>

#### Culminating Experience

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH 4970</td>
</tr>
<tr>
<td>ERTH 4980</td>
</tr>
</tbody>
</table>

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1. Biology Requirement: BIOL 1010 if taken in the second year, but may be BIOL 4320 if taken in the third or fourth year.
2. With permission of the Department Head, a student may select another Math course (Course numbers MATH xxxx, MATP xxxx, or courses cross-listed with these numbers).
Electives

The following are recommended as electives for the geology curriculum:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4850</td>
<td>Principles of Ecology</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 4410</td>
<td>Macroscopic Physical Chemistry</td>
<td>4</td>
</tr>
<tr>
<td>CIVL 2630</td>
<td>Introduction to Geotechnical Engineering</td>
<td>4</td>
</tr>
<tr>
<td>CIVL 4150</td>
<td>Experimental Soil Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>ENVE 4310</td>
<td>Applied Hydrology and Hydraulics</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 4200</td>
<td>Applied Micropaleontology</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4600</td>
<td>Advanced Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4700</td>
<td>Foundations of Applied Mathematics</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4800</td>
<td>Numerical Computing</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4820</td>
<td>Introduction to Numerical Methods for Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>MTLE 2020</td>
<td>Introduction to Ceramic Materials</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4100</td>
<td>Thermodynamics of Materials</td>
<td>4</td>
</tr>
</tbody>
</table>

Hydrogeology

The program shown below requires a total of 124 credit hours. The program leads to a B.S. in Hydrogeology.

**FIRST YEAR**

<table>
<thead>
<tr>
<th>Term</th>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td>CHEM 1100</td>
<td>Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ERTH 1100</td>
<td>Geology I: Earth’s Interior</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td><strong>Spring</strong></td>
<td>CHEM 1200</td>
<td>Chemistry II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ERTH 1200</td>
<td>Geology II: Earth’s Surface</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH 1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**SECOND YEAR**

<table>
<thead>
<tr>
<th>Term</th>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td>MATH 2010</td>
<td>Multivariable Calculus and Matrix Algebra</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS 1100</td>
<td>Physics I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CSCI 4961</td>
<td>Data Science2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td><strong>Spring</strong></td>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS 1200</td>
<td>Physics II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Biology Requirement1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**THIRD YEAR**

<table>
<thead>
<tr>
<th>Term</th>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td>ERTH 2120</td>
<td>Structural Geology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ERTH 2210</td>
<td>Field Methods</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ERTH 4070</td>
<td>Sedimentology/Stratigraphy</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective</td>
<td>2-4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td><strong>Spring</strong></td>
<td>ERTH 2140</td>
<td>Introduction to Geochemistry</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

1 Biology Requirement: BIOL 1010 if taken in the second year, but may be BIOL 4320 if taken in the third or fourth year.

2 It is highly recommended that students take this course during the fall term of the second year.
FOURTH YEAR

Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVE 2110</td>
<td>Introduction to Environmental Engineering</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 4190</td>
<td>Environmental Measurements</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 4710</td>
<td>Groundwater Hydrology</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Spring

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH 4970</td>
<td>Out-of-Classroom Experience in Earth Sciences</td>
<td>2 to 4</td>
</tr>
<tr>
<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERTH 4980</td>
<td>Undergraduate Research Thesis</td>
<td>2 to 4</td>
</tr>
<tr>
<td></td>
<td>Culminating Experience</td>
<td>3-4</td>
</tr>
<tr>
<td>Electives</td>
<td></td>
<td>10-11</td>
</tr>
</tbody>
</table>

Electives

A total of 30 credit hours of free electives is required. These electives should be designed to provide a depth of understanding in a sub-discipline of hydrogeology (e.g., geology, mathematics, chemistry, physics, biology, computer science, engineering, etc.). A limited list of suggested courses for free electives includes the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4620</td>
<td>Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4700</td>
<td>Freshwater Ecology</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 4410</td>
<td>Macroscopic Physical Chemistry</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 4420</td>
<td>Microscopic Physical Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 4810</td>
<td>Chemistry of the Environment</td>
<td>4</td>
</tr>
<tr>
<td>CIVL 4240</td>
<td>Introduction to Finite Elements</td>
<td>3</td>
</tr>
<tr>
<td>CSCI 1200</td>
<td>Data Structures</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 4510</td>
<td>Digital Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>ERTH 2100</td>
<td>Introduction to Geophysics</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 2140</td>
<td>Introduction to Geochemistry</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 4540</td>
<td>Organic Geochemistry</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 4690</td>
<td>Aqueous Geochemistry</td>
<td>4</td>
</tr>
<tr>
<td>ISYE 4140</td>
<td>Statistical Analysis</td>
<td>4</td>
</tr>
<tr>
<td>MATP 4600</td>
<td>Probability Theory and Applications</td>
<td>4</td>
</tr>
<tr>
<td>MATP 4700</td>
<td>Mathematical Models of Operations Research</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 2350</td>
<td>Experimental Physics</td>
<td>4</td>
</tr>
</tbody>
</table>

Minor Programs

Astrobiology Minor for Geology Majors

Program Requirements

The Biology, Biochemistry and Biophysics, Chemistry and Chemical Biology, Earth and Environmental Sciences, and Physics Departments participate in a multidisciplinary minor in Astrobiology for students majoring in these or other disciplines. To be eligible for the minor, students must pass the three-credit course ASTR 4510 Origins of Life - A Cosmic Perspective and at least two semesters of the one-credit seminar course ISCI 4510; they must also undertake a four-credit research project on a topic related to Astrobiology under the supervision of a faculty member engaged in Astrobiology research in one of the above departments; finally, they must complete a further two courses outside the major field of study, selected from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR 2050</td>
<td>Introductory Astronomy and Astrophysics</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 2120</td>
<td>Introduction to Cell and Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4620</td>
<td>Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4760</td>
<td>Molecular Biochemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 2250</td>
<td>Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 4810</td>
<td>Chemistry of the Environment</td>
<td>4</td>
</tr>
<tr>
<td>ENVE 2110</td>
<td>Introduction to Environmental Engineering</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 4540</td>
<td>Organic Geochemistry</td>
<td>4</td>
</tr>
</tbody>
</table>

Additional Information

The requirement that two selected courses must be outside the major is reduced to one in the case of a dual or double major, provided that both majors are in the primary relevant areas of study (i.e., biology, chemistry, geology, and physics).
Geology Minor

Program Requirements
Students not majoring in geology may take a minor by completing from the ERTH group at least 16 credit hours, eight of which should be at the 4000 level. ERTH 1030 and 1040 (Natural Sciences) do not count towards the minor.

Hydrogeology Minor

Program Requirements
Students not majoring in hydrogeology may take a minor by taking the following courses and electing from the ERTH group at least two additional courses except for ERTH 1030 and ERTH 1040.

<table>
<thead>
<tr>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH 4180</td>
</tr>
<tr>
<td>ERTH 4710</td>
</tr>
</tbody>
</table>

Interschool Minor in Energy

Students interested in developing a broad, multidisciplinary background in energy to complement their more focused major program should consider this minor. See the Science and Technology Minor Programs Section of the School of Humanities, Arts, and Social Sciences portion of this catalog for details.

Accelerated Programs

An accelerated program with emphasis in geophysics or environmental geochemistry is available for students interested in combining a B.S. and an M.S. in geology. Students interested in developing an accelerated course of study in this or another area of geological sciences should consult their advisers.

Special Undergraduate Opportunities

Out-of-Classroom Experience
In consultation with his or her adviser, each hydrogeology student may select and engage in an out-of-classroom experience for up to four hours of course credit. The experience should have intellectual content relevant to the student's educational or career goals. Envisioned as a summer activity, this experience usually occurs after the sophomore or junior year, although it could also occur during the fall or spring terms. Appropriate experiences might include an individual or group research project (on or off campus), an independent study project, a co-op assignment, a public service internship, or study abroad. A written proposal and a final written report submitted for evaluation to the Earth and Environmental Sciences Department Undergraduate Curriculum Committee is required.

Graduate Programs
Research programs leading to the M.S. and Ph.D. degrees are available in a range of specialties (see below). Interdisciplinary research takes place with other groups, including the Darrin Fresh Water Institute and the Departments of Biology, Physics, Civil and Environmental Engineering, and Materials Science and Engineering. Recently the department has been involved in the interdisciplinary Astrobiology initiative. Applicants to degree programs should consult Graduate Admissions for details.

Master's Programs
The department offers the M.S. degree in Geology and Environmental Science. Candidates must complete 30 hours of graduate study based on an approved Plan of Study. A thesis based on original research is usually submitted. This requirement may be waived at the discretion of the candidate's adviser. The department also provides supervision of research and curriculum planning for students in the Applied Science Master's program in areas including contaminant geochemistry and applied geophysics.

Five-Year B.S.-M.S. Program
The department offers the M.S. degree in Geology and Environmental Science. Candidates must complete 30 hours of graduate study based on an approved Plan of Study. A thesis based on original research is usually submitted. This requirement may be waived at the discretion of the candidate's adviser. The department also provides supervision of research and curriculum planning for students in the Applied Science Master's program in areas including contaminant geochemistry and applied geophysics.
Doctornal Programs
The department offers the Ph.D. degree in a range of specialties, including geochemistry, geophysics, paleoceanography, and igneous and metamorphic petrology. Candidates for the Ph.D. degree must fulfill the requirements of the Office of Graduate Education. Evidence of success in graduate-level study and research must be shown. There is no language requirement. A dissertation based on original research is required. Ongoing research is described on the department Web page. Applicants are encouraged to discuss current research topics with individual faculty members.

Course Descriptions
Courses directly related to all Earth and Environmental Sciences curricula are described in the Course Description section of this catalog under the department code ERTH.

Mathematical Sciences

Head: Donald Schwendeman  
Associate Head: Bruce Piper  
Chair of the Graduate Committee: John Mitchell  
Departmental Home Page: http://www.math.rpi.edu/index.html

Through the centuries, mathematics has been a central feature of our intellectual and technological development. Today its role in the physical sciences and engineering is well established. Its role in the life and social sciences, medicine, management, and the arts is undergoing remarkable growth—a virtual mathematization of the culture. The Department of Mathematical Sciences is directly engaged in this process through its educational and research programs. Our focus is the study and development of mathematical and computational methods and their application to problems of contemporary significance to our society.

The Department of Mathematical Sciences provides an in-depth education in both the foundations of mathematical thought as well in the applications of mathematics to real-life phenomena. For this reason, we offer a baccalaureate degree with a specialization in mathematics, applied mathematics, mathematics of computation, or operations research. The department’s programs are also designed to provide a broad spectrum of opportunities for students. This flexibility allows students and advisers to tailor programs to individual objectives and talents. As a result, the curricula are equally advantageous for individuals who will seek immediate employment upon graduation, for those who plan graduate-level education in the mathematical sciences, and for those who will apply their education to pursuits outside the mathematical arena. Our graduates have entered careers in law, medicine, engineering, management, and psychology, as well as in pure and applied mathematics, computer science, and operations research.

At the graduate level, Rensselaer is especially well-known as a center for advanced study and research in applied mathematics. The department’s M.S. and Ph.D. programs emphasize:

Methods of applied mathematics, including ordinary and partial differential equations, approximation theory, asymptotic analysis, functional analysis, and numerical analysis;

• methods of applied mathematics, including ordinary and partial differential equations, approximation theory, asymptotic analysis, functional analysis, and numerical analysis;

• applications in the physical sciences, biological sciences, and engineering;

• computational mathematics, including the development, analysis and implementation of numerical methods for mathematical models that arise in applications;

• mathematical programming, including nonlinear, combinatorial, and multiple objective optimization and their applications.

At the highest level, continual interplay between the construction of the mathematical model and the solution of the resulting mathematical problem characterizes applied mathematics. The ideal applied mathematician, therefore, must be knowledgeable both in mathematics and in at least one field in which problem areas are found. A sound knowledge of the application area assists in constructing suitable models, and a high level of mathematical judgment and expertise may be required to solve the resulting mathematical problems.
Research Innovations and Initiatives

Faculty research activities in the Department of Mathematical Sciences center on applied mathematics, analysis, scientific computing, mathematical programming, and operations research. The faculty’s interest in applied research often leads to a synthesis of techniques from two or more research areas. Further, the formulation, solution, and interpretation of a problem often contain ideas that can be applied to problems in other areas. Focusing different research areas on real problems and the diversity of applications of real problem solutions creates an atmosphere of interaction and cooperation within the department and the university, as well as with other major research institutions.

Numerical Analysis and Scientific Computation

Investigations range from the study of fundamental problems in linear algebra to the development and analysis of numerical methods for solving particular physical or life science problems. Research activities include the numerical solution of optimization problems, inverse eigenvalue problems, and free boundary problems; finite difference and finite element methods for stiff initial and boundary-value problems; and methods of resolving problems involving composite materials. Applications of these studies include reacting flows, shockwave propagation, semiconductor performance, biomathematics, acoustic signal propagation, and incompressible flow in various geometries.

Inverse Problems

This research involves the recovery and imaging of internal biological, mechanical, electrical, or magnetic properties of a system from boundary, spectral, scattering or internal data. The physical system is modeled by a differential equation system with specific unknown terms representing, for example, stiffness in an elastic system or electric permittivity in an electromagnetic system. The measured data is indirectly related to the unknown quantities so the mathematical model of physical processes that produces the data plays an important role in the recovery of the unknown quantities. Rensselaer has established a center for Inverse Problems at RPI. Current research applies functional analysis, perturbation theory, numerical analysis, and optimization to determine optimal datasets, to study the nonlinear dependence of the unknown physical quantities on the available data, and to obtain approximations of the nonlinear operators that will yield efficient reconstruction algorithms. There is a significant role for modeling, analysis, scientific computation, and algorithm development to obtain the targeted solutions to these problems.

Dynamical Systems

Dynamical systems are used to model time-evolving processes from physics to engineering and biology, which frequently require large numbers of variables for their description, and evolve in complex, unpredictable ways. Using ordinary, partial, and stochastic differential and difference equations, as well as deterministic and stochastic numerical simulations, investigations are made into models of phenomena ranging from internal waves in the ocean, vortex dynamics, and turbulence, through large-scale neuronal and social networks, inner-ear dynamics, sleep cycles, fluid flow stability, detonations, and shock dynamics.

Wave Propagation

These studies focus on determining wave propagation and understanding the influence of wave effects. A major area of interest is ocean acoustic transmissions. Mathematical models are developed and analyzed to describe acoustic consequences of ocean environmental features (such as large-amplitude internal waves, ocean current and frontal systems and sediment variations) on the propagation of signals in both frequency and time domains, and to improve the accuracy of computational methods. Improved numerical and asymptotic methods are derived and tested, providing new ways to extract information in complex propagation environments. Stochastic propagation effects are modeled and analyzed, and results are used to explain variability in data observed by ocean scientists. Results are generalized and applied to other acoustic propagation environments, ranging from the atmospheres of Jupiter and the Earth to the upper layer of the Earth’s crust.

Mathematical Programming and Operations Research

Mathematical programming endeavors to find optimal solutions for a broad range of problems including medical, financial, scientific, and engineering problems. Research is conducted on the development, evaluation, and comparison of serial and parallel algorithms for a variety of mathematical programming problems. Current research topics include interior point methods for linear, integer, and nonlinear programming; branch-and-bound and branch-and-cut approaches to integer programming problems; column generation methods; financial optimization; and mathematical programs with complimentary constraints. Also under investigation are mathematical programming approaches to problems in artificial intelligence such as machine learning, neural networks, support vector machines, pattern recognition, and planning. This research also considers combining operations research and artificial intelligence problem-solving methods, scalability of these methods to large problems in data mining, mathematical programming approaches to other areas in computer science such as database query optimization, and stochastic programming.

Biomathematics

Mathematical biology is a very active area of applied mathematical research. This is an interdisciplinary endeavor, with a strong interaction with biological and biomedical scientists. Projects of current interest include cardiac imaging and the use of computer graphics to construct pictures of the heart, mechanoreception, mathematical modeling of biological systems that transform mechanical stimuli (e.g., sound, touch, etc.) into ionic or neural signals and molecular systems in cells. Also being studied are nonlinear ionic diffusion in polymeric gels and the mechanics of multiphasic tissues like cartilage and the cornea. Numerical analysis, asymptotics, and functional analysis are used to investigate mathematically posed problems resulting from the models.
Fluid Mechanics
Methods of applied mathematics are being used to study how fluids behave under a wide spectrum of conditions. The physical problems treated, which are multi-scaled, usually lead to partial differential equations, which may be linear or nonlinear. Current problems deal with fluid mechanics in engineering systems, the flow and stability of two-phase mixtures, the transition from laminar to turbulent flow in boundary layers, and the evolution of non-Newtonian (e.g., polymer) fluid flow. Other geophysical initiated flows such ocean interacions of nonlinear internal waves and acoustics are being investigated.

Combustion Theory
Investigations include mathematical modeling of combustion and explosion phenomena, and analytical and computational studies of the resulting systems of nonlinear ordinary and partial differential equations. Topics of interest are evolution and interaction of waves in reactive media, combustion and vortex breakdown in swirling flows, and transition from deflagration to detonation in granular explosives. Recent studies have focused on the development and analysis of multi-phase and multi-physics models of confined granular explosives, both from the micro and the macro points of view.

Geometric Design
In many design and animation applications, the appearance of objects and shapes are of primary importance. There are a variety of mathematical properties of curves and surfaces that correspond to visual aesthetics. Research in this area uses mathematical techniques from differential geometry, computational geometry and optimization to create and analyze schemes for curve, surface and animation design.

Complex Systems
The study of complex systems can be loosely characterized as the investigation of phenomena that arise in systems with many nonlinearly interacting degrees of freedom, with modern examples drawn from the study of lasers, nonlinear and fiber optics, waves and turbulence in fluids, molecular and cellular biology, and neuroscience. The mathematical treatment of these systems generally involve two themes: a statistical or stochastic characterization of some degrees of freedom, and the development of systematic links between the rules of nonlinear interaction between individual elements with the effective collective behavior of the system. Among the tools employed for this latter objective are homogenization theory, weak turbulence theory, and various stochastic mode reduction and averaging procedures.

Bioinformatics
The massive volume of new data being produced by genome sequencing projects point to an increasing need for bioinformatics. This is a highly interdisciplinary field, involving faculty in mathematical sciences, biology, computer science, chemistry and several departments in the school of engineering. Rensselaer has established a joint bioinformatics center with the nearby Wadsworth Laboratories in the New York State Department of Public Health. Current activities at Rensselaer comprise the development and application of algorithms that aim to solve biological problems using DNA and amino acid sequence, structure, and related information. Some of the problems addressed are the search for patterns in biomolecular sequences that are functionally important, such as transcription binding sites; the prediction of structure or function from nucleic acid or protein sequence data; the development of methods and databases to classify large amounts of biological information, and the development of algorithms and software that are important for current biotechnology applications.

Faculty*

Professors

Bennett, K.P.—Ph.D. (University of Wisconsin); mathematical programming, operations research, machine learning, data mining, artificial intelligence, applications of these methods to problems in engineering, business, medicine, biology, chemistry, and public health.

Boyce, W.E.—Ph.D. (Carnegie Institute of Technology); applied mathematics, mathematics education (emeritus).

Drew, D.A.—Ph.D. (Rensselaer Polytechnic Institute); applied mathematics, fluid mechanics, mathematical biology.

Ecker, J.G.—Ph.D. (University of Michigan); mathematical programming, multiobjective programming, geometric programming, mathematical programming applications, ellipsoid algorithms, linear and nonlinear bi-level programming.

Fleishman, B.A.—Ph.D. (New York University); nonlinear differential equations, mathematics education (emeritus).

Habetler, G.J.—Ph.D. (Carnegie Institute of Technology); functional analysis, numerical analysis (emeritus).

Herron, I.—Ph.D. (Johns Hopkins University); applied mathematics, fluid mechanics, hydrodynamics, stability, biometrics.

Holmes, M.—Ph.D. (University of California, Los Angeles); perturbation methods, biomathematics, nonlinear continuum mechanics.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Isaacson, D.—Ph.D. (New York University); mathematical physics, biomedical applications.

Jacobson, M.J.—Ph.D. (Carnegie Institute of Technology); applied mathematics, acoustic and electromagnetic wave propagation (emeritus).

Kapila, A.—Ph.D. (Cornell University); applied mathematics; fluid mechanics; multi-scale, multi-phase and multi-physics problems; scientific computation.

Kovacic, G.—Ph.D. (California Institute of Technology); applied mathematics, nonlinear dynamics, nonlinear optics.

Lim, C.C.—Ph.D. (Brown University); network science, nonequilibrium statistical physics, applied probability and stochastic process, vortex dynamics and quasi-2D fluid flows.

Lvov, Y.—Ph.D. (University of Arizona); mathematical physics and nonlinear phenomena.

McLaughlin, H.W.—Ph.D. (University of Maryland); applied geometry.

McLaughlin, J.R.—Ph.D. (University of California, Riverside); inverse bioelasticity problems, inverse vibration and inverse scattering problems, wave propagation, analysis, applied mathematics.

Mitchell, J.E.—Ph.D. (Cornell University); optimization, integer programming, conic optimization, mathematical programs with complementary constraints, column generation methods, stochastic optimization, interdependent infrastructure, humanitarian logistics.

Roytburd, V.—Ph.D. (University of California, Berkeley); applied mathematics, combustion theory.

Siegmann, W.L.—Ph.D. (Massachusetts Institute of Technology); applied mathematics, wave propagation.

Schwendeman, D.W.—Ph.D. (California Institute of Technology); applied mathematics, scientific computing.

Zuker, M.—Ph.D. (Massachusetts Institute of Technology); bioinformatics.

Associate Professors

Kramer, P.R.—Ph.D. (Princeton University); turbulent diffusion, stochastic processes.

Li, E.—Ph.D. (Brown University); numerical analysis and scientific computing; finite element methods; discontinuous Galerkin methods; numerical methods for Maxwell equations, Maxwell equations, conservation laws, Hamilton-Jacobi equations, magneto-hydrodynamics equations.

Piper, B.R.—Ph.D. (University of Utah); computer-aided geometric design, numerical analysis, computer graphics.

Assistant Professor

Li, E.—Ph.D. (Brown University); numerical analysis and scientific computing; finite element methods; discontinuous Galerkin methods; numerical methods for Maxwell equations, Maxwell equations, conservation laws, Hamilton-Jacobi equations, magneto-hydrodynamics equations.

Lecturers

Boudjelkha, M.—Ph.D. (Rensselaer Polytechnic Institute); ordinary and partial differential equations, special functions, Riemann-Bessel functions, asymptotics.

Kiehl, M.—Ph.D. (Rensselaer Polytechnic Institute); biomathematics.

Schmidt, D.A.—Ph.D. (Rensselaer Polytechnic Institute); graph theory, qualitative matrix analysis, mathematics education.

Research Assistant Professor

Nolan, C.J.—Ph.D. (Rice University); medical and seismic imaging using microlocal analysis.

Joint Appointment with Computer Science—Professor

Rogers, E.H.—Ph.D. (Carnegie Institute of Technology); VLSI architecture, computer applications (emeritus).
Undergraduate Programs

Mathematics has always been the cornerstone of scientific development. Rensselaer’s aim is to provide an education in mathematics, both as a subject in itself and as a discipline to aid in the development of other social and scientific fields. The undergraduate mathematics program educates students in a variety of mathematical areas. The flexibility in this program, with its numerous options, permits selection of courses ranging from pure theory (which builds a foundation for more advanced studies), to applied subjects focusing on mathematical modeling and the solution of real-world problems. In particular, Rensselaer’s Department of Mathematical Sciences is one of the few American programs with a strong faculty orientation toward mathematics applications. Reflecting this emphasis are the many undergraduate courses dealing with areas of mathematical applications and the applied flavor with which department faculty typically teach them.

Baccalaureate Programs

Four curricula leading to a B.S. in Mathematics have been designed to permit the construction of programs that reflect individual student interests and career objectives. These curricula include:

- Mathematics—a traditional program emphasizing the elements of pure and applied mathematics.
- Applied Mathematics—emphasizing both the modeling of physical phenomena and methods of analyzing the resulting mathematical problems.
- Mathematics of Computation—a program bridging mathematics and computer science, with emphasis on numerical methods for solution of problems in science and engineering.
- Mathematics of Operations Research—emphasizing the use of mathematics in developing and studying analytical models of discrete systems, especially those that arise in management, engineering, and social sciences.

These four curricula share several common features. First, they each contain eight free electives that permit students to design unique programs. These electives also allow students to concentrate on a subject in addition to mathematics, to obtain a broad-based education, or to complement their mathematics program. A second common feature is the Humanities, Arts, and Social Sciences requirement of 24 credits. Finally, completion of all four curricula requires a total of 124 credits.

An immediate choice among these four curricula is not necessary, since for the first two years, all mathematics students follow the same basic curriculum. This initial two-year course of study is outlined in the Programs section of this catalog and is followed by sample junior/senior curricula for each of the department’s four undergraduate programs. In addition to the specific requirements in each track, it is strongly recommended that students planning to pursue graduate study in mathematics take the following courses:

MATH 4100 Linear Algebra
MATH 4200 Mathematical Analysis I
MATH 4210 Mathematical Analysis II
MATH 4300 Introduction to Complex Variables

THE FIRST TWO YEARS - MATHEMATICS

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<th>FIRST YEAR</th>
<th>Credit Hours</th>
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<tbody>
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<tr>
<td>CSCI 1100</td>
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<tr>
<td>MATH 1010</td>
<td>Calculus I .................................................. 4</td>
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<tr>
<td>MATH 1900</td>
<td>Art and Science of Mathematics I ................................ 1</td>
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<tr>
<td>PHYS 1100</td>
<td>Physics I .................................................... 4</td>
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<td>HASS Elective ............................................... 4</td>
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<tr>
<td>MATH 1020</td>
<td>Calculus II .................................................. 4</td>
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<td>MATH 1910</td>
<td>Art and Science of Mathematics II ................................ 1</td>
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<td>Science Elective ............................................... 4</td>
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<td></td>
<td>HASS Elective ............................................... 4</td>
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1 The courses BIOL 1010 and PHYS 1100 may be taken in any semester they are offered and in either order.
SECOND YEAR

Fall

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<thead>
<tr>
<th>Course</th>
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Spring

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<th>Course</th>
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<td>MATH 2400</td>
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<td>MATH 4090</td>
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<td>HASS Elective</td>
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</table>

Program Information

In the above curriculum, the first-year seminar courses MATH 1900 and MATH 1910 are not required, but are strongly recommended. This weekly seminar course for math majors presents interesting and challenging mathematical problems and ideas for discussion.

The science electives should be courses from the School of Science outside of math. Note that mathematical science includes all courses with MATH and MATP codes (and any course cross-listed with a MATH or MATP course).

THIRD YEAR

Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tr>
<td>MATH 4200</td>
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<td>HASS Elective</td>
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Spring

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<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tr>
<td>MATH Option or Algebra Option</td>
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FOURTH YEAR

Fall

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<th>Course</th>
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<tr>
<td>MATH 4950</td>
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Spring

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<th>Course</th>
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Program Information

The above curriculum provides a broad and basic education in mathematics. It is especially suited to those intending to continue on to graduate education in mathematics or some other scientific and engineering field. Considerable flexibility is built into this program to allow students and their advisers to tailor programs to individual objectives. As a result, by choosing appropriate mathematical options, the curriculum is equally useful to those seeking immediate employment upon graduation.

Students should note that the mathematics options listed above are any 4000-level or higher course from the Department of Mathematical Sciences at most one of which may be taken Pass/No Credit. (Students planning on graduate study are advised against using Pass/No Credit on mathematics options.). The algebra option is MATH 4100 or MATH 4010 and may not be taken Pass/No Credit.

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1 The courses BIOL 1010 and PHYS 1100 may be taken in any semester they are offered and in either order.
2 The course PHIL 2140 is strongly recommended as an HASS course in the fall of the first or second year.
3 Students taking MATH 4090 in the fall semester of their sophomore year may consider MATH 4120, MATH 4200, or MATH 4010, as another proof based course for spring semester.
APPLIED MATHEMATICS CURRICULUM

THIRD YEAR

Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>MATH 4800 Numerical Computing</td>
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<td>Elective</td>
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<tr>
<td>Mathematics Option</td>
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Spring

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<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Mathematics Option</td>
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<tr>
<td>Mathematics Option</td>
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FOURTH YEAR

Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>MATH 4700 Foundations of Applied Mathematics</td>
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<td>MATH 4950 Senior Research</td>
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Spring

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<th>Course</th>
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<td>Mathematics Option</td>
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</table>

Program Information

The above curriculum stresses courses that involve the construction, analysis, and evaluation of mathematical models of real-world problems and those areas of mathematics most widely used to solve them. Thus, it prepares students to deal with mathematical problems that arise in science, engineering, or management. Applied mathematics students enjoy considerable flexibility, but are urged to acquire a solid background in the three principal areas of applied mathematics, which are modeling, analysis or solution methods, and numerical analysis.

Students should note that the mathematics options listed above are any 4000-level or higher course from the Department of Mathematical Sciences at most one of which may be taken Pass/No Credit. (Students planning on graduate study are advised against using Pass/No Credit on mathematics options.) It is also recommended that students take PHYS 1100 and PHYS 1200.

MATHEMATICS OF COMPUTATION CURRICULUM

THIRD YEAR

Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tr>
<td>MATH 4800 Numerical Computing</td>
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Spring

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<tbody>
<tr>
<td>Computation Option</td>
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FOURTH YEAR

Fall

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<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>MATH 4950 Senior Research</td>
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<td>CS Option</td>
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Spring

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</table>
Program Information
Computers and computational methods play an important role in all fields of science and engineering. Thus, the above curriculum focuses on the mathematical development, analysis, and application of numerical methods. Surrounding this main focus are courses that build mathematical expertise in analysis, modeling, and applications. This curriculum also allows the flexibility to pursue courses in computer science and other fields of science and engineering.

Students should note that the mathematics options listed above are any 4000-level or higher course from the Department of Mathematical Sciences and the CS options are any 2000-level or higher courses from Computer Science (i.e., courses coded CSCI and not cross listed with any math course), and at most one of the four courses may be taken Pass/No Credit. (Students planning on graduate study are advised against using Pass/No Credit on mathematics options.) The computation option is either MATH 4820 or MATP 4820 and may not be taken Pass/No Credit.

It is also recommended that students take PHYS 1200 and CSCI 1200.

MATHEMATICS OF OPERATIONS RESEARCH CURRICULUM

THIRD YEAR

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>MATP 4700</td>
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<tr>
<td>Mathematical Models of Operations Research</td>
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<table>
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<td>MATP 4xxx</td>
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<tr>
<td>OR Option</td>
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FOURTH YEAR

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<tbody>
<tr>
<td>MATH 4950</td>
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<td>Senior Research</td>
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</table>

Program Information
The above curriculum emphasizes the use of mathematics for developing and studying analytical models of systems. These models are used to form better decisions in areas such as management, engineering, and the social sciences. In mathematical programming, a problem is modeled as an objective function with constraints on the possible solutions, then the resulting model is optimized. The models are solved using computer programs. Algebra, analysis, and discrete mathematics all play a role in analyzing the models and in developing computer algorithms to solve them. Frequently, the inputs and outcomes of the model are not known with certainty, thus probability and statistics are used.

Students should note that the mathematics options listed above are any 4000-level or higher course from the Department of Mathematical Sciences, plus up to two 4000-level or higher courses from Industrial and Systems Engineering (ISYE) or Computer Science (CSCI). In other words, of the four mathematics options, a minimum of two must be coded MATH or MATP, and at most one of these four courses may be taken Pass/No Credit. (Students planning on graduate study are advised against using Pass/No Credit on mathematics options.)

Also, the OR option in this curriculum is either MATP 4600 or MATP 4820 and may not be taken Pass/No Credit.

Minor Programs
Students not majoring in mathematics may receive a minor in math by taking four courses at the 4000 level or above from the MATH and MATP course groups. These courses should form a coherent program and have the prior approval of the chairman of the Department of Mathematical Sciences.
Dual Major Programs

The requirements for a dual major are described in the section on Academic Information and Regulations. Interest in such programs is increasing, and recent combinations have included math and physics, math and computer science, and math and psychology. Typical schedules for such combinations can be found at the department’s Web site under dual majors.

Accelerated Programs

Qualified students may earn a B.S. and M.S. degree in the same or different areas in a shorter-than-usual time. They may do so through the use of advanced placement credit, by taking additional courses during the fall and spring semesters, and/or by taking summer courses.

For example, a student with advanced placement credit for Calculus I and II may earn the B.S. and M.S. degrees within four years by taking an additional course each regular fall and spring semester. Since a student may take up to 21 credit hours per semester at no additional charge, it may be possible to earn both degrees for the cost of a B.S. alone. As a second example, rather than taking more courses during the academic year, a student may earn two degrees in four years by taking eight courses distributed over three summers.

Such a joint degree program requires that the student apply to and be accepted by the Office of Graduate Education at an appropriate stage. A wide variety of joint degree programs can be arranged depending on the student’s background, interests, and desired rate of progress. The interested student should consult the faculty adviser to design an optimum program.

Graduate Programs

The Department of Mathematical Sciences offers programs leading to the M.S. and Ph.D. degrees. Each curriculum is highly flexible, and each student's program of study is individually designed.

A departmental colloquium series, in which both mathematics faculty and guest lecturers present current research work, supplements course work. In addition, graduate students organize a weekly seminar, in which they present material from their research. Moreover, each semester, faculty and students organize informal seminars that explore topics of mutual interest. In a special course called Introduction to Research in Mathematics, each week a faculty member discusses his or her research program and describes current problems for graduate students to investigate. In addition, through formal course work and individual contact with the faculty, students become familiar with all departmental research activities. The department’s Web site also provides an overview of these research activities and lists the faculty working in each area.

Undergraduates with backgrounds in mathematics or any related major with significant mathematical content are admissible to the graduate program.

Master's Program

Applied Mathematics M.S.

The emphasis of this program is on mathematics and how it is employed to study science, engineering, or management problems. It stresses construction, analysis, and evaluation of mathematical models of real-world problems, and those areas of mathematics that are most widely used to solve them. The requirements for this degree allow students to prepare for entry into the Ph.D. program in applied mathematics or for employment in business, industry, or government.

The student must meet the requirements of the Office of Graduate Education and follow a Plan of Study acceptable to this office and the Department of Mathematical Sciences. Each student’s program of study must include:

- At least four graduate (6000) level courses of four credits each, of which at least two must be in math (MATH 6xxx or MATP 6xxx).
- At least four courses coded MATH or MATP of four credits each.
- At least one three- or four-credit course at the 4000 or 6000 level outside the department (i.e., not coded MATH or MATP and not cross listed with any department course), selected in consultation with the math adviser.
- Each student must participate in a capstone professional experience, by registering for and completing one of the following alternatives: 1) a Master’s Project in Mathematics, MATH 6980; 2) a Master’s Practicum, MATH 6970, such as a graduate cooperative internship or active participation in the Applied Mathematics Industry Workshop (a department faculty member must approve a student's plans in advance and must certify its satisfactory completion); 3) two 6000-level MATH courses, with second digit either 4, 5, 6, 7 or 8 (one may be an appropriate Special Topics course MATH 696x, subject to adviser’s approval); 4) two 6000-level MATP courses (one may be an appropriate Special Topics course MATP 696x, subject to adviser’s approval).
Mathematics M.S.
The student must meet the requirements of the Office of Graduate Education and follow a Plan of Study acceptable to this office and the Department of Mathematical Sciences. The Plan of Study should represent a reasonably broad program in mathematics and must contain:

- At least four graduate (6000) level courses of four credits each, of which at least two must have numbers in the range MATH 6000 to MATH 6390.
- At least four courses coded MATH or MATP of four credits each.
- Each student must participate in a capstone professional experience, by registering for and completing one of the following alternatives: 1) a Master’s Project in Mathematics, MATH 6980; 2) a Master’s Practicum, MATH 6970, such as a graduate cooperative internship (a department faculty member must approve a student's plans in advance and must certify its satisfactory completion).

Doctoral Programs
Students working for the doctorate must demonstrate high achievement both in scholarship and in independent research. All programs must follow the general rules of the Office of Graduate Education.

The Ph.D. degree results from following a program of study in mathematics or in applied mathematics. In either case, the student’s program of study must include:

- At least six, four-credit (nonthesis) graduate mathematics courses (i.e., those with numbers MATH 6xxx or MATP 6xxx).
- At least one three- or four-credit course at the graduate (6000) level outside the department (i.e., not coded MATH or MATP and not cross-listed with any department course), selected in consultation with the math adviser.
- At most 30 thesis/research credits.
- All doctoral students must pass a written preliminary exam as well as an oral qualifying examination, and complete an oral candidacy presentation. Descriptions of these requirements can be found on the department’s Web site.

In addition, the course MATH 6591 Research in Mathematics is strongly suggested. Any deviations from these requirements must have the approval of the Department's Graduate Committee.

Course Descriptions
Courses directly related to all Mathematical Sciences curricula are described in the Course Description section of this catalog under the department code MATH or MATP.

Physics, Applied Physics, and Astronomy

Head: Angel E. Garcia
Associate Head: Peter D. Persans
Department Home Page: http://www.rpi.edu/dept/phys/physics.html

Physics is the source of new concepts about the nature of the universe and is a driving force for new technologies. The fundamental physics research of one generation frequently leads to the applied physics and technology of the next.

The Department of Physics, Applied Physics, and Astronomy programs prepare undergraduate students to contribute to these new concepts and technologies through innovative teaching methods that combine student-faculty interactions, computer-based education, and "hands-on" experience in modern laboratories. The curricula are flexible so that students can prepare for either technical employment upon graduation or for graduate study in physics, applied physics, engineering, or other disciplines. Physics also provides an excellent foundation for a nontechnical career. Another important aspect of the physics program is student-faculty research projects involving collaboration between physics undergraduates and faculty on a variety of research topics at the forefront of the field.

The Department of Physics, Applied Physics, and Astronomy's graduate programs lead to the M.S. and the Ph.D. in physics. These degrees are available in several research areas that are summarized below. For graduate students specializing in Astronomy and Astrophysics, the M.S. degree is available either in Astronomy or Physics with specialization in Astrophysics.
Rensselaer’s graduate study in physics prepares students for a variety of careers including industrial research and development, government laboratory research, and university research and teaching. The department conducts both fundamental and applied research, often in collaboration with researchers from other Rensselaer departments, other universities, industry, or the National Laboratories. Characterizing the Physics Department’s intellectual climate are lively interactions between theorists and experimentalists with common research interests. Colloquia and department seminars supplement course work. As an important part of their graduate education, students collaborate with faculty members to make original research contributions in their area of specialization. Many have won national competitive graduate student research awards.

Research Innovations and Initiatives

Astronomy and Astrophysics
Research in the astrophysics group includes astrobiology, the chemistry of the interstellar medium, and Galactic structure. Research in astrobiology is funded by NASA through a grant to the interdisciplinary New York Center for Astrobiology. This research seeks to understand how interstellar clouds evolve into new solar systems. Current observational work focuses on spectroscopic detection of organic molecules in interstellar dust and gas and their contribution to the organic inventory of protoplanetary disks. Theoretical projects include multifluid magnetohydrodynamic shock waves and shock chemistry. Galactic structure research focuses on the outer structure of the Milky Way as revealed by millions of stars in the Sloan Digital Sky Survey and the Chinese Guoshoujing Telescope (formerly LAMOST) spectral survey of Galactic stars. The structure is used to constrain the processes by which the Milky Way galaxy formed and the distribution of the dark matter within it. The astrophysics group makes use of ground-based telescopes located at world class observing sites in the USA and Chile. Rensselaer also has access to data from major orbiting and airborne facilities, including the Hubble Space Telescope, Chandra, the Infrared Space Observatory, the Spitzer Space Telescope and the Stratospheric Observatory for Infrared Astronomy, and large ground-based astronomy projects, including the Sloan Digital Sky Survey and the Two Micron All Sky Survey (2MASS).

Biological Physics
Current research addresses theoretical and computational aspects of dynamics and statistical mechanics of biomolecular systems. The objectives are to understand the structure, dynamics, stability and function of biomolecules from physical principles. Protein folding, self-assembly, binding, and dynamics are important for understanding how proteins work and how they interact with other biomolecules. Knowledge gained from this research has applications in biotechnology, drug design, and biomaterials. Parallel computer simulation methods are being applied to study protein folding, and aggregation. Highly parallel computer simulations of the folding dynamics and thermodynamics of biomolecules in aqueous solutions are being performed. Other research interests include the hydrophobic effect, enzyme catalysis, nucleic acids, proteins, and membranes.

Research in complex biological systems also addresses competition and invasion phenomena in large-scale ecological systems and population dynamics, and investigating epidemic spreading and contagion in social networks. On-campus collaborations and facilities include the Social Cognitive Network Academic Research Center.

Condensed Matter Physics
The program concerns many aspects of matter in the condensed phase. The bulk of the matter, its surfaces, interfaces and the physics at reduced-dimensional systems, is distinguished in experiment and theory. Of interest are new concepts, materials, and techniques for high technology, nano technology, and green technology such as renewable energy, energy conservation, conversion, storage, and transmission. Many research projects are highly interdisciplinary and part of dedicated centers.

For the experimental study of materials, structures, and devices, metals, semiconductors, and insulators are prepared in thin film deposition and epitaxial growth. Their structural, electronic transport, spin, and optical properties are characterized and compared to theoretical and numerical investigations.

In theoretical work, the behavior of individual atoms, molecules and entire nanostructures are predicted in first principles calculations based on the fundamental concepts of quantum mechanics. The research requires the use of state-of-the-art supercomputer-systems and is therefore conducted in close partnership with the CNNI.

The matter of particular study includes wide bandgap semiconductors, photonic crystals, polymers, semiconductor nanoparticle composites, dielectrics, magnetic, and metallic thin films and nanostructures.

Characterization techniques include a wide range of electron, x-ray, ultraviolet, visible, infrared, terahertz, and scanning probe spectroscopies and microscopies. Methods of first principles calculation, low-temperature, vacuum, optics, electronics, and gas handling systems are being utilized.

Facilities include a Linux cluster, a local Blue Gene/Q super computer, and access to national computer facilities. On-campus resources include also the Micro and Nano Fabrication Clean Room, the Microelectronics Clean Room, and the Electron Microscope Laboratory. Off-campus accelerators at the University of Albany and the National Synchrotron Light Source are being used.
The faculty substantially contribute to the Smart Lighting Engineering Research Center, the Center for Integrated Electronics, the Focus Center for Interconnects, and the New York State Center for Future Energy Systems.

**Optical Physics**

Department research in optical physics covers a wide range of activities related to photons and their interaction with various materials. Experimental and theoretical research is on-going to give innovative solutions to today’s problems in both fundamental and application aspects of the research area. Particularly, the goals of the activities are directed towards the development of novel nanoelectronic and nanophotonic devices, and creative solutions for homeland security, renewable energies, biological and biomedical investigations, solar harvesting, and smart lighting.

Faculty research includes photonic crystals, plasmonics, photonic nanostructures, light emitting diodes, terahertz photonics, spectroscopy, chemical and biological sensing and identification, ultrafast and nonlinear phenomena, the development of novel ultrafast spectroscopic techniques, development of novel optical materials including wideband gap and narrow band gap semiconductors, metallic nanoparticles, nanowires and their arrays, semiconducting quantum dots and quantum wells, amorphous materials. Major facilities include various types of ultrafast lasers and ultrafast spectroscopy systems, terahertz spectroscopy systems, a micro and nanofabrication clean room for semiconductor processing, linear and nonlinear optical absorption, luminescence, Raman and Brillouin scattering, and various types of modulation spectroscopy systems.

Many faculty members in optical physics are simultaneously involved in other research areas such as condensed matter physics. Faculty members in this area contribute to the activities in the Interconnect Focus Center, the Smart Lighting Engineering Research Center, and the New York State Center for Future Energy Systems.

**Particle Physics**

The nature and structure of matter and energy remains one of mankind’s leading research frontiers. The faculty members are engaged in experimental and theoretical studies of the fundamental interactions of matter at sub-femtometer distances. This includes continued measurements of neutrino oscillations using a nuclear reactor complex in China, and R&D for a future neutrino experiments in the US and China. A longstanding program of experiments at the Thomas Jefferson National Accelerator Facility (JLab), examines the properties of the proton and its excited states, as well as novel investigations of nuclear matter properties with astrophysical significance.

The theoretical high energy physics research program focuses on aspects of physical interactions beyond the Standard Model. This includes investigations of new strong dynamics using lattice simulations and gauge-gravity dualities, with applications to supersymmetric and composite Higgs mechanism models.

**Faculty**

**Professors**

Garcia, A.E.—Ph.D. (Cornell University); theoretical and computational statistical mechanics of biomolecules.

Jackson, S.A.—Ph.D. (Massachusetts Institute of Technology); theoretical physics (Joint appointment with Engineering).

Korniss, G.—Ph.D. (Virginia Tech); statistical mechanics, dynamics in complex networks.

Lin, S.-Y.—Ph.D. (Princeton University); theory, fabrication, and experimental assessment of photonic crystal structures.

Lu, T.-M.—Ph.D. (University of Wisconsin); thin films and interfaces.

Morse, J.A.—Ph.D. (University of North Carolina, Chapel Hill); observational astronomy and astrophysics.

Napolitano, J.J.—Ph.D. (Stanford University); experimental nuclear and particle physics.

Nayak, S.K.—Ph.D. (Jawaharlal Nehru University); theoretical and computational physics, first principle calculations.

Newberg, H.J.—Ph.D. (University of California, Berkeley); astrophysics.

Persans, P.D.—Ph.D. (University of Chicago); spectroscopy of semiconductors, thin films, optical materials.

Roberge, W.G.—Ph.D. (Harvard University); theoretical astrophysics.

Schroeder, J.—Ph.D. (Catholic University of America); physics and biological physics high pressure.

Shur, M.S.—Dr.Sc. (Ioffe Institute); semiconductor physics, ballistic transport, terahertz radiation. (Primary appointment with ECSE also with PAPA, SOC).

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
Stoler, P.—Ph.D. (Rutgers University); experimental particle/nuclear physics, structure of hadrons.

Wang, G.-C.—Ph.D. (University of Wisconsin); growth and characterization of nanostructures.

Wetzel, C.M.—Ph.D. (Technical University, Munich); III-V nitride semiconductor physics, materials and devices in particular for lighting and electronics.

Whittet, D.C.B.—Ph.D. (St. Andrews University); astrophysics, observational astronomy, interstellar dust; origins of life.

Zhang, S. B.—Ph.D. (University of California at Berkeley); computational condensed matter theory, lower-dimension materials, defects in optoelectronic and photovoltaic materials, and physics and chemistry of energy storage materials.

Associate Professors

Lewis, K.M.—Ph.D. (University of Michigan); molecular electronics; quantum transport in nanoscale systems; low temperature characterization techniques; nanoscale fabrication.

Meunier, V.—Ph.D. (University of Namur, Belgium); computational solid state physics, electronic transport, energy storage, and low-dimensional structures; nano science.

Wilke, I.—Ph.D. (Swiss Federal Institute of Technology); ultrafast optics, photonics, optoelectronics and terahertz science and technology.

Yamaguchi, M.—Ph.D. (Hokkaido University); THz wave generation, pulse shaping, THz spectroscopy; acoustic/thermal transport in nanoscale materials; phonon and electron dynamics in condensed matter.

Assistant Professors

Giedt, J.—Ph.D. (University of California, Berkeley); particle phenomenology, lattice field theory, string compactifications, high energy mathematical and computational physics.

Stark, P.R.H.—Ph.D. (Harvard University); surface plasmon/photon interactions (Primary appointment with School of Architecture).

Professor of Practice

Washington, M.A.—Ph.D. (New York University); photonics.

Research Assistant Professors

Herce, H.D.—Ph.D. (North Carolina University); computational and experimental molecular biology.

Sun, Y.—Ph.D. (National University of Singapore); computational materials science.

Adjunct Faculty

Dwyer, S.R.—Ph.D. (Rensselaer Polytechnic Institute); tribology, surface science and physics education.

Kubarovsky, V.—Ph.D. (Institute for High Energy Physics, Russia); experimental nuclear physics.

Lee, S.L.—Ph.D. (University of Michigan); X-ray diffraction, environmentally-friendly thin films and nanostructures.

Lee, S.M.—Ph.D. (Harvard); photonics and x-ray optics.

Trinkala, M.—Ph.D. (SUNY Albany); theoretical physics, gravitation.

Undergraduate Programs

Undergraduate students begin with core curriculum courses that teach basic scientific principles and develop skills in problem solving, scientific thinking, and clear oral and written expression. Students also choose from a broad range of advanced courses in the Department of Physics, Applied Physics, and Astronomy and in other science and engineering departments depending upon their individual career goals.

Baccalaureate Programs

Rensselaer offers two undergraduate programs in physics, one leading to the B.S. in Physics and the other to the B.S. in Applied Physics. Students in the applied physics program must declare a concentration in a specific technological area, in which they take at least four elective courses.
## PHYSICS CURRICULUM

### FIRST YEAR

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
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<tbody>
<tr>
<td><strong>Fall</strong></td>
<td>CHEM 1100</td>
<td>Chemistry I</td>
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<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
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<td></td>
<td>PHYS 1100</td>
<td>Physics I*</td>
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<td>HASS</td>
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<tr>
<td><strong>Spring</strong></td>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
<td>4</td>
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<td>MATH 1020</td>
<td>Calculus II</td>
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<td></td>
<td>PHYS 1200</td>
<td>Physics II*</td>
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### SECOND YEAR

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<tr>
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<td></td>
<td>PHYS 2210</td>
<td>Quantum Physics I</td>
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<td></td>
<td>Elective</td>
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<tr>
<td><strong>Spring</strong></td>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
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<td>Elective II</td>
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### THIRD YEAR

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<td>Experimental Physics</td>
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<td>PHYS 4330</td>
<td>Theoretical Mechanics</td>
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<td>MATH 4xxx</td>
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<td>PHYS 4100</td>
<td>Introductory Quantum Mechanics</td>
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<td>PHYS 4210</td>
<td>Electromagnetic Theory</td>
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<td>PHYS 4420</td>
<td>Thermodynamics and Statistical Mechanics</td>
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<td>MATH 4xxx</td>
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### FOURTH YEAR

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<td>PHYS 4910</td>
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<td>PHYS 4xxx or ASTR 4xxx-level</td>
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<td><strong>Spring</strong></td>
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<td>HASS</td>
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</table>

1. HASS courses shall total 24 credits and meet distribution requirements in the catalog.
2. CSCI 1010 may be substituted for CSCI 1100.
3. Honors Physics I and II (PHYS 1150 and PHYS 1250) may be substituted for PHYS 1100 and PHYS 1200, respectively.
4. MATH 4xxx electives to be chosen from the following:
   - MATH 4100 Linear Algebra
   - MATH 4300 Introduction to Complex Variables: Theory and Applications
   - MATH 4400 Ordinary Differential Equations and Dynamical Systems
   - MATH 4500 Methods of Partial Differential Equations of Mathematical Physics
   - MATH 4600 Advanced Calculus
   - MATH 4700 Foundations of Applied Mathematics
   - MATH 4800 Numerical Computing

* Students must complete a capstone experience, which may be fulfilled through research participation or by passing a designated senior elective course in Physics or Astronomy along with the accompanying PHYS 4910 independent study culminating experience.
# APPLIED PHYSICS CURRICULUM

## FIRST YEAR

### Fall

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<td>CHEM 1100</td>
<td>Chemistry I</td>
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<td>MATH 1010</td>
<td>Calculus I</td>
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<td>PHYS 1100</td>
<td>Physics I</td>
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<td>BIOL 1010</td>
<td>Introduction to Biology</td>
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<td>MATH 1020</td>
<td>Calculus II</td>
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<td>PHYS 1200</td>
<td>Physics II</td>
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<tr>
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<td>Thermodynamics and Statistical Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>Technical Elective 2</td>
<td></td>
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<tr>
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## FOURTH YEAR

### Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Technical Elective 2</td>
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<tr>
<td>Technical Elective 2</td>
<td></td>
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</tr>
<tr>
<td>HASS 1</td>
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### Spring

<table>
<thead>
<tr>
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<tr>
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<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>HASS 1</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

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1. HASS courses shall total 24 credits and meet distribution requirements in the catalog.
2. Technical Electives are to be selected with the aid of an adviser in order to create a concentration in an appropriate applied physics field.
3. CSCI 1010 Intro. Comp. Sci. may be substituted for CSCI 1100.
4. Honors Physics I and II (PHYS 1150 and PHYS 1250) may be substituted for PHYS 1100 and PHYS 1200, respectively.
5. Students must complete a culminating experience which may involve research or coursework approved by the Physics Undergraduate Program Committee.
Concentrations
The applied physics program requires a concentration of four technical courses that focuses on a specific technological area. Possible concentrations include, but are not limited to optical physics, microelectronics, semiconductor physics, optoelectronics, geophysics, biophysics, computation applied physics, environmental physics, nuclear science, and space science. Two such concentrations are illustrated below:

Optical Physics
A concentration in optical physics might include four courses from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 2620</td>
<td>Fundamentals of Optics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 4630</td>
<td>Lasers and Optical Systems</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 4640</td>
<td>Optical Communications and Integrated Optics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 4720</td>
<td>Solid-State Physics</td>
<td>4</td>
</tr>
</tbody>
</table>

Microelectronics
A concentration in microelectronics might include four courses from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE 2050</td>
<td>Introduction to Electronics</td>
<td>4</td>
</tr>
<tr>
<td>ECSE 2210</td>
<td>Microelectronics Technology</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4220</td>
<td>VLSI Design</td>
<td>3</td>
</tr>
<tr>
<td>ECSE 4250</td>
<td>Integrated Circuit Processes and Design*</td>
<td>3</td>
</tr>
<tr>
<td>MTLE 4160</td>
<td>Semiconducting Materials</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 4720</td>
<td>Solid-State Physics</td>
<td>4</td>
</tr>
</tbody>
</table>

Electives
Physics or applied physics majors planning to continue on to graduate studies in these areas should take some combination of advanced physics courses to prepare for these studies. These courses should be chosen from the following undergraduate- and graduate-level courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR 4220</td>
<td>Astrophysics</td>
<td>4</td>
</tr>
<tr>
<td>ASTR 4240</td>
<td>Gravitation and Cosmology</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 4630</td>
<td>Lasers and Optical Systems</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 4720</td>
<td>Solid-State Physics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 6510</td>
<td>Quantum Mechanics I</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 6520</td>
<td>Quantum Mechanics II</td>
<td>4</td>
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</tbody>
</table>

Additional Information
Students planning on graduate work in astronomy or astrophysics are urged to choose electives from the above list, as well as include the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR 2050</td>
<td>Introductory Astronomy and Astrophysics</td>
<td>4</td>
</tr>
<tr>
<td>ASTR 4120</td>
<td>Observational Astronomy</td>
<td>4</td>
</tr>
<tr>
<td>ASTR 4220</td>
<td>Astrophysics</td>
<td>4</td>
</tr>
<tr>
<td>ASTR 4240</td>
<td>Gravitation and Cosmology</td>
<td>3</td>
</tr>
</tbody>
</table>

Dual Major Programs
Physics students can obtain a dual major with any other degree at Rensselaer by fulfilling the requirements for both degrees. Overlapping requirements can be applied to both programs, permitting many dual degrees to be completed with the credits required for one degree. In some cases, special templates have been agreed upon which permit specific substitutions of courses. An example, the Applied Physics/ECSE program, can be found online at the ECSE department Web site.

Co-terminal Program
Students may generally select, in their junior year, to follow a five-year B.S.-M.S. program. These students receive the B.S. in physics and the M.S. in either physics or another science or engineering discipline.

* Students cannot receive credit for ECSE 4250 and MTLE 4160.
Minor Programs

Astrobiology Minor

The Biology, Biochemistry and Biophysics, Chemistry and Chemical Biology, Earth and Environmental Sciences, and Physics Departments participate in a multidisciplinary minor in Astrobiology for students majoring in these or other disciplines. To be eligible for the minor, students must pass the three-credit course ASTR 4510 Origins of Life - A Cosmic Perspective and at least two semesters of the one-credit seminar course ISCI 4510; they must also undertake a four-credit research project on a topic related to Astrobiology under the supervision of a faculty member engaged in Astrobiology research in one of the above departments; finally they must complete a further two courses outside the major field of study, selected from the following:

Program Requirements
For a double major, the requirement that the two selected courses must be outside the major field of study is reduced to one provided both majors are in the primary relevant areas of study (i.e. biology, chemistry, geology, and physics).

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR 2050</td>
<td>Introductory Astronomy and Astrophysics</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4620</td>
<td>Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4760</td>
<td>Molecular Biochemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 2250</td>
<td>Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 4810</td>
<td>Chemistry of the Environment</td>
<td>4</td>
</tr>
<tr>
<td>ENVE 2110</td>
<td>Introduction to Environmental Engineering</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 4540</td>
<td>Organic Geochemistry</td>
<td>4</td>
</tr>
</tbody>
</table>

Astronomy Minor

Program Requirements
Physics and Applied Physics majors are required to take four courses or 16 credits at the 2000 or 4000 level with the ASTR course code.

To complete an astronomy minor, a student should take:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR 2050</td>
<td>Introductory Astronomy and Astrophysics</td>
<td>4</td>
</tr>
<tr>
<td>ASTR 4120</td>
<td>Observational Astronomy</td>
<td>4</td>
</tr>
<tr>
<td>ASTR 4510</td>
<td>Origin of Life: A Cosmic Perspective</td>
<td>3</td>
</tr>
<tr>
<td>ASTR 4960</td>
<td>Topics in Astronomy and Astrophysics</td>
<td>4</td>
</tr>
</tbody>
</table>

Astrophysics Minor

This minor is available to students majoring in physics and planning on graduate study in astronomy or astrophysics. To complete this minor, a student should take PHYS 2110 or PHYS 2510, ASTR 4220, at least one four-credit research project in astrophysics, and at least three semesters of the one-credit ASTR 4900.

Physics Minor

Students not majoring in physics may minor in this subject by taking at least 16 credit hours of physics courses (coded PHYS) at the 2000 level or higher.

Graduate Programs

Graduate students develop flexible individual programs of study and research in one or more of the available research areas. The department offers both the M.S. and Ph.D. degrees in physics, and a M.S. degree in astronomy.

Master's Program

M.S. in Astronomy

Completion of the M.S. in astronomy requires 30 credits of graduate work beyond the bachelor's degree, including a minimum of 21 credits in course work. At least 15 credits must be at the 6000 level or above. The cumulative GPA for all courses applied towards a master's degree must be 3.0 or higher.
Course work should meet the needs of the individual student, but must include:

• (1) One course from: PHYS 6410 (Electrodynamics), PHYS 6510 (Quantum Mechanics), PHYS 6520 (Quantum Mechanics II), PHYS 6590 (Statistical Physics)

• (2) Two courses from: ASTR 4120 (Observational Astronomy), ASTR 4220 (Astrophysics), ASTR 4240 (Gravitation and Cosmology), ASTR 4510 (Origins of Life: A Cosmic Perspective), ASTR 6250 (Interstellar Medium), ASTR 6960 (Special Topics in Astronomy and Astrophysics)

• (3) Three semesters of ASTR 6900 (Astrophysics Seminar)

• (4) A six- to nine-credit formally presented thesis or multiple-semester project in astronomy or astrophysics

M.S. in Physics
Completion of the M.S. requires 30 credits of graduate work, including a minimum of 21 credits in course work. Course work should meet the needs of the individual student, but must include PHYS 6510 and two of the following three courses: PHYS 6410, PHYS 6520 and PHYS 6590. The master’s degree also requires some credits of research, which may culminate in a formally presented thesis (six to nine credits) or a research project (three credits). Some teaching experience is required for the degree.

Doctoral Programs
Ph.D. in Physics
Seventy-two credits beyond the bachelor’s degree or 42 credits beyond the M.S. are required, including credits for original research culminating in a formally presented thesis. A manuscript on the thesis research should be prepared for publication.

Admission to the Ph.D. program is granted only upon passing a written qualifying examination by the beginning of the third semester of Rensselaer graduate work. The advanced undergraduate-level exam is given in two parts: 1) Mechanics and Electrodynamics and 2) Quantum Mechanics, Thermodynamics, and Statistical Mechanics. The examination is given twice annually in August and January.

Doctoral requirements do not state a minimum number of course credits. However, students must take the basic core of four courses including PHYS 6410, PHYS 6510, PHYS 6520, and PHYS 6590. Students are expected to obtain a grade of at least B in each of these courses. In addition to the above sequence of core courses, there are the following doctoral course requirements. In addition to these core courses, each student must take 14 additional credits of technical electives at the 4000 and 6000 level, as approved by the student’s adviser and the Graduate Program Committee. Of these 14 credits, at least seven credits must have a PHYS or ASTR prefix, and at least seven credits must be at the 6000 level (a single class can be counted towards both requirements). Students must also pass the Physics Colloquium in four semesters. Note: PHYS 6530 is strongly recommended for all students (all theory students should take this course). There are special requirements for students specializing in astrophysics and biophysics.

Once students have chosen a Ph.D. project and assembled a committee, they will present a brief written thesis proposal to the committee and orally defend it. In the oral exam, members of the committee question students specifically on the planned research and more generally on the physics related to that research. This candidacy exam is normally taken at the end of the third year.

Some teaching experience is also required for the Ph.D. degree.

Course Descriptions
Courses directly related to all Physics, Applied Physics, and Astronomy curricula are described in the Course Description section of this catalog under the department codes PHYS or ASTR.

Interdisciplinary Degree Programs
Rensselaer’s commitment to providing opportunities for interdisciplinary education is especially apparent within the School of Science. The successful pursuit of almost any Rensselaer field of study requires a strong background in one or more of the sciences. Furthermore, the various scientific disciplines overlap in many ways, just an example of which are the mathematics-based fields of chemistry and physics. The School of Science offers an impressive array of unique programs that cross not only scientific disciplines, but also disciplines within other Rensselaer Schools.

The special interdisciplinary opportunities administered by the School of Science allow students to develop a breadth and depth of knowledge in multiple disciplines, and include both degree and research programs. By nature, these programs are highly flexible and often involve working in teams with faculty and students representing multiple disciplines.
Additional interdisciplinary programs available at Rensselaer are outlined within the catalog sections for other Institute schools and for the Information Technology and Web Science program.

**Biochemistry and Biophysics**

**Director, Graduate Degree Program:** Chunyu Wang

Biochemistry and biophysics are closely related fields. Biochemistry focuses on the interconversion of compounds in the many complex reactions of life, on the mechanisms whereby enzymes catalyze and regulate these reactions, and the function and structure of the molecular components of living organisms. Biophysics is principally concerned with processes of energy conversion, information transmission, and the structure and properties of materials in biological systems, as explored with methods of physics. Biochemical and biophysical research is advancing the basic life sciences and making possible advances in more applied fields such as medicine and agriculture. For example, in the pharmaceutical industry, elucidating mechanisms of drug action and devising new ways of dealing with diseases increasingly depend on application of knowledge and techniques of biochemistry and biophysics.

Rensselaer’s biochemistry and biophysics undergraduate curriculum includes thorough grounding in mathematics, chemistry, and physics, along with modern biochemistry, biophysics, and molecular-level biology. Advanced biochemistry and biophysics courses impart knowledge and training in cutting-edge research approaches. Students following this curriculum are thus well prepared for graduate school and employment in the biotechnology industry. The curriculum also provides an excellent background for students planning careers in medicine. While rigorous, the undergraduate curriculum offers sufficient flexibility and course choices to allow students to tailor their education to particular career paths. Most students pursue undergraduate research in faculty laboratories. Some seek industrial experience through Rensselaer’s Cooperative Education Program, and the high degree of flexibility facilitates fitting a co-op experience into the degree program.

The master’s degree program prepares students for jobs in biotechnology, pharmaceuticals, and other related industry sectors and is well suited to students wishing to upgrade their skills while employed in industry. The program may also be attractive to students wishing to obtain an M.S. degree before proceeding to professional study in medicine, veterinary science, dentistry, etc. Those with a B.S. degree in a field not closely related to modern biological science who wish to enter into a doctoral program at Rensselaer or elsewhere may also benefit from the program.

The Ph.D. program in Biochemistry and Biophysics includes faculty from several departments in the Schools of Science and Engineering, interested in molecular-level life sciences, biochemistry, and biophysics. State-of-the-art research laboratories and core facilities in the Center for Biotechnology and Interdisciplinary Studies provide research opportunities for doctoral students in a wide range of topics.

**Research Innovations and Initiatives**

Biophysical research at Rensselaer includes the study of areas as diverse as photosynthesis, bioenergetics of Na+ transport, myosin mechanics, microtubule-based motors, cellular bioengineering, and biofluid mechanics. A variety of approaches, including molecular modeling, spectroscopic probes, nuclear magnetic resonance, electron spin resonance, and molecular biology are being used to study protein structure. Biochemical research includes the application of chromatography to large-scale purification of biological macromolecules, biosensors, prebiotic chemistry, biochemical signaling, glycochemistry, proteomics, DNA aptamers, rational protein design, and folding and stability of RNA and proteins.

**Faculty**

The science and engineering faculty members of the Center for Biophysics listed below provide a variety of research opportunities for undergraduate and graduate students enrolled in the Biochemistry and Biophysics degree programs. Faculty members from the Biology and Chemistry Departments who are involved in the teaching of biochemistry and biophysics courses are designated with an asterisk (*).


**Biomedical Engineering:** D. Vashishth

**Chemistry and Chemical Biology:** C.M. Breneman, W. Colon,* J. Kempf,* K.V. Lakshmi, R.J. Linhardt, L. McGown, M.D. Platt, M. Wentland

**Mathematical Sciences:** M.H. Holmes, D. Isaacson, M. Zuker

**Chemical and Biological Engineering:** G. Belfort, C. H. Collins, S.M. Cramer, J.S. Dordick, S. Garde

**Physics:** A. Garcia, I. Wilke, X.-C. Zhang
## Undergraduate Programs

### FIRST YEAR

#### Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CHEM 1110</td>
<td>Chemistry I with Advanced Lab&lt;sup&gt;1&lt;/sup&gt;</td>
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<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>Elective&lt;sup&gt;2&lt;/sup&gt;</td>
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<td>4</td>
</tr>
<tr>
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#### Spring

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<tr>
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<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>BIOL 2120</td>
<td>Introduction to Cell and Molecular Biology</td>
<td>4</td>
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<tr>
<td>CHEM 1200</td>
<td>Chemistry II</td>
<td>4</td>
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<tr>
<td>MATH 1020</td>
<td>Calculus II</td>
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### SECOND YEAR

#### Fall

<table>
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<tbody>
<tr>
<td>CHEM 2230</td>
<td>Organic Chemistry Laboratory I</td>
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<tr>
<td>CHEM 2250</td>
<td>Organic Chemistry I</td>
<td>3</td>
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<tr>
<td>BIOL 2500</td>
<td>Genetics and Evolution</td>
<td>4</td>
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<tr>
<td>Quantitative Option</td>
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#### Spring

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4620</td>
<td>Molecular Biology&lt;sup&gt;2&lt;/sup&gt;</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 2240</td>
<td>Organic Chemistry Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 2260</td>
<td>Organic Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 1200</td>
<td>Physics II</td>
<td>4</td>
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<tr>
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### THIRD YEAR

#### Fall

<table>
<thead>
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<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>BCBP 4760</td>
<td>Molecular Biochemistry I</td>
<td>4</td>
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<tr>
<td>CHEM 2440</td>
<td>Physical Chemistry for Life Sciences&lt;sup&gt;3&lt;/sup&gt;</td>
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<td>Laboratory Option</td>
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<td>4</td>
</tr>
<tr>
<td>HASS&lt;sup&gt;1&lt;/sup&gt;</td>
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#### Spring

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<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCBP 4770</td>
<td>Molecular Biochemistry II</td>
<td>4</td>
</tr>
<tr>
<td>Elective&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Elective&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>HASS&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td>4</td>
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</table>

### FOURTH YEAR

#### Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCBP 4990</td>
<td>Senior Research Thesis&lt;sup&gt;5&lt;/sup&gt;</td>
<td>4</td>
</tr>
<tr>
<td>Molec. Biophysics Module</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Elective&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td>4</td>
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<tr>
<td>Elective&lt;sup&gt;2&lt;/sup&gt;</td>
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#### Spring

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molec. Biophysics Module</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Elective&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Elective&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

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1. Humanities, Arts, and Social Science (HASS) courses should minimally add up to 24 credits.
2. Molecular Biology may be taken in the spring of the third year.
3. Students may substitute CHEM 4410 and CHEM 4420.
4. Students may substitute CHEM 1110 for CHEM 1110.
5. Students may substitute for Senior Research Thesis any 4000- or 6000-level BCBP, BIOL, or CHEM course that is not a required course or one that has been used to fulfill the Laboratory Option or the requirement for two Molecular Biophysics Modules.
6. Premedical students should take BIOL 1010.
### Molecular Biophysics Modules (Choose 2)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCBP 4310</td>
<td>Genetic Engineering</td>
<td>4</td>
</tr>
<tr>
<td>BCBP 4640</td>
<td>Proteomics</td>
<td>4</td>
</tr>
<tr>
<td>BCBP 4780</td>
<td>Protein Folding</td>
<td>4</td>
</tr>
<tr>
<td>BCBP 4870</td>
<td>Protein Structure Determination</td>
<td>4</td>
</tr>
</tbody>
</table>

### Quantitative Option (Choose 1)

<table>
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<tr>
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<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>CSCI 1010</td>
<td>Introduction to Computer Programming</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 1100</td>
<td>Computer Science I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2010</td>
<td>Multivariable Calculus and Matrix Algebra</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2400</td>
<td>Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4720</td>
<td>Mathematics in Medicine and Biology</td>
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</table>

### Laboratory Option (Choose 1)

<table>
<thead>
<tr>
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<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCBP 4710</td>
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<td>4</td>
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### Recommended Electives

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</tr>
<tr>
<td>BCBP 2900</td>
<td>Research in Biochemistry/Biophysics</td>
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<td>Introduction to Cell and Molecular Biology</td>
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<td>BIOL 2500</td>
<td>Genetics and Evolution</td>
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<td>BIOL 4200</td>
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<td>BIOL 4270</td>
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<tr>
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<td>Molecular Biology Laboratory</td>
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<td>Cell and Developmental Biology Laboratory</td>
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<tr>
<td>CHEM 2110</td>
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<td>CHEM 4330</td>
<td>Drug Discovery</td>
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<tr>
<td>CHEM 4620</td>
<td>Introduction to Polymer Chemistry</td>
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<td>CHEM 4640</td>
<td>Experimental Techniques in Macromolecular Chemistry</td>
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<td>Introduction to Differential Equations</td>
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<tr>
<td>MATH 4720</td>
<td>Mathematics in Medicine and Biology</td>
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### Paths

Depending on immediate and long-range goals, students whose plans include one or more of the following career paths are advised to consider including the courses listed below among their module, option, or free elective choices. Students should consult their advisers when selecting courses from these lists.

### Graduate School—Biochemistry

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<td>Research in Biochemistry/Biophysics</td>
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<td>BIOL 4260</td>
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### Bioinformation

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### Minor Programs

#### Biochemistry/Biophysics Minor for Biology Majors

Students majoring in chemistry, biology, or biomedical or chemical engineering may obtain a minor in Biochemistry and Biophysics by completing the courses listed below. Since different essential courses are included in the requirements of each major, the minor requirements vary for different majors.
## Program Requirements

**Biochemistry/Biophysics Minor for Biomedical Engineering Majors**

Students majoring in chemistry, biology, or biomedical or chemical engineering may obtain a minor in Biochemistry and Biophysics by completing the courses listed below. Since different essential courses are included in the requirements of each major, the minor requirements vary for different majors.

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<td>MATH 4720</td>
<td>Mathematics in Medicine and Biology</td>
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## Program Requirements

**Biochemistry/Biophysics Minor for Chemical Engineering Majors**

Students majoring in chemistry, biology, or biomedical or chemical engineering may obtain a minor in Biochemistry and Biophysics by completing the courses listed below. Since different essential courses are included in the requirements of each major, the minor requirements vary for different majors.

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Biochemistry/Biophysics Minor for Chemistry Majors

Students majoring in chemistry, biology, or biomedical or chemical engineering may obtain a minor in Biochemistry and Biophysics by completing the courses listed below. Since different essential courses are included in the requirements of each major, the minor requirements vary for different majors.

Program Requirements

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And two of the following:

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<tr>
<td>CHEM 4310 Math in Medicine and Biology</td>
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<td>MATH 4720 Mathematics in Medicine and Biology</td>
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Graduate Programs

Master's Programs

Web Page: http://www.rpi.edu/dept/bcbp/graduate.html

Both the Master of Science and Master of Applied Science degrees are available within the Biochemistry and Biophysics program. Each requires a total of 30 credit hours.

For the Master of Science degree in Biochemistry and Biophysics, 15 credits must be in courses at the 6000–6999 level. In addition, six to nine credits must be in research. Students must either have had in their undergraduate study or must include in their M.S. Plan of Study three of the Molecular Biophysics Module courses listed above in the undergraduate curriculum, or their graduate equivalents. A thesis based on original work is required.

The Master of Applied Science degree program features the possibility of combining graduate level cooperative education participation, or equivalent industrial experience, with course work for the degree in Biochemistry and Biophysics.

Doctoral Program

Web Page: http://www.rpi.edu/dept/bcbp/graduate.html

In addition to satisfying Institute requirements for the Ph.D. degree, entering students must either complete the Molecular Biochemistry I course (BCBP 4760), or have had the equivalent as part of their previous education, and must complete graduate versions of three of the Molecular Biophysics Module courses listed above in the undergraduate curriculum. Additional courses may be chosen relevant to the area of specialization of each student’s research.

The Doctor of Philosophy degree in Biochemistry and Biophysics (BCBP) requires a dissertation based on an original research project. Entering students must undertake two or three research rotations during the first year of study. These research rotations must be carried out with faculty members selected from the above list of participating faculty. The faculty members selected to direct these research rotations must be based in at least two different departments. After completing two or three research rotations, a thesis adviser must be chosen from the list of participating faculty by the end of the second semester. A seminar must be presented, and a candidacy exam completed, by the end of the second year of study.

Course Descriptions

Courses of interest to Biochemistry and Biophysics students are described in the Course Description section of this catalog under the codes BIOL, BCBP, and CHEM. Course selections should be discussed with the student’s adviser.
Bioinformatics and Molecular Biology

Director, Undergraduate and Graduate Degree Programs: Chris Bystroff
Program Home Page: http://www.rpi.edu/dept/bio/undergraduate/bsbioinfo.html

Revolutions in biotechnology and information technology are changing the world. Advances in molecular genetics, coupled with improved capability in robotics, computer science, and other technologies, have made mass sequencing of genetic material a part of the scientific landscape. Numerous genome-sequencing projects have produced complete sequences of viruses, bacteria, and increasingly complex eukaryotic organisms. The complete human genome was completed in 2003, with 20,000 genes and 3 billion base pairs. Today thousands of human genomes have been sequenced.

The enormous treasure trove of information that the sequence databases and their smaller structural counterparts represent is a priceless resource. Applications include the identification of targets for drug discovery, the study of structural and functional relationships, and work on molecular evolution. Timely advances in computer science have made the storage, organization, and utilization of these very large data collections possible.

Research Innovations and Initiatives

There are extensive opportunities for bioinformatics and molecular biology majors to pursue undergraduate research in faculty laboratories, sometimes adding a computational capacity to experimental labs, and sometimes by serving as a bridge between computational and experimental biology. Several experimental research programs have benefited from undergraduate researchers who are trained in sequence analysis, molecular modeling, and database design. Bioinformatics research at Rensselaer includes the design and application of algorithms for sequence database searching, sequence alignment, and sequence analysis, molecular modeling, and allied areas in computational chemistry and simulation of biological processes. Closely related research in molecular genetics and biochemistry provides concrete applications for graduate and undergraduate students.

Research in computational biology is funded by a diverse group of agencies including NIH, NSF, the American Diabetes Association, and NASA. Computational biology research projects range from data mining, machine learning, drug discovery, chemoinformatics, enzymology, signal transduction, protein engineering, protein folding, protein design, biosensing, and studies on environmental adaptations of microorganisms.

Graduate Program

The primary goal of the master's degree program in this field is to educate students for jobs in biotechnology, pharmaceuticals, and related industry sectors. The professional Master of Science in Applied Science program with a concentration in bioinformatics is also available to those wishing to upgrade their skills while employed in industry. The Master of Science in biology with a concentration in bioinformatics may attract those desiring an M.S. degree before proceeding to professional study in medicine or an allied health field. It may also be useful to students with a B.S. degree in biological sciences who wish to prepare for eventual entry in to a doctoral program at Rensselaer or elsewhere. It is possible to enter the doctoral program in biology with a concentration in bioinformatics.

Faculty


Computer Science: B. Szymanski, M. Zaki, L. Newberg, B. Yener

Chemistry and Chemical Biology: C. Breneman, W. Colon, M. Wentland, R. Lindhart, K. Lakshmi, L. McGown

Mathematical Sciences: M. Zuker, K. Bennett

Chemical and Biological Engineering: J. Dordick, S. Garde, M. Koffas, R. Kane, P. Tessier, C. Collins, P. Karande

Industrial and Systems Engineering: M. Embrechts

Physics: A. Garcia

Computer and Information Science at Hartford: H. Younessi
Undergraduate Program

Rensselaer’s bioinformatics and molecular biology undergraduate curriculum includes training in mathematics, chemistry, computer science, and physics. At the program’s core are courses in the theory and practice of bioinformatics that deal with topics such as database design, search algorithms, sequence analysis, molecular modeling, and molecular dynamics. The experimental side includes courses in molecular biology sequence and drug discovery.

The curriculum is extremely flexible, allowing for dual majors with other disciplines including computer science, biochemistry and biophysics, and mathematics. Advanced courses are available through the biology program and the biochemistry and biophysics program, including a strong set of advanced laboratory courses. Through appropriate elective selection, students may train for careers as molecular biologists with a computational background, or as computer scientists with a strong background in the biological sciences. The bioinformatics and molecular biology program also serves as an excellent premedical curriculum.

BIOINFORMATICS AND MOLECULAR BIOLOGY CURRICULUM

This degree program is designed to prepare students for admission to graduate or professional school. The philosophy behind it is to leave as many options as possible to the student. This flexibility is essential for those students who have specific interests and goals other than those spelled out in more traditional curricula.

FIRST YEAR

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<td>CHEM 4330 Drug Discovery</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 4340 Drug Discovery Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Math Elective^</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4770 Molecular Biochemistry II</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

\^ Choose from one of the following courses: MATP 4600, CSCI 2300, or MATH 2400.
# FOURTH YEAR

<table>
<thead>
<tr>
<th>Fall Credit Hours</th>
<th>Spring Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4540 Sequence Analysis ..................................................... 4</td>
<td>BIOL 4550 Molecular Modeling .................................................... 4</td>
</tr>
<tr>
<td>BIOL 4630 Molecular Biology II .................................................... 4</td>
<td>Elective ............................................................. 4</td>
</tr>
<tr>
<td>BIOL 4720 Molecular Biology Laboratory.............................................. 4</td>
<td>Elective ............................................................. 4</td>
</tr>
<tr>
<td>Elective ............................................................. 4</td>
<td>Elective ............................................................. 4</td>
</tr>
<tr>
<td>Culminating Experience2 ................................................ 4</td>
<td>Culminating Experience2 ................................................ 4</td>
</tr>
</tbody>
</table>

## Elective Recommendations

### Biochemistry Credit Hours

<table>
<thead>
<tr>
<th>Biochemistry</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCBP 2990 Research Thesis</td>
<td>3 to 4</td>
</tr>
<tr>
<td>BCBP 2900 Research in Biochemistry/Biophysics</td>
<td>1 to 4</td>
</tr>
<tr>
<td>BCBP 2930 Out-of-Classroom Experience in Biochemistry/Biophysics</td>
<td>1 to 4</td>
</tr>
<tr>
<td>BCBP 2940 Readings in Biochemistry/Biophysics</td>
<td>1 to 4</td>
</tr>
<tr>
<td>BCBP 4310 Genetic Engineering</td>
<td>4</td>
</tr>
<tr>
<td>BCBP 4640 Proteomics</td>
<td>4</td>
</tr>
<tr>
<td>BCBP 4710 Biochemistry Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>BCBP 4870 Protein Structure Determination</td>
<td>4</td>
</tr>
</tbody>
</table>

### Biology Credit Hours

<table>
<thead>
<tr>
<th>Biology</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 2500 Genetics and Evolution</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4270 Human Physiology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 4740 Cell and Developmental Biology Laboratory</td>
<td>4</td>
</tr>
</tbody>
</table>

### Chemistry Credit Hours

<table>
<thead>
<tr>
<th>Chemistry</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2440 Physical Chemistry for Life Sciences</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 4300 Medicinal Chemistry</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 4310 Bioorganic Mechanisms Cr</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 4410 Macroscopic Physical Chemistry</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 4420 Microscopic Physical Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 4620 Introduction to Polymer Chemistry C</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 4640 Experimental Techniques in Macromolecular Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 4810 Chemistry of the Environment</td>
<td>4</td>
</tr>
</tbody>
</table>

### Computer Science Credit Hours

<table>
<thead>
<tr>
<th>Computer Science</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 2200 Foundations of Computer Science</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 2300 Introduction to Algorithms</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 4020 Graph Theory</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 4380 Database Systems</td>
<td>4</td>
</tr>
</tbody>
</table>

### Mathematics Credit Hours

<table>
<thead>
<tr>
<th>Mathematics</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 2010 Multivariable Calculus and Matrix Algebra</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2400 Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>MATH 4720 Mathematics in Medicine and Biology</td>
<td>4</td>
</tr>
<tr>
<td>MATP 4600 Probability Theory and Applications</td>
<td>4</td>
</tr>
</tbody>
</table>

### Other Credit Hours

<table>
<thead>
<tr>
<th>Other</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISYE 4140 Statistical Analysis</td>
<td>4</td>
</tr>
</tbody>
</table>

This curriculum requires a minimum of 128 credit hours.

## Environmental Science

**Director:** Richard Bopp

**Program Home Page:** [http://www.rpi.edu/dept/envsci](http://www.rpi.edu/dept/envsci)

No place on the planet has escaped perturbation resulting from human activities. The challenge is to maintain those attributes of Earth that make it habitable while, at the same time providing for human needs. Science will play a critical role in enabling technological civilizations to move toward sustainable interactions with the natural world. The effective environmental scientists must be rigorously educated in one area of science and have a perspective far broader than any single science discipline affords. Rensselaer’s Environmental Science degree addresses these challenges with a multifaceted program.

---

2 Chosen from one of the following courses: BIOL 4550, BIOL 4900, or BIOL 4990 or by department approval of another course or project.
The Environmental Seminar considers topical environmental issues from numerous perspectives. Through it, students receive a broad overview of environmental challenges.

A guided selection of courses in the humanities, arts, and social sciences broadens perspective and understanding of the human approach to and interactions with the natural world.

Two courses, IENV/ERTH 4500 and IENV 4700, taken in the final two years of study, enable the student to grasp the broadly varied, interdisciplinary dimensions of the natural environment and its human dimension.

The science core and student-elected concentration provide depth of scientific preparation.

With judicious use of the elective credit hours, a student can prepare to pursue a number of career options including graduate study in the concentration discipline.

## Research Innovations and Initiatives

The School of Science offers numerous opportunities for advanced study. Some examples include trace metal and organic contaminant geochemistry in natural waters of the Hudson basin, the impact of acid rain on the Adirondacks, studies of aquatic biota in Lake George, and nitrogen cycling in local ecosystems. Students are encouraged to seek research opportunities in environmental science as described in each of the traditional scientific disciplines.

## ENVIRONMENTAL SCIENCE CURRICULUM

This curriculum leads to a B.S. in environmental science. A typical four-year program is illustrated below. However, the order in which students take courses within the first two years is flexible.

### FIRST YEAR

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
<td>4</td>
</tr>
<tr>
<td>Fall</td>
<td>CHEM 1100</td>
<td>Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>Fall</td>
<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>CHEM 1200</td>
<td>Chemistry II</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>ERTH 1200</td>
<td>Geology II: Earth’s Surface</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>MATH 1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### SECOND YEAR

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>CHEM 2250</td>
<td>Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>Fall</td>
<td>ERTH 2210</td>
<td>Field Methods</td>
<td>3</td>
</tr>
<tr>
<td>Fall</td>
<td>IENV 1910</td>
<td>Environmental Seminar</td>
<td>2</td>
</tr>
<tr>
<td>Fall</td>
<td>PHYS 1100</td>
<td>Physics I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>BIOL 2120</td>
<td>Introduction to Cell and Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concentration and Elective</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HASS Elective</td>
<td>1</td>
</tr>
</tbody>
</table>

### THIRD YEAR

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>Concentration and Elective</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>HASS Elective</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>ERTH 4180</td>
<td>Environmental Geology</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>Concentration and Elective</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

1. HASS courses should be selected in consultation with the adviser and the Environmental Science Faculty Committee. Examples of environmentally relevant options include: ECON 4230, ECON 4250, IHSS 2100, PHIL 4300, STSS 1110, STSS 2300, STSS 4540, and STSS 4320.
2. With permission of the director of Environmental Sciences, a student may elect another math course (course numbers MATH xxxx, MATP xxxx, or courses cross-listed with these numbers).
3. With permission, a student may substitute ERTH 4540.
4. With permission, a student may elect to substitute BIOL 4320, 4700, or 4850.
5. Each student is required to elect one of the concentrations listed below.
FOURTH YEAR

**Fall**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>IENV 4700</td>
<td>One Mile of the Hudson River</td>
</tr>
<tr>
<td>Concentration and Elective</td>
<td>8</td>
</tr>
<tr>
<td>Culminating Experience</td>
<td>3-4</td>
</tr>
</tbody>
</table>

**Spring**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration and Elective</td>
<td>16</td>
</tr>
</tbody>
</table>

Concentrations

The environmental science degree program requires one concentration. Three of the concentration areas, Biology, Chemistry, and Geology explore environmental applications of traditional scientific disciplines. The Geoinformatics concentration specifically addresses the increasing role of high volumes of complex data acquired from a variety of sources both in-situ and remotely sensed. Geoinformatics combines relevant computer science knowledge and skills with geotemporal and geospatial analysis and modeling, curation of geo-databases, information system design and development, human-computer interaction including visualization, use of modern cyberinfrastructure and networking technologies.

**Biology**

<table>
<thead>
<tr>
<th>All of the following</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 2500</td>
<td>Genetics and Evolution</td>
</tr>
<tr>
<td>BIOL 4620</td>
<td>Molecular Biology</td>
</tr>
<tr>
<td>BIOL 4760</td>
<td>Molecular Biochemistry I</td>
</tr>
<tr>
<td>CHEM 2260</td>
<td>Organic Chemistry II</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>One of the following</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4700</td>
<td>Freshwater Ecology</td>
</tr>
<tr>
<td>BIOL 4850</td>
<td>Principles of Ecology</td>
</tr>
</tbody>
</table>

**Chemistry**

<table>
<thead>
<tr>
<th>All of the following</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2030</td>
<td>Inorganic Chemistry I</td>
</tr>
<tr>
<td>CHEM 2110</td>
<td>Equilibrium Chemistry and Quantitative Analysis</td>
</tr>
<tr>
<td>CHEM 4410</td>
<td>Macroscopic Physical Chemistry</td>
</tr>
<tr>
<td>CHEM 4810</td>
<td>Chemistry of the Environment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>One of the following</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2260</td>
<td>Organic Chemistry II</td>
</tr>
<tr>
<td>CHEM 4420</td>
<td>Microscopic Physical Chemistry</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>One of the following</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 4xxx</td>
<td>Chemistry Elective</td>
</tr>
<tr>
<td>CHEM 2950</td>
<td>Undergraduate Research</td>
</tr>
<tr>
<td>CHEM 4990</td>
<td>Senior Thesis</td>
</tr>
</tbody>
</table>

**Geology**

<table>
<thead>
<tr>
<th>(Six of the following courses, three of which must be at the 4000 level)</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH 4xxx</td>
<td>(with permission of Director of Environmental Science)</td>
</tr>
<tr>
<td>ERTH 2100</td>
<td>Introduction to Geophysics</td>
</tr>
<tr>
<td>ERTH 2120</td>
<td>Structural Geology</td>
</tr>
<tr>
<td>ERTH 2140</td>
<td>Introduction to Geochemistry</td>
</tr>
<tr>
<td>ERTH 2330</td>
<td>Earth Materials</td>
</tr>
<tr>
<td>ERTH 2610</td>
<td>Oceanography</td>
</tr>
<tr>
<td>ERTH 4070</td>
<td>Sedimentology/Stratigraphy</td>
</tr>
<tr>
<td>ERTH 4190</td>
<td>Environmental Measurements</td>
</tr>
<tr>
<td>ERTH 4540</td>
<td>Organic Geochemistry</td>
</tr>
<tr>
<td>ERTH 4690</td>
<td>Aqueous Geochemistry</td>
</tr>
<tr>
<td>ERTH 4710</td>
<td>Groundwater Hydrology</td>
</tr>
<tr>
<td>ERTH 4750</td>
<td>Geographic Information Systems in the Sciences</td>
</tr>
</tbody>
</table>

---

6 This course is offered every other year in the fall term of even-numbered years and therefore is a junior year course for some students.

7 Each student is required to engage in an activity that qualifies as an intensive environmental experience as described below.
### Geoinformatics

All of the following

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 4xxx</td>
<td>Data Science</td>
<td></td>
</tr>
<tr>
<td>CSCI 1100</td>
<td>Computer Science I</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 1200</td>
<td>Data Structures</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 4380</td>
<td>Database Systems</td>
<td>4</td>
</tr>
<tr>
<td>CSCI 4960</td>
<td>Topics in Computer Science</td>
<td>1 to 4</td>
</tr>
</tbody>
</table>

One of the following

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI 2300</td>
<td>Introduction to Algorithms</td>
<td>4</td>
</tr>
<tr>
<td>ERTH 4750</td>
<td>Geographic Information Systems in the Sciences</td>
<td>4</td>
</tr>
</tbody>
</table>

### Minor Programs

#### Minor in Energy

Students interested in developing a broad, multidisciplinary background in energy to complement a more focused major program should consider – the Interschool Minor in Energy. See Interdisciplinary Programs and Research in the Humanities, Arts, and Social Sciences section of this catalog for details on this program.

#### Minor in Environmental Science

A minor in Environmental Science will consist of at least 16 credit hours, eight of which must be at the 4000 level. Interested students should consult with the Director of Environmental Science to develop an appropriate list of courses.

### Dual Majors

Students pursuing a dual major in Environmental Science and Biology, Chemistry, or Geology must choose a different concentration for their Environmental Science degree. Similarly, students enrolled as dual majors in Computer Science and Environmental Science cannot choose the Geoinformatics concentration.

### Intensive Environmental Experience

In consultation with the adviser and with the approval of the director of the Environmental Science Program, students must select and engage in an intensive activity related to the environment. This culminating experience will be associated with earning 3 to 4 academic credits in a URP project or Out of Classroom Experience (e.g., as a co-op or intern). To fulfill this requirement, students must document the experience and obtain prior approval from the Environmental Science Faculty Director.

### Interdisciplinary Science

**Head:** David L. Spooner

The Interdisciplinary Science curriculum provides an education in the sciences for undergraduate students whose interests range outside the traditional disciplines and career paths. It is suitable for students wishing to combine sciences in innovative ways or to combine science with other disciplines such as management, law, education, communication, public service, economics, policy-making, or community affairs. Students who are undecided among the sciences, have particular special interests, or seek nontraditional career paths may follow the Interdisciplinary Science curriculum while becoming familiar with their options.

The introductory courses recommended are the same as those for departmental science majors. However, the deep undergraduate concentration in a single science area that is characteristic of departmental majors is replaced by a broader coverage of science areas and a greater choice of courses, including nonscience courses. Students vary their programs to emphasize preparation for their own particular professional objectives.

This curriculum is suited especially for students who wish to:

- prepare for work in interdisciplinary areas of science such as material science or climatology.
- combine a strong foundation in science with studies in arts, philosophy, psychology, management, economics, or public affairs.
- develop a broader and more interdisciplinary education in the health-related science areas.
- prepare to teach science at the secondary school or junior college level.
- do graduate work in the history or philosophy of science or are interested in science as part of American culture.

A bachelor’s program in interdisciplinary science is excellent preparation for an MBA or a degree in a field such as law or communications. Combinations such as these prepare students for many effective roles in today’s community.
Undergraduate Program

The core course requirements of the Interdisciplinary Science curriculum are 20 science courses, each carrying three or more credits, chosen from offerings in the fields of astronomy, biology, biochemistry and biophysics, chemistry, computer science, environmental science, geology, mathematical sciences (course codes MATH and MATP) and physics. Each curriculum must include eight credit hours of mathematics including MATH 1010 Calculus I and BIOL 1010 Introduction to Biology; and PHYS 1100, Physics I. Each curriculum must include courses in at least six science disciplines. For this purpose, course codes MATH and MATP are a single discipline as are course codes ASTR and PHYS. In order to ensure depth and breadth, the curriculum must consist of at least eight courses in one discipline and four courses in each of two other disciplines. The remaining four courses are to be chosen from at least three other disciplines. The eight-course concentration must include two or more courses at the 4000 level. Other Institute-wide requirements for graduation such as the humanities, arts, and social sciences core requirements must also be met.

The student’s specific objectives will determine the balance of the curriculum to yield a total of 124 credits needed for graduation.

This curriculum leads to the Bachelor of Science in Interdisciplinary Science.

### FIRST YEAR

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>CHEM 1100</td>
<td>Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH 1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS 1100</td>
<td>Physics I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>CHEM 1200</td>
<td>Chemistry II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH 1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS 1200</td>
<td>Physics II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

### SECOND YEAR

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>BIOL 1010</td>
<td>Introduction to Biology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Science Option</td>
<td>All six science options must be fulfilled. (a) Eight courses from a single discipline; (b) Four courses from a second discipline; (c) Four courses from a third discipline; and (d) One course from each of the three disciplines not represented in (a), (b), or (c). Two or more of the courses in the eight-course sequence must be at the 4000 level. These include the required courses listed above.</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Science Option</td>
<td></td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Spring</td>
<td>Science Option</td>
<td></td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Science Option</td>
<td></td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Science Option</td>
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<td>3-4</td>
</tr>
<tr>
<td></td>
<td>HASS Elective</td>
<td></td>
<td>3</td>
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</tbody>
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### THIRD YEAR

<table>
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<tr>
<th>Semester</th>
<th>Course Code</th>
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</table>

1. Science Options are chosen from among the offerings of the departments of Biology, Chemistry, Computer Science, Earth and Environmental Sciences, Mathematics and Physics. ERTH 1030 and ERTH 1040, Natural Science I and II do not satisfy the Science Options. MATH and MATP are a single discipline. ASTR and PHYS are a single discipline. BIOL and BCBP are a single discipline.

2. Science Option: All six science options must be fulfilled. (a) Eight courses from a single discipline; (b) Four courses from a second discipline; (c) Four courses from a third discipline; and (d) One course from each of the three disciplines not represented in (a), (b), or (c). Two or more of the courses in the eight-course sequence must be at the 4000 level. These include the required courses listed above.

3. Humanities and Social Sciences courses shall total 24 and meet distribution requirements in the catalog.

4. The sequencing of courses may be rearranged to meet students’ needs as long as prerequisites are met, i.e. Biology may be moved to the first, third, or fourth year if desired.
Interdisciplinary Research Centers

Darrin Fresh Water Institute

Director: Sandra A. Nierzwicki-Bauer

Associate Directors: Charles W. Boylen, Richard F. Bopp

The Margaret A. and David M. Darrin’40 Fresh Water Institute, with research facilities both on the main campus and at the field station on Lake George, provides opportunities for Rensselaer undergraduate and graduate students, faculty, and visiting scientists to study a number of ecosystems and conduct basic and applied research on environmental problems. The research field station, located at Bolton Landing, N.Y., includes a renovated, year-round Educational Center (within the Adirondack lodge, which houses a multi-computing facility and provides housing for students studying at the Institute, and is available year-round), several small cottages, a boathouse, and a 7,500-square-foot laboratory facility for research and teaching.

Computer-simulation models integrate field studies with laboratory experiments. Studies of ecosystem function and the influence of human activities on specific environmental systems help prevent or minimize adverse environmental impacts. The Lake George ecosystem has been under intensive study for the past 30 years and will continue to be one focal point for the Institute’s research activities. Other areas of research concentration include the Hudson River ecosystem, the effects of land use on watersheds, studies and controls of exotic species (e.g., Eurasian Milfoil and Zebra Mussels), and the effects of environmental pollutants on both terrestrial and aquatic systems.

The Institute fosters a multidisciplinary team approach in both education and research with participants from the various disciplines within the School of Science, as well as other environmental programs across the Rensselaer campus. Collaborations with faculty at other universities and field stations also enhance research and educational programs.

The Darrin Fresh Water Institute also has research facilities on campus with the W. M. Keck Foundation Water Quality Laboratory. This New York State certified laboratory is equipped with state-of-the-art instrumentation to conduct sophisticated studies of water quality and the fate of pollutants. Analytical equipment for water and soil chemistry analyses and microscopy equipment to study interactions between organisms and substrates are components of this interdisciplinary research laboratory, located in the Materials Research Center. Recently, the Keck Lab is working collaboratively with Rensselaer’s Center for Polymer Synthesis on fuel cell research (a promising new technology in helping to meet the world’s energy needs).

The Darrin Fresh Water Institute remains at the forefront of environmental activities at Rensselaer and continues to be a local, state, national, and international resource. A semester of study at the Darrin Fresh Water Institute is offered each fall semester and consists of 16 credits of environmental courses, seminar and internship. Student participation in research activities at the Institute is encouraged through participation with individual faculty and student internships available each summer. We continue to integrate new and emerging bio and information technologies with traditional ecology methods for the study and preservation of freshwaters. The Institute’s research, education, and outreach activities are important contributions to advancing The Rensselaer Plan. More information on these activities can be found on the DFWI Web site, http://www.rpi.edu/dept/dfwi/, which also includes a “virtual tour” of the facilities at the Bolton Landing field station.

1 Science Options are chosen from among the offerings of the departments of Biology, Chemistry, Computer Science, Earth and Environmental Sciences, Mathematics and Physics. ERTH 1030 and ERTH 1040, Natural Science I and II do not satisfy the Science Options. MATH and MATP are a single discipline. ASTR and PHYS are a single discipline. BIOL and BCBP are a single discipline.

2 Science Option: All six science options must be fulfilled. (a) Eight courses from a single discipline; (b) Four courses from a second discipline; (c) Four courses from a third discipline; and (d) One course from each of the three disciplines not represented in (a), (b), or (c). Two or more of the courses in the eight-course sequence must be at the 4000 level. These include the required courses listed above.

4 All students must successfully complete at least one culminating experience carrying three or more credits. Some examples are Thesis Research, Project, Software Development and Critical Assessment of Literature.
Inverse Problems at RPI (IPRPI)

**Director:** Joyce R. McLaughlin  
**Center Home Page:** [www.iprpi.rpi.edu](http://www.iprpi.rpi.edu)

IPRPI Center research programs emphasize cross disciplinary inverse problems where (1) solutions have a significant impact on society, and advance scientific understanding; and (2) contribute to the education of young people who will join the scientific and engineering enterprise. The focus of inverse problems is to find objects and/ or their material or biological properties that cannot be directly measured. For these problems, application areas include geophysics and geotechnical work including earthquake dynamics, medical imaging that targets medical diagnosis, radar imaging including enhancing home security, and a broad set of problems in solid mechanics and electromagnetics. Applied mathematics and computation play a central role. This is a vast scientific area, in which Rensselaer has a significant, high quality, well established science and engineering base.

Among those problems addressed at Rensselaer, are some at the most basic scientific level, for example finding properties of the earth’s substructure from seismic measurements, or defining new experiments where the data yield new human tissue properties. Others are focused on direct applications, for example finding sediment properties of the seabed, establishing the integrity of dikes, locating objects concealed by vegetation cover, locating mines in the sea environment, finding malignant tumors in biological tissue, locating sources of heart malfunction, or finding temperature distributions in inaccessible regions. In all cases it is either not possible, as in determining the earth’s substructure properties, or not desirable, as in locating tumors in tissue, to make direct measurements. In all cases, solution of these problems results in improved quality and safer lives.

Scientific challenges include modeling of the physical problem, creation of new mathematics for analysis of the model, identification of appropriate (often large) and/ or rich data sets, scientific computing and visualization, and experimental verification. Approaches are based on effective use of a mathematical model in order to make optimal use of the data. Since inverse problems are concerned with the processing of data and extraction of relevant information, the field is a part of Computation and Information Technology. Each individual application may also be part of one additional thrust such as Bioengineering and Biotechnology (e.g. for tissue property identification), or the Energy and the Environment (e.g. establishing the integrity of dikes).

Rensselaer’s goal in creating this center is to create a synergistic group of researchers with complementary talents and related interests whose combined expertise can successfully solve an even wider group of important problems. Funding includes significant opportunity for postdoctoral fellows and graduate students who work in team environments to advance problem solutions.

**Affiliated Faculty**

**Mathematical Sciences:** M. Cheney, D. Isaacson, J. McLaughlin  
**Earth and Environmental Sciences:** S. Roecker  
**Mechanical, Aerospace and Nuclear Engineering:** A. Maniatty, A. Oberai  
**Civil Engineering:** M. Zeghal  
**Electrical, Computing and Systems Engineering:** B. Yazici
New York Center for Astrobiology

**Director:** Douglas Whittet, Department of Physics, Applied Physics and Astronomy

**Associate Director:** John W. Delano, Department of Earth and Atmospheric Sciences, and Department of Chemistry, University at Albany

**Program Home Page:** [http://www.origins.rpi.edu](http://www.origins.rpi.edu)

The New York Center for Astrobiology is devoted to investigating the origins of life on Earth and the conditions that lead to formation of habitable planets in this and other solar systems. Based within the School of Science at Rensselaer Polytechnic Institute, the center is a member of NASA’s Astrobiology Institute and a partnership between Rensselaer and several other universities, including the State University of New York at Albany and Syracuse University. Researchers include faculty, postdoctorals, graduate students and undergraduates at Rensselaer and at partner campuses. The center promotes undergraduate education, including a minor in Astrobiology, and hosts a weekly Origin of Life seminar. Major areas of research are summarized below.

**Research Innovations and Initiatives**

**The Origins of Preplanetary Matter**
This research seeks to understand the cosmic origins of molecules essential to life, including water, hydrocarbons, alcohols, and other precursors of amino acids. Data from telescopes on the Earth and in space are used to investigate the nature and origin of interstellar dust and the chemical and physical processes that link interstellar matter to the origins of new solar systems. In parallel with the observational investigations, we are developing and testing models that describe the physical and chemical processes that govern the evolution of these molecules, linking interstellar chemistry to primitive bodies (comets and asteroids) in our solar system that may have delivered volatiles and organic molecules to the early Earth and Mars. The goal is to test the hypothesis that the molecules necessary for life are common ingredients of new solar systems, and that delivery of these ingredients to planetary surfaces is an essential step toward the origins of life.

**The Bombardment History of the Earth-Moon System**
This research will assess the importance of interplanetary material not only as a source of raw materials for the origin of planetary life, but also as a potential threat in the form of impacts by large cometary and asteroidal bodies that may have sterilized the Earth during the first few hundred million years of its history. Because the impact record on Earth is destroyed over time by weathering, volcanism, and tectonic movement of the crust, the nearby Moon is studied as a valuable proxy: much of its ancient surface remains virtually undisturbed. Investigations are made regarding the chemical composition and chronology of glasses from the Moon that were produced by the extreme heat and pressure of impacts. Results enable the bombardment history of the Moon (and hence the Earth) to be determined.

**The Environment of Early Earth and the RNA World**
Understanding the chemical state of the earliest atmosphere and oceans is critical to any theory of the origin of life on Earth. Conditions in the first few hundred million years of Earth’s history are explored by reading the “chemical memories” carried by zircons and other ancient crystals that survive from this epoch, with the goal of establishing the timescale on which the Earth became suitable as a host for complex organic molecules and life itself. One scenario for the emergence of life is the RNA World hypothesis, which proposes that the first life on Earth was based on RNA rather than DNA. Our research has shown that RNA chains some 50 units long can be formed in the laboratory from activated RNA monomers using montmorillonite clay as a catalyst. Future research will investigate reactions of these RNAs to generate the more complicated biomolecules that may have been essential to the first life.

**Vistas of Early Mars**
NASA is planning in the next decade an unprecedented development in Mars exploration: a mission to return samples from the Martian surface, gathered at locations that appear most promising as environments for present or past life. To better prepare for the selection and detailed analysis of such samples, experiments will be conducted to assess the ability of various minerals known to be present on Mars to retain evidence of past habitable environments (e.g. water) and life itself through preservation of isotopic biosignatures.

**Astrobiology Minor (Multidisciplinary)**
The Biology, Biochemistry and Biophysics, Chemistry and Chemical Biology, Earth and Environmental Sciences, and Physics Departments participate in a multidisciplinary minor in Astrobiology for students majoring in these or other disciplines. To be eligible for the minor, students must pass the three-credit course ASTR 4510 Origins of Life - A Cosmic Perspective and at least two semesters of the one-credit seminar course ISCI 4510; they must also undertake a four-credit research project on a topic related to Astrobiology under the supervision of a faculty member engaged in Astrobiology research in one of the above departments; finally, they must complete a further two courses outside the major field of study, selected from the following:
Program Requirements

For a double major, the requirement that the two selected courses must be outside the major field of study is reduced to one provided both majors are in the primary relevant areas of study (i.e., biology, chemistry, geology, and physics).

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
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<td>ASTR 2050</td>
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<tr>
<td>BIOL 4620</td>
<td>Molecular Biology</td>
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<td>BIOL 4760</td>
<td>Molecular Biochemistry I</td>
<td>4</td>
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<tr>
<td>CHEM 2250</td>
<td>Organic Chemistry I</td>
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<td>CHEM 4810</td>
<td>Chemistry of the Environment</td>
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<tr>
<td>ENVE 2110</td>
<td>Introduction to Environmental Engineering</td>
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</tr>
<tr>
<td>ERTH 4540</td>
<td>Organic Geochemistry</td>
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</table>

Affiliated Faculty

Baldwin, S.—Professor, Department of Earth Sciences, Syracuse University

Delano, J.—Distinguished Teaching Professor, Department of Earth & Atmospheric Sciences and Department of Chemistry, State University of New York at Albany

Ferris, J.—Professor Emeritus, Department of Chemistry & Chemical Biology

McGown, L.—William Weightman Walker Professor, Department of Chemistry & Chemical Biology

Roberge, W.—Professor, Department of Physics, Applied Physics, & Astronomy

Watson, B.—Institute Professor of Science, Department of Earth & Environmental Sciences

Whittet, D.—Professor, Department of Physics, Applied Physics, & Astronomy

New York State Center for Polymer Synthesis

Acting Director: James A. Moore, Department of Chemistry and Chemical Biology

Center Home Page: http://www.rpi.edu/polymers

Dedicated in 1998, the New York State Center for Polymer Synthesis provides bridges for companies to work with Rensselaer faculty and students in designing, producing, and testing novel polymers than can change the way people live and work. Many high-technology industries remain materials limited, meaning that significant improvements in technology could be made if new, structurally tailored polymers with specific, predictable properties were prepared. Often, the creation of new polymers spawns entirely new industries. Thus, the center is committed to working with companies on their polymer-related problems. An extensive foundation in polymer science and special expertise in polymer synthesis has made the center highly successful in these endeavors.

To facilitate its research projects, the center houses advanced technology for the discovery, scale-up, processing, and evaluation of unique polymers. The Center’s focus is threefold: groundbreaking research, corporate and government partnerships, and undergraduate and graduate research.

Current research under way at the center includes work on protein design and synthesis, studies of protein folding and its effect on diseases, using enzymes for polymer synthesis, block copolymers, inorganic polymers, controlled free radical polymerizations, preparing polymer membranes for fuel cells, and creating polymer nanocomposites. Award-winning research that involves turning waste cellulose from paper mills into the raw materials that go into new plastics has also been conducted at the center. In addition, it is also the site of world-renowned and pioneering work on photo-initiated polymerizations and their applications in photoresists and adhesive curing.

Affiliated Faculty

Chemical Engineering: G. Belfort, S. Cramer, J. Dordick, S. Garde, R. Kane

Chemistry and Chemical Biology: W. Colon, J. Crivello, J. Moore, C. Ryu

Materials Science and Engineering: R. Ozisik, L. Schadler
Reserve Officers Training Corps

The Reserve Officers Training Corps (ROTC) programs are elective programs for students who desire commissions in the armed forces. The objective is to develop professional officers who have varied educational backgrounds in major fields of interest and have the professional knowledge and standards needed for future growth. Although the aim in each service is the same, the individual programs differ because of varying responsibilities assigned newly commissioned officers in the three services and differing plans of continuing education.

Program benefits are available only to students who meet the requirements and standards of the particular branch of the armed forces sponsoring the ROTC unit. Each armed services/ROTC program has its own requirements and standards.

Students who satisfy the requirements for baccalaureate degrees become eligible for commissions on completion of the appropriate ROTC programs. ROTC programs are undertaken concurrently with baccalaureate degree studies, with the following provisions:

- Certain courses approved by the appropriate ROTC department chairman may be substituted for ROTC courses to fulfill ROTC program requirements.
- An ROTC educational program must incorporate the course work that leads to a commission. In addition, any student may take ROTC courses as free electives. Although there is no fixed limit to the number of ROTC courses that can count toward a baccalaureate degree, at least six credit hours of courses in ROTC may be counted as general elective credits in the appropriate baccalaureate program. Only the student’s curriculum and faculty adviser limits the number of ROTC credit hours applied to a degree. However, an ROTC course should not replace a humanities and social sciences core course (unless the School of Humanities, Arts, and Social Sciences accepts a specific course for this purpose). Also, an ROTC course should not replace a technical elective (unless a specific course is accepted for this purpose by the student’s department chairperson).
- Cross-Registration: The home institution may limit the number of credit hours and/or grades to be applied. Refer to home institution catalog.

Air and Space Studies

Chairman: Lt. Col. David M. Jurk

The Department of Air and Space Studies offers the Air Force Reserve Officer Training Corps (AFROTC) leadership development curriculum as an elective program to eligible male and female qualified students who wish to pursue commissions as officers in the U.S. Air Force. The program has two phases, a General Military Course (GMC) taken during the first two years and a Professional Officer Course (POC) taken during the last two years. Entry into the POC is competitive and is based upon demonstrated proficiency in the GMC, medical qualifications, academic standing, physical conditioning requirements, the successful completion of field training, aptitude for further officer training, and citizenship. The program consists of academic courses, Leadership Laboratory (LLAB) and Physical Training (PT).

Cadets selected for entry into the POC must attend several weeks of Field Training in the summer immediately preceding their junior year. Additionally, opportunities exist to attend Professional Development Training (PDT) during the summer months. These programs include freefall training, space operations, language and cultural immersion, combative courses, nurse orientation, and many others. Base visit opportunities are used to familiarize cadets with the real-world Air Force operations. Other extracurricular activities include the drill team, honor guard, and Taylor Trophy and Silver Falcons intramural sports teams. Cadets may also join the Arnold Air Society service organization.

Air Force scholarships are awarded on a merit basis and are available to both high school seniors and full-time college students. Multiple-year scholarships are available, as well as some specialized one-year programs and incentives. Refer to the Undergraduate Financial Aid section, ROTC Financial Aid Programs. For more information, you may also visit our Web site at the following address:
http://www.rpi.edu/dept/afrotc or call (518) 276-6236.

Air and Space Leadership Studies Minor

The minor in Air and Space Leadership Studies is offered to any student completing the Air Force ROTC academic course of study (Leadership Laboratory does not apply). The minor provides any student the opportunity to study one of our country’s major organizational
military instruments of power, the United States Air Force. In addition to studying Air Force organizations, missions, and operations, the student will gain a broad perspective of the Department of Defense in general by studying the foundations of the Air Force, the History of the Air Force, Leadership and Management Studies, and National Security studies.

**Joint Military Studies Minor**

A minor in Joint Military Studies is available to any student by completing 16 credit hours of ROTC academic coursework. The minor provides any student the opportunity to study our country’s military instruments of power. The student will gain a broad perspective of Department of Defense leadership, management, skills and careers by studying the foundations and history of the Services, leadership and management, and national security studies.

**Active Duty Obligation**

Enrollment in Air and Space Studies courses carries no obligation to the Air Force; the academic courses are open to all students. Students who complete the Air Force ROTC program and receive a commission normally incur a four-year active duty service commitment. Commissioned officers selected for flying duty will incur additional commitments from the time they complete their pilot training. Students who do not pursue an Air Force commission but desire to complete the courses for a minor are considered special status students and do not incur any active duty service commitment. Field Training and PDT are not available to Special Status students. Other activities may be available based on current policy.

**Faculty***

Professor: D. Jurk

Assistant Professors: J. Heaton, E. Hentnik

**Air Force Reserve Officers Training Corps**

**GENERAL MILITARY COURSE**

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<td>Air Force Leadership Laboratory</td>
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<td>USAF 0010</td>
<td>Air Force Leadership Laboratory</td>
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<tr>
<td>USAF 1010</td>
<td>Air and Space Studies 100A (Foundations of the U.S. Air Force)</td>
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<td>USAF 1020</td>
<td>Air and Space Studies 100B (Foundations of the U.S. Air Force)</td>
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<td>Air Force Leadership Laboratory</td>
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<td>USAF 2030</td>
<td>Air and Space Studies 200A (The Evolution of USAF Air and Space Power)</td>
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<td>USAF 2050</td>
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<td>USAF 2060</td>
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<td>USAF 0080</td>
<td>Air Force Leadership Laboratory</td>
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<td>USAF 2070</td>
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</tr>
<tr>
<td>USAF 2080</td>
<td>Air and Space Studies 400B (National Security Affairs and Preparation for Active Duty)</td>
</tr>
</tbody>
</table>

**Supplemental Courses**

In order to receive a commission, individuals must also meet weight, fitness, academic, and military retention standards.

Air Force uniforms will be issued only to students meeting all Air Force requirements.

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*Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.*
Military Science

Chairman: Lt. Col. Samantha Ross

The purpose of the courses offered by the Military Science and Leadership Department are to train quality college students to become the future leaders of the United States Army and the civilian community. The course of study is divided into two parts—the first two years (Basic Course) and the last two years (Advanced Course). Students incur no military obligation while enrolled in the Basic Course and may withdraw from the course at their option. Selection for the Advanced Course is competitive. Students selected for the Advanced Course participate on a contractual basis and receive $300-$500 stipend per school month payment and an additional $900-$1200 book allowance each year from the government. Emphasis of the Advanced Course is on applied, individual leadership development, and exposure of the student to military management systems and techniques.

Students not desiring an Army commission may still enroll and complete any military science course for elective credit. Such participation does not incur any contractual obligations.

A student may satisfy requirements for application to the Advanced Course in pursuit of a commission in one of three ways:

1. Completion of the first two years (Basic Course) allows a student to earn four academic credits towards graduation while qualifying for the Advanced Course. The student is expected to attend one hour of classroom instruction during the Basic Course.

2. Students may also qualify for entrance into the Advanced Course by selection to the four-week Leadership Training Course (LTC) held the summer between their sophomore and junior year at Fort Knox, KY. Qualified students may compete for two-year scholarships while attending the summer Leadership Training Course. Students may elect to enter the Advanced Course upon successful completion of LTC. All expenses to attend the course are fully funded by the military. Attendance at the summer Basic Camp does not obligate the student to enroll in ROTC unless they are awarded and accept a scholarship.

3. Students with Junior ROTC, Senior ROTC, service academy experience, or prior military service may also qualify to enter the Advanced Course.

The ROTC program may be pursued in conjunction with any academic major offered at RPI. Completion of the Advanced Course qualifies graduates to receive an officer’s commission concurrent with the baccalaureate degree and does not necessarily interfere with subsequent graduate or professional studies.

During the senior year, the student has the option of applying for one of two types of commissions. The first type, a Reserve Forces Duty commission as a citizen Soldier with the Reserve Forces, is for graduates wishing to serve in the US Army Reserve or US Army National Guard, while pursuing a civilian occupation. The second option enables the graduate to go on active duty, perhaps after completing graduate and/or post-graduate scholastic requirements.

Laboratories offered by the Department of Military Science and Leadership focus on the application of leadership methods and techniques that are taught in the classroom. Some are scheduled on weekdays and some on weekends, and they are typically conducted at off-site locations. Laboratories also stress adventure and outdoor activity as a means to build personal confidence. This is an optional activity for students who are not pursuing a commission. Labs are mandatory for students in the Advanced Course and for those who are receiving scholarship benefits.

All students accepted into the Advanced Course must attend the Leadership Development and Assessment Course (LDAC) during the summer after their junior year. The purpose of LDAC is to evaluate the leadership potential of officer candidates who wish to pursue a commission in the United States Army. This four-week course builds upon the skills and methods taught in the junior year.

Exciting internships are offered to enrolled sophomores and juniors who qualify. These internships offer students the ability to become certified in skills taught by U.S. Army Schools. Some of these skills are parachutist certification, rappelling certification and outdoor survival certification. Other internships include foreign language programs in other countries and the opportunity to serve in multiple career fields found in the United States Army as junior leaders.

Faculty*

Professor: S. Ross
Instructor: J. Hamblin

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
### Army Reserve Officers Training Corps

#### BASIC COURSE

<table>
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<th>First Year</th>
<th>Credit Hours</th>
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<td>Fundamentals of Military Science Lab I __________________________ 0</td>
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<td>Fundamentals of Military Science Lab II __________________________ 0</td>
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<td>USAR 2020</td>
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#### Leadership Laboratory

Leadership laboratory stresses leadership opportunities, instruction in basic military skills, and physical fitness activities to include the following subjects: rappelling, junior leader skills; marksmanship; weapons familiarization; map reading; tactics; orienteering; military ceremonies; communication techniques; and first aid. Leadership laboratories occur inside normal class schedules and grow progressively more complex in each successive semester depending on a student’s class. Only contracted and scholarship Cadets are required to attend.

*Note: Students must register for their Military Science course and corresponding lab.*

#### Military Science

#### ADVANCED COURSE

<table>
<thead>
<tr>
<th>Third Year</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAR 0050</td>
<td>Applied Military Leadership Lab I ________________________________ 0</td>
</tr>
<tr>
<td>USAR 0060</td>
<td>Applied Military Leadership Lab II ________________________________ 0</td>
</tr>
<tr>
<td>USAR 2060</td>
<td>Applied Military Leadership I ________________________________ 2</td>
</tr>
<tr>
<td>USAR 2070</td>
<td>Applied Military Leadership II ________________________________ 2</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Fourth Year</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>USAR 0070</td>
<td>Advanced Military Management and Leadership Lab I __________________________ 0</td>
</tr>
<tr>
<td>USAR 0080</td>
<td>Advanced Military Management and Leadership Lab II __________________________ 0</td>
</tr>
<tr>
<td>USAR 4010</td>
<td>Advanced Military Management and Leadership I __________________________ 2</td>
</tr>
<tr>
<td>USAR 4020</td>
<td>Advanced Military Management and Leadership II __________________________ 2</td>
</tr>
</tbody>
</table>

#### Supplemental Courses

All students who intend to progress through the advanced course must take a course in Military History subject to the approval of the Military Science adviser.

*Note: Students must register for their Military Science course and corresponding lab.*

#### Naval Science

**Chairman: Capt. Daniel D. Arensmeyer**

The Department of Naval Science offers an elective program to qualify male and female students for a reserve commission in the United States Navy or Marine Corps. There are two categories of students: (1) scholarship and (2) college program.

Scholarship students receive up to four years of full scholarship benefits and a monthly stipend. Awards are based on an annual nationwide competition conducted by the Department of the Navy. College program students receive basic benefits and are given the opportunity to become scholarship students.
Faculty*

Clinical Professor: Capt. Daniel D. Arensmeyer
Clinical Associate Professor: Lt. Col. Patrick R. Blanchard
Clinical Assistant Professors: Lt. H.S. Dent, Lt. Craig J. Famoso, Lt. Andrew J. Gacek, Lt. John Hertzell
Assistant Marine Officer Instructor: Sgt. N Nibardo Serrano III

Naval Reserve Officers Training Corps

BASIC COURSE

First Year – Summer Training (scholarship and two-year students)  
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USNA 0010</td>
<td>Drill/Laboratory</td>
</tr>
<tr>
<td>USNA 1010</td>
<td>Introduction to Naval Science</td>
</tr>
<tr>
<td>USNA 2020</td>
<td>Sea Power and Maritime Affairs</td>
</tr>
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Second Year – Summer Training (scholarship and two-year students)  
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>USNA 0030</td>
<td>Drill/Laboratory</td>
</tr>
<tr>
<td>USNA 2030</td>
<td>Naval Leadership and Management I</td>
</tr>
<tr>
<td>USNA 2070</td>
<td>Naval Ships Systems II</td>
</tr>
<tr>
<td>USNA 2150</td>
<td>Evolution of Warfare**</td>
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ADVANCED COURSE

Third Year – Summer Training (all students)  
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>USNA 0050</td>
<td>Naval Laboratory</td>
</tr>
<tr>
<td>USNA 2050</td>
<td>Navigation</td>
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<tr>
<td>USNA 2070</td>
<td>Naval Ships Systems II</td>
</tr>
<tr>
<td>USNA 2150</td>
<td>Evolution of Warfare**</td>
</tr>
<tr>
<td>USNA 2170</td>
<td>Amphibious Warfare**</td>
</tr>
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Fourth Year  
<table>
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<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USNA 0070</td>
<td>Naval Laboratory</td>
</tr>
<tr>
<td>USNA 2060</td>
<td>Naval Operations</td>
</tr>
<tr>
<td>USNA 2170</td>
<td>Amphibious Warfare**</td>
</tr>
<tr>
<td>USNA 7190</td>
<td>Naval Leadership and Ethics</td>
</tr>
</tbody>
</table>

Supplemental Courses

In addition, the NROTC midshipman must complete the following courses to ensure minimum acceptable standards for commissioning:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>One course in computer science.</td>
<td></td>
</tr>
<tr>
<td>One approved course in political science/international affairs.</td>
<td></td>
</tr>
<tr>
<td>Two approved courses in English and writing assessment.</td>
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</tr>
<tr>
<td>STSH 2530</td>
<td>World War II</td>
</tr>
</tbody>
</table>

Note: In order to receive a commission, individuals must also meet academic and military retention standards.
Naval uniforms will be issued only to students that are part of the NROTC program.
Students must register for the Naval Science course and corresponding lab.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2013 Board of Trustees meeting.
** Spring term even-numbered years.
Baccalaureate Program

Program for Graduates of U.S. Navy Nuclear Power Training School
Rensselaer’s Program in Nuclear Engineering for Graduates of the U.S. Navy Nuclear Power Training School is being transitioned to Rensselaer’s main campus in Troy and is no longer available at the Malta site. For further information, please contact Marie Dieffenbach by email at dieffm@rpi.edu or by phone at 518-276-2255.

Course Descriptions

For course descriptions see the Course Descriptions section of this catalog under the designation USAF, USAR, USNA.
Course Descriptions

Subject Codes

Descriptions of all undergraduate and graduate courses are given on the pages that follow. The sections are alphabetized according to the four letter department names (see below). The credit hours for each course are stated at the end of the description; contact hours are stated only if they differ from the credit hours.

It is generally expected that, when so indicated, courses will be given in the term shown. However, the university reserves the right to withdraw any course for which interest is insufficient or to make changes in time of offering or in staff. Current course listings are published each term, prior to registration, in posted announcements.

The course numbering system is alphanumeric beginning with a four-letter department name, followed by a dash, the three-digit course number, and a zero.

Four-Letter Subject Codes by School

Architecture (SOA)
ARCH Architecture
LGHT Lighting

Engineering (SOE)
BMED Biomedical Engineering
CHME Chemical Engineering
CIVL Civil Engineering
ECSE Electrical, Computer, and Systems Engineering
ENGR General Engineering
ENVE Environmental Engineering
ESCI Engineering Science
ISEE Industrial and Systems Engineering
MANE Mechanical, Aerospace, and Nuclear Engineering
MTLE Materials Science and Engineering

Humanities, Arts, and Social Sciences (Humanities Courses) (HSSH)
ARTS Arts
COMM Communication
IHSS Interdisciplinary Studies
LANG Foreign Languages
LITR Literature
PHIL Philosophy
STSH Science and Technology Studies (Humanities Courses)
WRIT Writing

Information Technology and Web Science (ITWS)
ITWS Information Technology and Web Science

Management and Technology (LSOM)
MGMT Management

Science (SOS)
ASTR Astronomy
BCBP Biochemistry and Biophysics
BIOL Biology
CHEM Chemistry
CISH Computer Science at Hartford
CSCI Computer Science
ISCI Interdisciplinary Science
ERTH Earth and Environmental Science
MATH Mathematics
MATP Mathematical Programming, Probability, and Statistics
PHYS Physics

Interdisciplinary and Other (MISC)
IENV Interdisciplinary Environmental Courses
USAF Aerospace Studies (Air Force ROTC)
USAR Military Science (Army ROTC)
USNA Naval Science (Navy ROTC)
NSST Natural Science for School Teachers

Humanities, Arts, and Social Sciences (Social Sciences Courses) (HSSS)
COGS Cognitive Science
ECON Economics
IHSS Interdisciplinary Studies
PSYC Psychology
STSS Science and Technology Studies (Social Sciences Courses)
ARCH Architecture (SOA)

ARCH 1200
Beginners Architecture Career Discovery Program
Two-week introduction to architecture for rising juniors and seniors includes morning programs and introductory lectures in history and theory of architecture, computing and simulation, freehand and extreme drawing, building ecologies, building conservation, and construction systems. There will be field trips and career counseling. Afternoons will have individually critiqued (tutored) design studios, group and individual projects, reviews, and public presentation. Acts as an opportunity for career discovery to decide whether a design education in architecture is appropriate.
Offered: Summer term annually.

ARCH 1210
Advanced Architecture Career Discovery Program
Similar structure as the Beginners program. The Advanced program will continue to cultivate design foundations explored in the Beginners course.
Prerequisite: ARCH 1200.
Offered: Summer term annually.

ARCH 2110
The Building and Thinking of Architecture 1
This course addresses the history of architectural and related developments in selected Western and non-Western civilizations to construct a conceptual and strategic understanding of the relationships between architecture, geography, culture, technology, and thought.
Offered: Fall term annually.
4 credit hours

ARCH 2120
The Building and Thinking of Architecture 2
This course expands upon notions introduced in ARCH 2110 that architecture is a practice embedded in human cultures characterized by particular ways of thinking in action. In addition, notions that its domain of interests, physically and intellectually, extends beyond the limits of individual buildings are elaborated through specific examples. This is done against the background of the major shift in intellectual developments beginning in the 17th century that provide stimulus for the scientific, cultural, technological, and social revolutions of the 18th, 19th, and 20th centuries. Unlike ARCH 2110, this course for the most part, does not proceed in a chronological fashion.
Prerequisite: ARCH 2110.
Offered: Spring term annually.
2 credit hours

ARCH 2130
Contemporary Design Approaches
Contemporary practices in architecture are examined and used as foils in order to better understand one’s own individual approach to design. The point is to help uncover some of the self-evidently “true” presuppositions that we all make when we design. By knowing what we take for granted and knowing also that others work with presuppositions which may be substantively different from our own, we begin to realize both our ability to exercise choices and our responsibility to think through the consequences of those choices. Each of the approaches is explored as to its ontological, epistemological, value, and methodological presuppositions. Two very direct questions help in this reflection: What relation does the given approach have to the formative conditions of the contemporary city? and, How does each of the design approaches relate to the American experiences in thought and action?
Prerequisite: ARCH 2120.
Offered: Fall term annually.
2 credit hours

ARCH 2140
The Building and Thinking of Architecture 3
This course builds on the content and ideas of ARCH 2110 and 2120 to examine the history of architecture in medieval and Renaissance periods of Western civilization. In doing so it will examine the implications of these developments for the architecture of later eras as well as the chronology of specific important events in the time period from the 9th to the 17th centuries.
Prerequisite: ARCH 2120.
Offered: Spring term annually.
2 credit hours

ARCH 2200
Design Studio
Design studio introducing students from all disciplines to general design through a series of short projects. The projects stress critical and creative thinking and invention, interdisciplinary collaboration, observation and perception, communication and visualization. Students will begin open-ended investigations using sketching, photography, model making, and computing.
Offered: Fall and summer terms annually.
4 credit hours

ARCH 2210
Architecture Design 1
Design studio introducing students to the processes of critical inquiry specifically as it relates to architecture investigations. These processes are seen as interrelated and always informed by the societal, technological, and historical contexts within which architects work. Parallel instruction in drawing, computing, and construction technology are integrated within the work of this studio. Technology 1: The technology aspects focus on discovering the basic systems used to create space, such as structural systems, enclosure types, and systems for movement. Emphasis is placed upon constructability and sustainability. These discoveries are through hands-on applications and field visits. Computing: Explorations with the computer focus on both the development of a fundamental knowledge of 3-D modeling and 2-D image manipulation software and a nontraditional application of this knowledge to design representations. The
computer media (3-D modeling “space” computer printouts, video projections) are conceived of as yet another “physical” material for experimentation, and are integrated in this way with the studio design projects. Drawing: The drawing segment consists of freehand drawing exercises that relate to studio projects and help students develop basic drawing skills and a familiarity with two-dimensional design concepts.

**Offered:** Spring and summer terms annually.

**6 credit hours**

**ARCH 2220**

**Architecture Design 2**

A continuation of the pursuit of architecture as critical inquiry within a broad societal context. Instruction integrates considerations of drawing, computers, and construction with design projects. Technology 2: The technology aspects focus on the microclimate and environment context, including shade and shadow analysis, developing skyline plots, and sharing system design and analysis, as well as outdoor environments with emphasis on structure, material, and passive solar systems. Computing: explorations with the computer continue to focus on developing knowledge of 3-D modeling and 2-D image manipulation software and its application to design representations. Computer media are integrated with studio design projects. Drawing: freehand drawing exercises related to studio projects further develop basic drawing skills and familiarly with 2-D design concepts.

**Prerequisite:** ARCH 2210.

**Offered:** Fall and summer terms annually.

**6 credit hours**

**ARCH 2230**

**Architecture Design 3**

Architecture Design Studio 3 develops practices that focus on the relationship between specific architectural design situations and issues of representation; conceptual, analytical, and critical thinking; ethical dilemmas; and the role that technical issues play in space-making.

**Prerequisite:** ARCH 2220.

**Offered:** Spring and summer terms annually.

**6 credit hours**

**ARCH 2330**

**Structures 1**

Introduction to Structures introduces the student of Architecture to the principles of structural mechanics and their application to basic architectural structures comprised primarily of wood. The fundamentals of statics are presented in order to gain an understanding of the way in which external forces produce internal stresses in individual members and, in essence, flow through the building system to be resolved at the foundation level. The principles of strength of materials are studied to understand how particular structural materials and configurations manage to resist these forces without unacceptable distortions, or even failure. Wood structural properties are studied in all their complexity as a means to internalize the more theoretical topics broached. Through in-class presentations, reading, homework and project work, computer lab, field trips, and case studies the student will be aided in developing this intuitive (while practical) understanding. It is recognized that intuitions of building technologies are not acquired quickly but result from much study, observation, and practice. Introduction to Structures makes use of the several approaches above to ensure that the beginning student is provided with a broad, solid base for future structural investigations. WebCT will be used to expand the student’s access to course materials and allow for a measure of distance learning. Sustainability: The following notions are introduced as important attributes of sustainable structures and construction: durability and service life, and life cycle cost.

**Prerequisite:** ARCH 2510 except M.Arch. students.

**Offered:** Fall term annually.

**4 credit hours**

**ARCH 2350**

**Construction Systems**

Construction Systems centers on the development of a technical knowledge of, sensibility to, and intuition for the process by which an architectural design is realized in built form. The interdependence among building materials, acoustic qualities, enclosure systems, interior, finish, and other systems is investigated, with an emphasis on the broader architectural design endeavor. Drawing as a means of understanding forms the basis for a semester-long project to be done in small groups. Case studies will center on concepts and systems that have not yet found their way into mainstream practice. The course approach will involve in-class presentations, project work, field trips and case studies. WebCT will be used to expand the student’s access to course materials and allow for a measure of distance learning. Sustainability: The notion that design intentions can be nullified through incorrect construction is stressed. The importance of proper detailing, construction, and maintenance to accomplish lasting and efficient enclosures is highlighted. Skills to diagnose and treat incorrect construction are developed.

**Prerequisite:** ARCH 2510 except M.Arch. students.

**Offered:** Fall term annually.

**2 credit hours**

**ARCH 2360**

**Environmental and Ecological Systems**

An exploration of the fundamental principles of human physiology, thermal and luminous comfort, and indoor quality. Emphasis is on bioclimatic and psychrometric climate analysis and its relationship to architectural design, understanding the energy exchange between body in space, the natural meaning of enclosures, and nonstructural materials and systems. The focus is on passive heating, cooling, and daylighting systems and their design. Exercises include vital sign analysis of existing spaces (thermal, air, luminous), forming hypotheses of building performance, using scientific instrumentation, tenant survey techniques, and physical modeling and simulation techniques related to daylighting and shading techniques.

**Prerequisites:** PHYS 1050, ARCH 2220 or permission of instructor.

**Offered:** Spring term annually.

**4 credit hours**
ARCH 2410
Design Drawing
Drawing as the architect's chief design tool and most potent medium of communication. Major ideas about communication, its cultural roots, and its implications for architecture. Demonstrations of and studio practice in graphical techniques used in all phases of the design process, from initial conceptual patterning to final presentation. Drawing exercises in abstracting, symbolizing, behavioral mapping, depicting processes and typologies, expressing spatial character.
Prerequisite: At least one year of design studio courses recommended.
4 credit hours

ARCH 2510
Materials and Design
This course establishes an understanding of the most common materials, their properties and resulting uses, and the implications of their uses in the larger context of material life cycles. The structural makeup of metals, ceramics, polymers, and composite materials is discovered and their resulting properties, costs, and life cycle consequences are clarified. An understanding of basic mechanical properties is established hands on by conducting tension, compression, and 3-point bending tests (mse-lab). Physical performance of material constructs as synergy between form and material properties is further illustrated. Experiments are conducted that introduce such major concepts as structural loading, properties of sections, and resulting system performance. Sustainability: The concept of life cycles is introduced; material and energy flows are tracked throughout the entire material life cycle. This will be accomplished alongside introducing major material groupings (metals, polymers, ceramics, and composites). Students come to realize that environmental concerns are directly related to structural composition and material availability. Consequences of resource extraction, distribution, manipulation, use, and disposal, reuse or recycle are addressed at both local and global scales. Selected field trips to materials extraction, processing, manufacturing, disposal, and recycling facilities are aimed to give physical meaning to the concept of life cycle.
Offered: Spring term annually.
2 credit hours

ARCH 2600
Graduate Design Studio
Design studio introducing students to general design through a series of short projects. The projects stress critical and creative thinking and invention, interdisciplinary collaboration, observation and perception, communication and visualization. Students will begin open-ended investigations using sketching, photography, model making, and computing.
Offered: Summer and fall terms annually.
6 credit hours

ARCH 2610
Graduate Architecture Design 1
Design studio introducing students to the processes of critical inquiry specifically as it relates to architecture investigations. These processes are seen as interrelated and always informed by the societal, technological, and historical contexts within which architects work. Parallel instruction in drawing, computing, and construction technology are integrated within the work of this studio. Technology: The technology aspects focus on discovering the basic systems used to create space, such as structural systems, enclosure types, and systems for movement. Emphasis is placed upon constructability and sustainability. These discoveries are through hands-on applications and field visits. Computing: Explorations with the computer focus on both the development of a fundamental knowledge of 3-D modeling and 2-D image manipulation software and a nontraditional application of this knowledge to design representations. The computer media (3-D modeling “space” computer printouts, video projections) are conceived of as yet another “physical” material for experimentation, and are integrated in this way with the studio design projects.
Drawing: The drawing segment consists of freehand drawing exercises that relate to studio projects and help students develop basic drawing skills and a familiarity with 2-D design concepts.
Prerequisite: ARCH 2600.
Offered: Spring and summer terms annually.
6 credit hours

ARCH 2620
Graduate Architecture Design 2
A continuation of the pursuit of architecture as critical inquiry within a broad societal context. Instruction integrates considerations of drawing, computers, and construction with design projects. Technology: The technology aspects focus on the microclimate and environment context, including shade and shadow analysis, developing skyline plots, and sharing system design and analysis, as well as outdoor environments with emphasis on structure, material, and passive solar systems. Computing: explorations with the computer continue to focus on developing knowledge of 3-D modeling and 2-D image manipulation software and its application to design representations. Computer media are integrated with studio design projects. Drawing: freehand drawing exercises related to studio projects further develop basic drawing skills and familiarly with 2-D design concepts.
Prerequisite: ARCH 2610.
Offered: Fall and summer terms annually.
6 credit hours

ARCH 2630
Graduate Architecture Design 3
Graduate Design Studio 3 develops practices that focus on the relationship between specific architectural design situations and issues of representation; conceptual, analytical, and critical thinking; ethical dilemmas; and the role that technical issues play in space-making.
Prerequisite: ARCH 2620.
Offered: Spring and summer terms annually.
6 credit hours
ARCH 2940
Projects in Architecture and Environmental Design
Individual projects and readings adapted to the needs of individual students.
1 to 6 credit hours

ARCH 2960
Topics in Architecture and Environmental Design
Experimental courses tried out in one or two terms as the general program requires.
1 to 4 credit hours

ARCH 4040
Cities/Lands
This lecture-seminar is an examination of the parallel historical formation and operation of human settlements together with the territories associated with them, and the interrelations among them in Western Europe, North America, China, the Middle East, and North Africa. The purpose is to better understand the role spatial organization plays in the construction of social practices, human subjectivities, and technologies of power. While the differing paradigmatic notions of architectural and landscape practices will be explored in each cultural situation, the emphasis will be on the formative processes operating at all scales and among scales, and the more general design practices that have emerged, and could emerge, from these understandings.
Prerequisites: ARCH 2110, ARCH 2120, ARCH 2130, ARCH 2140, ARCH 2230, and ARCH 4140.
Offered: Spring term annually.
4 credit hours

ARCH 4060
Surface as Structures as Form
The seminar will analyze twentieth century pioneers of reinforced concrete as well as their contemporaries in art and sculpture. The analysis will consist of a general survey of the work of a particular architect, engineer, or artist, followed by an in-depth formal analysis of one of their projects. A new project will then be developed in order to speculate on the contemporary implications of these principles in conjunction with new instruments of computation.
Offered: Spring term annually.
4 credit hours

ARCH 4080
Landscape Patterns: From Region to Site
This course introduces the essential components of landscape planning from a design perspective. It will introduce methods for visualizing and interpreting landscape patterns, including the suitability analysis approach espoused by Ian McHarg and colleagues, the language of American landscape ecology, and Kevin Lynch's place legibility concept. Synthesis of this regional information will then be used to develop a focused understanding of sustainable design implications at the site level.
Offered: Spring term annually.
4 credit hours

ARCH 4140
Modernity in Culture and Architecture
An exploration of the idea of modernity as both a cultural phenomenon (extending back to Enlightenment ideas of progress, technological enframing of the world, scientific rationality, historical consciousness, etc.) and as an artistic/architectural discourse unfolding in the 20th century as a radical questioning of all traditional concepts of program, construction, and aesthetics. As such, this is both a theory and a history course.
Prerequisites: ARCH 2120 and ARCH 2130.
Offered: Spring term annually.
4 credit hours

ARCH 4240
Architecture Design 4
(Urban Design Studio) An upper level design studio emphasizing the interacting combinations of dynamic influences arising from both global and local scales in the design of portions of the urban landscape, usually including some substantial housing component.
Prerequisite: ARCH 2230.
Offered: Fall and summer terms annually.
6 credit hours

ARCH 4250
Architecture Design 5
A series of upper-level design studios that focus on significant concerns in architecture.
Prerequisites: ARCH 4240 for ARCH 4250. ARCH 4300 may be taken after ARCH 4250.
Offered: Fall and spring terms annually.
6 credit hours

ARCH 4260
Architecture Design 6
A series of upper-level design studios that focus on significant concerns in architecture.
Prerequisites: ARCH 4250 for ARCH 4260. ARCH 4300 may be taken after ARCH 4250.
Offered: Fall and spring terms annually.
6 credit hours

ARCH 4300
Design Development
A technology-based design studio emphasizing the materialization and making of architectural design projects. The integration of building code requirements for fire protection, life safety, accessibility, building environmental systems, structure, construction, and materiality is central to effectively achieving design intent. Students become aware of how these affect and inform design decisions. They learn to integrate technology, systems, and materials in the comprehensive resolution of building design and gain exposure to construction documents and design documentation. Construction and site visits are an integral part of the studio as is an integrated electronic media seminar on CAD applications. Students must coregister for ARCH 4540, a concurrent two-credit course.
that introduces codes, the regulatory process, agreements, contract documents, building design cost control, and administration. This course may be taken any time after ARCH 4250.

**Prerequisites:** ARCH 4250, ARCH 4330. ARCH 4740 may be taken as a prerequisite or corequisite. It is recommended that ARCH 4740 be deferred one semester for students studying abroad only (ex: China) and take ARCH 2360 as a corequisite.

**Offered:** Fall and spring terms annually.

**4 credit hours**

**ARCH 4330**

**Structures 2**

This course builds on the material presented in Structures 1, with an emphasis on the analysis and design of structures compressed primarily of steel and site cast and pre-cast concrete, with an overview of load-bearing masonry and advanced systems. The theoretical concepts covered in the introduction course form the conceptual basis for work in Structures 2, with relevant new concepts/techniques covered. Innovative, non-normative structural systems are investigated and discussed. Analysis and design will proceed using primarily computer-aided techniques. The course approach will involve in-class presentations, homework and project work, computer lab, field trips, and case studies. WebCT will be used to expand the student’s access to course materials and allow for a measure of distance learning. Sustainability: The following notions are introduced as important attributes of sustainable structures and construction: structural robustness, and programmatic flexibility. (Design optimization approaches are introduced and explored as avenues to accomplish more optimum design conditions under increasingly strict design constraints.)

**Prerequisites:** ARCH 2510 except M.Arch. students, ARCH 2350, ARCH 2330.

**Offered:** Fall term annually.

**4 credit hours**

**ARCH 4360**

**Graduate Architecture Design 4**

(Urban Design Studio) An upper level design studio emphasizing the interacting combinations of dynamic influences arising from both global and local scales in the design of portions of the urban landscape, usually including some substantial housing component as well as facilities for the public realm.

**Prerequisite:** ARCH 2630.

**Offered:** Fall and spring terms annually.

**6 credit hours**

**ARCH 4430**

**Electronic Media: Physical Design Processes**

This course will examine processes of design prototyping and fabrication via 3-D scanning, CNC milling, and other techniques in a critical design context. Two particular foci will be established: the application of these tools as means for physical design visualization of computer-based design work and the exploration of the systemic biases these tools give to the design conceptualization process. In both cases, creative exploration of design opportunity will be encouraged. Students will be expected to create multiple material experiments during the term and will be responsible for purchasing their own materials.

**4 credit hours**

**ARCH 4460**

**Electronic Media: Critical Visualization**

This course is offered as an advanced design course concerned with the integration of computer modeling, animation, and multimedia technologies into the design methods of the architect. It stresses the need to integrate critical thinking about computer technology and focused learning of software tools and methods. Software used will vary per instructor and will require no previous knowledge of these specific tools. Students, however, should have a fundamental knowledge of and be comfortable with computer systems and operating systems. Some background in computing, for example CSCI 1100, is recommended.

**Offered:** Spring term annually. Limited enrollment.

**2 credit hours**

**ARCH 4540**

**Professional Practice**

An introduction to architectural practice as related to accomplishing design projects. An overview of professional obligations, registration and conduct, architects’ roles in project delivery, and office organization and management for delivering professional services. In-depth examination of architects’ responsibilities for health, safety, and welfare in design; building code requirements for fire protection, life safety, and accessibility; economics of building systems and assemblies; design and construction contracts; and design documentation.

**Corequisite:** Students in ARCH 4300 are required to coregister.

**Offered:** Fall and spring terms annually.

**2 credit hours**

**ARCH 4560**

**Materials and Enclosures**

In a world of rapid technological change, this course aims to equip future architects with the ability to position, understand, and implement new materials and systems in meaningful ways. The working principles of selected advanced materials and systems are explained and issues of material development, applications, and integration into buildings systems are addressed. Emphasis is also placed on understanding the issues involved when combining and installing new materials or systems into buildings. Students are further introduced to detail development. Sustainability: New materials and systems are explored with the objective of formulating meaningful technological response to critical environmental and societal issues such as resource depletion, environmental degradation, and globalization.

**Prerequisites:** ARCH 2510 except M.Arch. students, and ARCH 2350.

**Offered:** Spring term annually.

**2 credit hours**

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**368 COURSE DESCRIPTIONS**
ARCH 4620
Introduction to Computation-Based Design and Programming
This course offers project-centered training in at least three different design-based programming toolkits. Students will gain a working and applied knowledge of design programming techniques as well as an introductory understanding of the general application of algorithms, automated design systems, and programming languages to architectural design.
Offered: Once annually. Limited enrollment.
4 credit hours

ARCH 4690
Case Studies: Investigations into Architectural Knowledge
“The best instructor of all...is a building which is being pulled down.” (John Willis Clark, “On the Construction of the Vaults of the Middle Ages” 1842). Buildings embody cultural knowledge. Their forms and spaces are invested with traces of habitation and beliefs through the employment of materials that are wrought by craft and technology. It is the intention of this course to teach how to investigate buildings in order to reveal the technological and cultural knowledge that is embedded within them. In this course, a select number of significant buildings are “disassembled” through intense questioning, and their artifactual significance is probed through careful analysis.
Prerequisites: ARCH 4140, ARCH 4330 and ARCH 4560; A pre or corequisite to ARCH 4300.
Offered: Fall term annually.
4 credit hours

ARCH 4740
Building Systems and Environment
Design analysis and performance characteristics of building environmental systems, emphasizing heating, cooling, ventilation, and lighting systems. In addition, building electrical systems, acoustics, water, waste, and drainage systems are covered in terms of fundamental theory, designs, and calculations. Case studies, field trips, and system design project work are required.
Prerequisite: ARCH 2360.
Offered: Spring term annually.
4 credit hours

ARCH 4760
Workshop
This course seeks to cultivate a more explicit understanding of “what is material!” through hands-on experiences with several standard building materials: concrete, steel, wood, etc. The basic characteristics of each material and a few basic techniques for working with each will be presented in discussion and demonstration. Students will work in groups with the given materials on several projects. The ambition of the course is for each student to attain an intuitive understanding of materials through direct experiences with them.
Offered: Fall and spring terms annually.
4 credit hours

ARCH 4810
Advanced Technology Seminar
Introduction to architectural research and emerging technologies as an essential component for changing architecture. A survey of people and organizations involved in research, design, prototyping, and use of emerging technologies. The emphasis is on exploring how emerging technologies impact architectural design and construction. Current issues and ideas are identified by the class and are explored in a series of student-organized, in-depth seminars with leading designers, scientists, and inventors.
Offered: Fall term annually.
2 credit hours

ARCH 4840
Architectural Acoustics 1
This course provides an overview of the essentials for architectural acoustics design of performance and public spaces, including concert halls, theaters, museums, classrooms, sports arenas, courtrooms, and religious buildings. There are no prerequisites, but the course may be used as the starting point for a certificate in Architectural Acoustics, a concentration in an architecture student’s professional electives, or the beginning of a master’s degree in acoustics. The course covers basic principles of sound, room acoustics, sound absorption in rooms, sound isolation and privacy, acoustics of mechanical systems, and sound quality. After both Architectural Acoustics 1 and 2, the student should be prepared for a basic entry-level position in either acoustics in architecture or in acoustical consulting.
Offered: Fall term annually.
4 credit hours

ARCH 4850
Architectural Acoustics 2
In the spring semester, students will have the opportunity to design their own performance hall. This process will include continued studies of acoustics measurements, simulated sound fields, community noise issues, and professional practice in acoustics consulting. The course will also have detailed lectures on concert hall acoustics, sound quality, and synthesized sound fields. Students will be introduced to a variety of simulation software and measurement equipment in the Acoustics Research Laboratory. After both Architectural Acoustics 1 and 2, the student should be prepared for a basic entry-level position in either acoustics in architecture or in acoustical consulting.
Prerequisite: ARCH 4840 or instructor approval.
Offered: Spring term annually.
4 credit hours

ARCH 4860
Applied Psychoacoustics
Topics include the functional overview of the auditory system, loudness, pitch, and timbre perception, masking, binaural hearing, auditory scene analysis, multi-modal integration, and auditory perception in rooms. Required signal processing methods will be covered as well. Course taught with ARCH 6860.
Offered: Spring term annually.
3 credit hours
ARCH 4940
Advanced Individual Projects in Architecture and Environmental Design
Individual projects and readings adapted to the needs of individual students at the advanced level.
1 to 6 credit hours

ARCH 4960
Special Topics in Architecture and Environmental Design
Experimental courses tried out in one or two terms as the general program requires.
1 to 4 credit hours

ARCH 4980
B.Arch. Final Project 1
In the context of a faculty directed design research area, students initiate, research, and plan a comprehensive project that creatively engages the material inhabited world. The FP1 semester is research intensive and the first of the two-semester Final Project sequence. The semester includes a research/methods seminar that is common to all students. The integrated design research phase is executed under the guidance of a final project studio professor in a studio context. In that phase, each student initiates, prepares, and develops a project for completion in ARCH 4990 Final Project 2. For students in the B.Arch. program only. This is a communication-intensive course.
Offered: Fall term annually.
5 credit hours

ARCH 4981
Methods Seminar
Situated within the context of the Final Project (ARCH 4980) directed research studio sequence, this course addresses general methods of design research with an emphasis on studying the ways in which the discipline of architecture engages other fields of knowledge. Through a series of historical and contemporary writings as well as specific precedents in architectural design, it will look at how the discipline of architecture has absorbed external disciplinary, technological, and cultural influences as a means of advancing itself in the world.
Co-requisite: Students in ARCH 4980 are required to co-register.
Offered: Fall term annually.
1 credit hour

ARCH 4990
B.Arch. Final Project 2
The final phase of B.Arch. Final Project culminates in a comprehensive investigation manifested in a design project that engages the material inhabited world. Students continue the integrated design research phase of an approved project that was initiated in Final Project 1 (ARCH 4980) and complete its design under the guidance of a final project studio professor. For students in the B.Arch. program only. This is a communication-intensive course.
Prerequisite: ARCH 4980.
Offered: Spring term annually.
6 credit hours

ARCH 6110
Design Explorations 1
Case studies — investigations into architectural knowledge. Selective architectural works will be deconstructed in order to uncover the knowledge invested in them. Case studies will be subjected to modes of inquiry that will reveal their deep content from conception to realization, including the mental frameworks of the designers, the methods of representation, the technological knowledge employed, the methods of production, and the ingrained cultural values, to develop methods of inquiry that will enable them to pursue similar investigations of any architectural work.
Offered: Fall term annually.
4 credit hours

ARCH 6120
Design Explorations 2
Architectural and urban environments are analyzed and explored so as to reveal significant but not obvious content. The precise topics vary but always address important issues. Currently they address the environmental performance of buildings and the role that spatial order/organization of urban environments plays in the construction of social practices, human subjectivities, and technologies of power. Topics alternate every other year.
Prerequisite: ARCH 6110.
Offered: Fall term annually.
4 credit hours

ARCH 6130
Design Explorations 3
Taught with ARCH 6120 with the same topics alternating every year, so that students cumulatively are taught an architectural topic and an urban one over a two-year period.
Prerequisite: ARCH 6120.
Offered: Fall term annually.
4 credit hours

ARCH 6210
Graduate Studio 1
Individual and group projects conducted within the framework of a preselected problem area (or number of problem areas). Individual students pursue specialized elements or aspects of the problem area with emphasis on revealing a deeper knowledge of the parts. Group activity centers on discussions of individual contributions and emphasizes the role of these contributions as they build a greater understanding of the total problem area. For students in the M.Arch. second professional degree program and M.S. in Building Sciences program only.
2 to 7 credit hours
ARCH 6220
Graduate Studio 2
Individual and group projects conducted within the framework of a preselected problem area (or number of problem areas). Individual students pursue specialized elements or aspects of the problem area with emphasis on revealing a deeper knowledge of the parts. Group activity centers on discussions of individual contributions and emphasizes the role of these contributions as they build a greater understanding of the total problem area. For students in the M.Arch. second professional degree program and M.S. in Building Sciences program only.
2 to 7 credit hours

ARCH 6310
Environmental History and Theory
This course has been conceived together with Material Systems and Productions and the Design Research Studio, such that each student will develop a complementary written analysis that critically situates the new material system that the student is developing in design studio within historical, socio-political, and economic flows. The written analysis will directly reference key themes contained within the required readings, lectures, and seminar discussions. Course taught in New York City.
Offered: Fall term annually.
3 credit hours

ARCH 6320
Built Ecologies 1
Advanced graduate level course focusing on the collection, analysis, and application of data for the generation of criteria within the design process. Multiple scales will be investigated, from the material and product scale, to the building/architectural scale, and finally to the urban, regional, and global scales. Course taught in New York City.
Prerequisites for undergraduates: ARCH 2360 or equivalent or ARCH 4740 or equivalent.
Offered: Fall term annually.
3 credit hours

ARCH 6330
Built Ecologies 2
In this seminar, students develop and analyze an ecologically sensitive built system related to their thesis topic with particular attention to the architectural, social, and political implications of the work and their inter-relationships. An awareness of the political and economic forces that are instrumental in the development of contemporary built ecologies creates opportunities for innovation in the cultures of making. Course taught in New York City.
Prerequisites: ARCH 6310, ARCH 6320, or departmental approval.
Offered: Spring term annually.
3 credit hours

ARCH 6340
Material Systems and Productions
This seminar will investigate emerging functional materials addressing physical adaptability to environmental and climatic fluctuations. Bio-climatic responsiveness via multi-scale intelligence will be examined from innovations on material simulation systems, low energy/low waste manufacturing, raw material reduction, and material consumption reduction within potential design applications. Design exercises will develop building systems or products that reduce material use, weight, volume, or energy consumption with the goal of increasing the environmental performance of the system. Course taught in New York City.
Offered: Fall term in New York City.
3 credit hours

ARCH 6350
Design Research Studio
This initial studio segment will explore variable phases of data collection, processing, and synthesis through explorative visualization methods. These methods will bear the complexity of mapping dynamic forces present in nature juxtaposed to cultural and economical factors. Course taught in New York City.
Offered: Fall term annually.
4 credit hours

ARCH 6360
Interdisciplinary Research Studio
The studio addresses interdisciplinary exchange within research practice, understanding that buildings operate within complex dynamic systems. Buildings and their material systems are composed of interdependent systemic relationships at multiple scales – ‘Built Ecologies’ – operating as metabolic systems within and upon existent natural and made systems. Design is a method of research, discovering and developing new systems and strategies transferable to many sites. Course taught in New York City.
Prerequisites: ARCH 6340 or equivalent, ARCH 6350 or equivalent, ARCH 6310 or equivalent, and ARCH 6320 or equivalent.
Offered: Spring term annually.
4 credit hours

ARCH 6510
Disciplinary Research Methods Seminar
A seminar in research methods. This course will review the major considerations and tasks involved in conducting research in areas appropriate to the architectural sciences. It introduces the essential aspects of designing, supporting, and conducting a research project. Major areas that will be considered include: history and present status of the quantitative and qualitative methods, strengths and weaknesses of each method and approach, location of resources, information and data, sampling or selection of research materials and/or participants, data collection, measurement, data analysis, and research writing and style.
Offered: Spring term annually.
4 credit hours
ARCH 6520
Interdisciplinary Ph.D. Seminar
This is a seminar course restricted to students in their second year of doctoral study. It provides a critical forum for the discussion of issues from methods to sources confronting the students on the dissertation. This course will form the core of the interdisciplinary experience of the Doctor of Philosophy in Architectural Sciences. It supports the position that advanced work in architecture frequently builds on knowledge from several disciplines, and as such provides a model for encouraging cross disciplinary work in the Institute. It will involve a combination of senior faculty and visitors and regular presentation of dissertation work in progress.
Offered: Fall term annually.
4 credit hours

ARCH 6810
Research Design Seminar
The principal objective of this seminar is to provide students with the opportunity to learn the fundamentals of research design. Research design includes: 1) identifying and selecting focused research problems/opportunities/ideas; 2) documenting the state of the art in the selected research area; 3) identifying the critical resources and settings to carry out the research; 4) designing the research program including strategies and tactics for carrying out the research. It is hoped that the knowledge gained in the RD Seminar will assist students in the development of their own individual thesis proposals.
Offered: Fall term annually.
2 credit hours

ARCH 6830
Graduate Thesis Seminar: Acoustics
The Graduate Thesis Seminar: Acoustics is designed to provide support to graduate students who are engaged in independent thesis research projects. It is a required course for all graduate students in the Architectural Acoustics programs. This seminar provides a formal opportunity for students and faculty from a range of concentrations to meet together and discuss thesis work in progress.
Prerequisite: ARCH 6810.
Offered: Spring term annually.
1 credit hour

ARCH 6840
Engineering Acoustics
Introductory materials of engineering acoustics for students with basic knowledge in mathematics. Much of the course material is taken from the textbook “Acoustics for Engineers” by Blauert & Xiang. The course includes mechanic and acoustic oscillations, electromechanic and electroacoustic, magnetic- and electric-field transduction, wave equations in fluids, governing equations for horns and ducts, spherical sound sources and arrays, diffraction and scattering, dissipation, reflection, refraction and absorption, isolation of air- and structure-borne sounds, noise propagation and noise control. Differential equations is recommended.
Offered: Fall term annually.
2 credit hours

ARCH 6860
Applied Psychoacoustics
This course covers the fundamentals of psychoacoustics with a focus on Architectural Acoustics. Topics include the functional overview of the auditory system, loudness, pitch, timbre perception, masking, binaural hearing, auditory scene analysis, multi-modal integration, and auditory perception in rooms. Required signal processing methods will be covered as well. The graduate-level course requires an extensive individual project and more advanced analysis.
Offered: Fall term annually.
3 credit hours

ARCH 6870
Sonics Research Laboratory 1
The Sonics Research Lab is completely research based. First, students will develop an understanding of the measurement equipment and analysis required in order to quantify qualitative aspects of various sonic environments. In addition, students will examine the ISO standards for measurements in order to develop specific research goals. Students and professors will travel to a performance hall and perform measurements. Students will then analyze the data and interpret the results. Dissemination of results will go toward furthering the practice of architectural acoustics and increasing the understanding of the resultant subjective quality of a room.
Corequisite: ARCH 4840 or instructor approval.
Offered: Fall term annually.
4 credit hours

ARCH 6880
Sonics Research Laboratory 2
The second semester of the Sonics Research Lab focuses on predictability models and virtual acoustics “auralization.” State-of-the-art software will be used for simulation of room acoustics in order to show the student how such programs assist in refining the design of performance and public spaces.
Prerequisite: ARCH 6870 or instructor approval.
Offered: Spring term annually.
2 credit hours

ARCH 6890
Aural Architecture
In this course, design processes in architectural acoustics will be studied from a psychoacoustical perspective. Different concepts to create physical and virtual acoustic spaces will be discussed based on perceptual design goals. Topics include ecological psychoacoustics, sound quality, auditory virtual environments, and auditory computational modeling.
Prerequisite: ARCH 6860.
Offered: Spring term annually.
3 credit hours
ARCH 6900
Graduate Thesis Seminar
Readings and discussion of topical materials that are selected to
place graduate projects and theses in a comprehensive context.
Offered: Fall and spring terms annually.
2 credit hours

ARCH 6910
Doctoral Seminar
This seminar cultivates a multi-disciplinary approach to the de-
velopment of problem definition and research method. The topics
being considered will be drawn from and situated between the
various fields of study that support doctoral study in architectural
sciences, as well as activities in related fields in engineering, sci-
ence, and the humanities. Case studies of prototypical architectural
science research will evaluate current practice, identifying state of
knowledge with the field and the resources and settings necessary
to support the research activity.
Prerequisite: Students must have passed the qualifying exam or
received permission of instructor.
Offered: Fall term annually.
4 credit hours

ARCH 6940
Advanced Individual Projects in Architecture and
Environmental Design
Individual projects and readings adapted to the needs of individual
students at the advanced level.
1 to 6 credit hours

ARCH 6960
Special Topics in Architecture and Environmental
Design
Experimental courses tried out in one or two terms as the general
program requires.
1 to 4 credit hours

ARCH 6970
Professional Project
Active participation in a semester-long project, under the supervi-
sion of a faculty adviser. A Professional Project often serves as a
culminating experience for a Professional Master’s program but,
with departmental or school approval, can be used to fulfill other
program requirements. With approval, students may register for
more than one Professional Project. Professional Projects must
result in documentation established by each department or school,
but are not submitted to the Office of Graduate Education and
are not archived in the library. Grades of A, B, C, or F are assigned
by the faculty adviser at the end of the semester. If not completed
on time, a formal Incomplete grade may be assigned by the faculty
adviser, listing the work remaining to be completed and the time
limit for completing this work.

ARCH 6980
Master’s Project
Active participation in a master’s-level project, under the supervi-
sion of a faculty adviser, leading to a master’s project report. Grades
of IP are assigned until the master’s project has been approved by
the faculty adviser. Grades will then be listed as S. If recommended
by the adviser, the master’s project may be accepted by the Office
of Graduate Education to be archived in the library.
1 to 9 credit hours

ARCH 6981
Methods Seminar
Situated within the context of the Master’s Thesis (ARCH 6990)
directed research studio sequence, this course addresses general
methods of design research with an emphasis on studying the
ways in which the discipline of architecture engages other fields of
knowledge. Through a series of historical and contemporary writ-
ings as well as specific precedents in architectural design, students
will look at how the discipline of architecture has absorbed external
disciplinary, technological, and cultural influences as a means of
advancing itself in the world.
Offered: Fall term annually.
1 credit hour

ARCH 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty
adviser, leading to a master’s thesis. Grades of S or U are assigned
by the adviser each term to reflect the student’s research prog-
ress for the given semester. Once the thesis has been presentend,
approved by the adviser, and accepted by the Office of Graduate
Education, it will be archived in a standard format in the library.

ARCH 9990
Dissertation
Active participation in research, under the supervision of a faculty
adviser, leading to a doctoral dissertation. Grades of IP are assigned
until the dissertation has been publicly defended, approved by
the doctoral committee, and accepted by the Office of Graduate
Education to be archived in a standard format in the library. Grades
will then be listed as S.
Offered: Fall and spring terms annually.
Variable credit hours
ARTS Arts (HSSH)

ARTS 1010
Music and Sound
This course, which is the prerequisite for further courses in music theory and in computer music, is an introduction to the materials of music. Using a variety of examples from classical, popular, and non-western music, the class will introduce concepts of melody, harmony, rhythm, and musical form. Students will use their laptop computers for aural skills practice, notation, and basic recording exercises. Although no musical experience is required for this course, sight singing is one of the important skills to be developed.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 1020
Media Studio: Imaging
This course introduces students to digital photography, Web design, and interactive multimedia in making art. Students broaden their understanding of such topics as composition, effective use of images, color theory, typography, and narrative flow. Inquiry and experimentation are encouraged, leading towards the development of the skill and techniques needed to create visual art with electronic media.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 1200
Basic Drawing
An introductory course in drawing designed to develop seeing ability and means of expressing visual ideas through graphic skills. The course consists of exercises in drawing from observation and studies from the history of art.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 2010
Intermediate Video
Intermediate Video is a hands-on intensive course that teaches the language, aesthetics, and techniques of video production. Working in groups and individually, students will develop and produce several short video projects. Emphasis will be on the acquisition of creative and technical production skills in visualizing, scripting, aesthetics, shooting, sound design, and editing.
Prerequisite: ARTS 1030 or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 2020
Computer Music
Music composition taught in the context of modern computerized production methods. Technical topics include basic principles of computer sound generation, digital sound sampling, and the use of small computers for musical control of electronic instruments. Musical topics include a study of important musical works and compositional techniques of the 20th century. Student projects involve hands-on work on a variety of computer instruments and software. This course is a prerequisite for further creative work with Rensselaer’s computer music facilities.
Prerequisite: ARTS 1010 or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 2040
Intermediate Digital Imaging
Intermediate Digital Imaging is a hands-on studio course exploring the use of computer technologies in making visual art. A study of contemporary issues in digital media and photography facilitates individual innovation and experimentation. Digital imaging and input/output techniques are employed in terms of giving visual form to ideas and personal expression in private and public settings.
Prerequisite: ARTS 1020 or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 2060
Fundamentals of Animation
Fundamentals of Animation is an introduction to animation as an art form. Most of this course will be traditional assignments designed to encourage spontaneous creativity, explore animation concepts, and learn animation terminology. Assignments will build a solid foundation for entrance into Animation 1. This course will also be a historical and theoretical investigation with screenings and readings followed with discussion.
Prerequisites: ARTS 1020 or ARTS 1962.
Offered: Fall term annually.
4 credit hours

ARTS 2070
Graphic Storytelling
A studio arts course exploring the fundamental concepts, techniques, styles, and mechanics used in the creation of graphic narrative. Contents to be covered include the fundamentals of sequential art, the purposes and formats of storyboards, basic terminology and concepts used in storyboard, and the applications of storyboard techniques. Key visual storytelling structures are explored for the following industry applications: comics, animated films, graphic novels, commercials, documentaries, live action feature films, and video gaming.
Prerequisite: ARTS 1020 or ARTS 1200 or permission of instructor.
Offered: Spring term annually.
4 credit hours
ARTS 2210
Sculpture I
A beginning sculpture course combining hands-on studio work sessions with lectures on the history and theory of sculpture practice. The studio component involves explorations of materials and techniques as tools for the enhancing of visual sensitivity and creative expression.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 2220
Fundamentals of 2-D Design
An introductory course which will present basic concepts about composition, line, pictorial space, light, and color in the visual arts in order to help students develop the means for expressing visual ideas effectively. Weekly homework design projects, using both traditional and electronic media, will be complemented by in-class slide lectures, video tapes, and critiques.
Offered: Fall term annually.
4 credit hours

ARTS 2300
Rensselaer Orchestra
Readings, rehearsals, and performances of works from the standard repertoire for orchestra from the Baroque through the 20th century. Prerequisite: demonstration of adequate skill in playing an orchestral instrument through audition.
Offered: Fall and spring terms annually.
1 credit hour

ARTS 2310
Rensselaer Concert Choir
Readings, rehearsals, and performances of works from the standard choral repertoire, from the Renaissance through the 20th century. Attendance is mandatory and preparation expected.
Offered: Fall and spring terms annually.
1 credit hour

ARTS Arts (HSSH)

ARTS 2320
Percussion Ensemble
Readings, rehearsals, and performances of works from the repertoire for percussion ensemble as well as special arrangements and original compositions, spanning the diverse styles of the genre from ragtime music and popular traditions to the classical, standard, and avant-garde. Regular attendance at rehearsals is required and preparation of music expected.
Prerequisite: Demonstration of adequate skills in at least some areas of percussion through formal or informal auditions.
Offered: Fall and spring terms annually.
1 credit hour

ARTS 2330
Jazz Ensemble
Readings, rehearsals, and performances of jazz compositions ranging from the traditional jazz canon to pieces from contemporary composers/arrangers. Preparation and attendance at rehearsals and all performances expected.
Prerequisite: Demonstration of adequate skill through audition.
Offered: Fall and spring terms annually.
1 credit hour

ARTS 2340
Introduction to Afro-Cuban Percussion
This course is an introduction to Afro-Cuban folkloric music traditions through lecture demonstration and class participation. The emphasis is on learning to play Afro-Cuban rhythms and percussion instruments (clave, conga, cowbell, shekere).
Offered: Fall and spring terms annually.
4 credit hours

ARTS 2350
Chamber Music Ensemble
An instrumental class that will be coached and rehearsed and will perform regularly. The larger ensemble will break up into smaller ensembles such as string quartets, woodwind quintets, trios, etc., depending on the make-up of the group, as well as into more unusual combinations that might be required to prepare 20th century repertoire. For intermediate and advanced players, entrance into the course is by authorization form/permission of instructor.
Offered: Fall and spring terms annually.
2 credit hours

ARTS 2360
Roots of Africa Music Ensemble
Roots of Africa Ensemble is a course devoted to learning and performing in African, Afro-Cuban, and New World Percussion. Students will learn to play current music performed by the ensemble, a percussion ensemble engaged in workshop study and public performance of folkloric music, original works by various composers, including compositions by Dr. Eddie Ade Knowles. Under his direction, students will learn significance of performance within folklore ensembles and how to play instruments from Africa, Cuba, and the New World.
Prerequisites: Successful completion of ARTS 2340, audition, and/or invitation by Professor Knowles.
Offered: Fall and spring terms annually.
1 credit hour
ARTS 2400
Music Theory I
This is the second of the three-course sequence in music theory and aural skills. The course covers the fundamentals of diatonic harmony and two-part species counterpoint. Aural skills include interval, scale and chord identification, rhythmic and tonal solfège, and dictation. Learning activities include weekly assignments in analysis, composition, performance and improvisation, and self-paced use of software in acquisition of aural skills.
Prerequisite: ARTS 1010 or permission of instructor.
Offered: Spring term annually.
4 credit hours

ARTS 2500
History of Western Music
The objective of this course is for students to be able to recognize and appreciate the stylistic elements of the major periods and composers from the earliest known music to the present. The influences on music by broad cultural and historical forces will also be explored. Beginning with the Greeks, the course will progress chronologically from the polyphonic religious music of the Middle Ages through the Renaissance, Baroque, Classical, Romantic, and modern periods.
Offered: Fall term annually.
4 credit hours

ARTS 2510
History of Jazz
Using rare film and video footage as well as records, CDs, texts, and live musicians, this course traces the development of jazz over its century of existence. This is a communication-intensive course.
Offered: Fall term annually.
4 credit hours

ARTS 2520
World Music
From “raves” to symphony hall, Indian film music to Tibetan chant, monster truck rallies to a mother’s lullaby, musical soundscapes surround us through all aspects of our daily lives. This course focuses on the study of music in or as culture. The exploration of music in human life will be comparative, using case studies from diverse world traditions and examining topics such as: ritual, media and technology, ethnicity/identity, music and dance, and musical transmission.
Offered: Spring term annually.
4 credit hours

ARTS 2530
Art History I: From Paleolithic to Renaissance
This course is a survey of the visual arts from the Paleolithic to the Renaissance era. Nearly 500 images are analyzed according to style, time, place, and character. Relationship of art to ritual, magic, religion, philosophy, literature, and music are examined. Material is presented in a form accessible to students without previous knowledge of Art History.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 2540
The Multimedia Century
This course will survey the history and theory of the diverse artistic practices of the twentieth century in relation to the development of the mass media and new technologies. Topics will include the Bauhaus, Surrealism, Pop Art, and Postmodernism and will span a spectrum of media from the more traditional, such as painting and photography, to electronic and new media, such as video and digital arts. This is a communication-intensive course.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 2550
History through Sound: Modern Music and Beyond
This course is about 20th century music and sound art, stressing the styles and genres that descend from the traditions of European-American art music. The course covers the advent of and reactions to Modernism in music and the growth of experimentalism to 1950; then post-World War II practices and theories including indeterminacy, improvisation, electronic music, and recent computer based practices.
Offered: Spring term annually.
4 credit hours

ARTS 2940
Studies in the Arts
Projects adapted to the needs of individual students.
1 to 4 credit hours

ARTS 2960
Topics in the Arts
Experimental courses offered for one or two terms as the general program requires.
2 to 4 credit hours

ARTS 4010
Interactive Arts Programming
IAP will examine theoretical concepts of interactive media as well as develop the practical skills needed to implement these concepts using the facilities of the iEAR studios. Topics include high and low level computer programming and electronics. Students will build installations and projects, which control live performance interactions with graphics, video, and sound.
Prerequisites: ARTS 2010 or ARTS 2020 or permission of the instructor.
Offered: Spring term annually.
4 credit hours
ARTS 4020
Advanced Digital 3-D Projects
This studio/seminar consists of longer projects with attention to concept, process, and finish. The student will either work individually or as a member on a team and be expected to have a vision or concept they are driven to create. Some possible topics covered may include virtual environments, advanced shader networks, MEL, compositing, non photorealistic rendering, 3-D graphics programming, game engines, or motion capture.
Prerequisites: ARTS 4070 or permission of instructor.
Offered: Spring term annually.
4 credit hours

ARTS 4030
Multimedia Performance Systems
Multimedia Performance Systems explores the composition and programming of real-time performance systems. The course will examine the basics of MIDI, sound synthesis, digital signal processing, and image/video manipulation. Final projects will consist of a real-time performance system or interactive installation.
Prerequisite: ARTS 2020, graduate status, or permission of instructor. This course is a good introduction for ARTS 4010, ARTS 4510, and special project seminars in the Electronic Arts.
Offered: Fall term annually.
Cross listed: ARTS 6030. Students cannot obtain credit for both courses.
4 credit hours

ARTS 4040
Rethinking Documentary: Video Production
This is a production course investigating non-traditional approaches to documentary or non-fiction film/video. Taking a broad look at what defines “documentary” media, this course will incorporate criticism with production. Students will produce a range of video works questioning conventional documentary styles, using radical and interventionist techniques. Students will study traditional documentary works including ethnographic films, cinema verité, propaganda films, “home movies,” reality TV, tabloid news, autobiographical and activist videos.
Prerequisite: ARTS 2010 or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

ARTS 4050
Professional Collaboration
This course provides professional training and experience for graduates and upper-level undergraduates by involving them in the production of a significant artistic project from start to finish. Projects often involve assisting or collaborating with prominent artists in residence at the iEAR studios.
Prerequisites: Graduate standing, or two 2000-level electronic arts courses, or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 4060
Animation I
An introduction to the techniques and principles of computer animation with a concentration on modeling, texturing, and rendering. Students use advanced software to develop directed creative 3-D animations in a hands-on studio. Lectures, discussion, and exposure to contemporary work enable students to develop skills in this rapidly evolving field.
Prerequisite: ARTS 2060 or ARTS 2040 or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

ARTS 4070
Animation II
An intermediate hands-on studio course in 3-D computer animation, in basic character animation, advanced modeling, advanced lighting, advanced rendering, dynamics, particle animation, scene description, and story building.
Prerequisite: ARTS 4060 or permission of instructor.
Offered: Fall term annually.
4 credit hours

ARTS 4080
Art, Community, and Technology
Through direct experience in the community, this course explores the complex roles and relationships of art, education, and technology. Students will develop a plan to work with a media arts center, community organization, or school; final teams will produce real-world arts and education projects that ultimately will be realized as significant additions to their professional portfolio. The projects can include a range from traditional arts practice to creative writing, creative IT models, to community art and activism.
Offered: Spring and fall terms annually.
4 credit hours

ARTS 4100
Electronic Arts Theory Seminar
This course will be devoted to the investigation of diverse topics of electronic arts history, theory, and practice.
Prerequisite: 2000-level Arts course or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours
ARTS 4130  
**New Media Theory**  
This course asks what is really new about New Media, and looks at creative practices, theoretical discourses, and social contexts to find answers. The course concentrates on cutting edge cultural expression using information and communication technologies. The objective to equip students with multiple perspectives — aesthetic, communications, historical — with which to analyze, critique, and develop original concepts about the uses of new media in art and culture. This is a communication-intensive course.  
**Prerequisites:** ARTS 2500, ARTS 2530, ARTS 2540 or a 2000-level history-theory course in Audio Culture.  
**Offered:** Spring term annually.  
**Cross listed:** ARTS 6130. Student cannot obtain credit for both courses.  
**4 credit hours**

ARTS 4150  
**Media Watch**  
This seminar is an investigation of the successes and failures of the news media, set within historical and contemporary contexts. The title “media watch” is intended to evoke a watch-dog approach found in independent media sources and organizations like human rights watch. Assignments involve analyzing how issues are portrayed in the media, and students choose their topics according to their interests. The course can therefore enhance capstone, thesis, or dissertation work.  
**Prerequisites:** 2000-level art, media, or cultural history course, or permission of instructor.  
**Offered:** Upon availability of instructor.  
**Cross listed:** ARTS 6150. Student cannot obtain credit for both courses.  
**4 credit hours**

ARTS 4200  
**Advanced Drawing**  
Advanced Drawing is designed to help students who have mastered basic drawing skills to enhance those skills and utilize them to explore visual ideas. Emphasis is placed on individual development of skills and subject matter to help students express themselves visually. Examples and studies are used from master drawings of the past to learn about the history of art and to stimulate ideas for the students’ own work.  
**Prerequisite:** ARTS 1200 or permission of instructor.  
**4 credit hours**

ARTS 4210  
**Sculpture II**  
An advanced studio course in sculpture for students who have taken Sculpture I. Students are encouraged to explore personal areas of interest and are required to develop a familiarity with the history of sculpture as well as mastering fabrication techniques.  
**Prerequisite:** ARTS 2210.  
**Offered:** Upon availability of instructor.  
**4 credit hours**

ARTS 4220  
**Painting**  
A painting course in water media with emphasis on color interaction, composition, and pictorial design. Using sources from observation and the history of painting, students are taught to see and convey effects of color on/in 2-D pictorial space and to develop critical skills in looking at paintings.  
**Prerequisite:** ARTS 1200.  
**4 credit hours**

ARTS 4400  
**Music Theory II**  
A continuation of studies in harmony, analysis, and ear-training. With an introduction to orchestration and 20th century techniques, the course will culminate with an original composition.  
**Prerequisite:** ARTS 2400.  
**Offered:** Spring term annually.  
**4 credit hours**

ARTS 4410  
**Deep Listening**  
Deep Listening is a practice created by the instructor to enhance and expand listening abilities and to encourage creative work. The class will explore different forms of listening including field recording. Each class time will involve experiential exercises, sound pieces, readings, and discussion. Musical training is not prerequisite.  
**Offered:** Fall and spring terms annually.  
**4 credit hours**

ARTS 4420  
**Experimental Telepresence**  
Experimental Telepresence: investigates the INTERNET as an experimental venue for audio and video performance through improvisation and composition. We will learn protocols for telepresence connections, connect with other institutions using a variety of media in local and co-located performances. The seminar multimedia ensemble Tintinnabulate will be used as a resource of projects.  
**Offered:** Spring term annually.  
**4 credit hours**

ARTS 4510  
**Experimental Game Design**  
Experimental Game Design is an upper level studio arts course focusing on the creation of innovative, workable game prototypes using a variety of interactive multimedia. Games are considered as a new genre and are analyzed as cultural artifacts. The aesthetics of game design including character development, level design, game play experience, and delivery systems are covered. Flow, game theory, and game play gestalt are considered. Alternate gaming paradigms and emerging forms are encouraged.  
**Prerequisite:** ARTS 1020 or permission of instructor.  
**Offered:** Fall and spring terms annually.  
**4 credit hours**
ARTS 4540  
Game Development II  
This course follows Game Development I. Students work in interdisciplinary teams to create one large-scale 3D game, working from concept to public release. Projects may include games, educational games, serious games and simulations, and interactive artworks, and will focus on creative design, technical execution, and use of game design principles. The course builds on skills and knowledge in previous courses in the GSAS core, including game design, game mechanics, game programming, art, and narrative.  
Prerequisites: Game Development I or consent of the instructor.  
Offered: Spring term annually.  
Cross listed: COGS 4960, CSCI 4969.  
4 credit hours

ARTS 4630  
Writing and Directing for Video  
The course introduces students to the art of writing and directing short videos, with an emphasis on generating ideas, and realizing them in a well developed final project. Major theories and principles are studied through a comparative analysis of scripts and films. Students learn to work with actors, write their own scripts, and direct videos. Two final projects — a script and a video — will integrate all of the elements covered in class. Lecture/Practicum.  
Prerequisites: One 2000-level video and one 2000-level writing course, or permission of instructor.  
Offered: Upon availability of instructor.  
4 credit hours

ARTS 4840  
Creative Seminar I  
This course is for senior EMAC and EART majors and is the core creative forum for the development and presentation of the senior thesis. The course is the first part of a two-semester study provided in two seminar courses. The focus of the course is to develop a proposal for a written thesis and a creative project that students will execute in the second seminar and exhibit in an exhibition.  
Prerequisites: Senior EMAC & EART majors only.  
Offered: Fall term annually.  
4 credit hours

ARTS 4850  
Creative Seminar II  
This course is for senior EMAC and EART majors. The goal of the Creative Seminar II is to develop and formulate ideas from Creative Seminar I into a unique project for the artists/communicator that will demonstrate his/her independent ideas, research, writing, and design skills. Students will develop a written thesis, creative project (e.g., art, graphic design, interaction design, music, performance), prepare and present their project in a public exhibition, and design the publicity for the show.  
Prerequisites: Creative Seminar I, seniors EMAC & EART majors only.  
Offered: Spring term annually.  
4 credit hours
ARTS 6080
Electronic Arts Practice
Development and completion of individual creative projects in electronic arts with discussions and critiques of student work in a seminar format. Projects may use any of the studios and combinations of media available in the iEAR Studios. All projects will be presented or performed in public concerts, exhibitions, and installations.
Prerequisite: Limited to M.F.A. students in electronic arts.
Offered: Fall term annually.
3 credit hours per semester, with a maximum of 6

ARTS 6110
Electronic Arts Overview
This seminar will deal with the history, theory, and creation of art, popular culture, and mass media from a contemporary perspective. Theoretical and historical texts and a spectrum of electronic arts and media will be investigated. This course is to be taken in conjunction with ARTS 6080, Electronic Arts Practice, in the first semester of graduate work in the M.F.A. program. It will support the students' development and articulation of the aesthetic, cultural, and theoretical underpinnings of their artistic work produced in ARTS 6080 and in other studio courses.
Prerequisite: Limited to M.F.A. students or permission of instructor.
Offered: Fall term annually.
3 credit hours

ARTS 6120
Fieldwork as Art
This course is an introduction to fieldwork and ethnographic methods in support of artistic creation. The class will guide students through interviews, participant-observation, and documentation at various field sites to produce diverse creative projects ranging from ethnographic essays to video to installations. Students will be encouraged to work on topical materials of their choice, focused on issues such as technological change, artistic subcultures, or environmentalism. Enrollment is restricted to students with graduate standing or by permission of the instructor.
Offered: Spring term annually.
3 credit hours

ARTS 6130
New Media Theory
This course asks what is really new about New Media, and looks at creative practices, theoretical discourses, and social contexts to find answers. The course concentrates on cutting edge cultural expression using information and communication technologies. The objective is to equip students with multiple perspectives — aesthetic, communications, historical — with which to analyze, critique, and develop original concepts about the uses of new media in art and culture.
Cross listed: ARTS 4130. Students cannot obtain credit for both courses.
3 credit hours

ARTS 6150
Media Watch
This seminar is an investigation of the successes and failures of the news media, set within historical and contemporary contexts. The title “media watch” is intended to evoke a watch-dog approach found in independent media sources and organizations like human rights watch. Assignments involve analyzing how issues are portrayed in the media and students choose their topics according to their interests. The course can therefore enhance capstone, thesis, or dissertation work.
Offered: Upon availability of instructor.
Cross listed: ARTS 4150. Student cannot obtain credit for both courses.
3 credit hours

ARTS 6240
Eco Chic: Living Art
Eco Chic: Living Art is an upper level production and theory class about art, biology, and the study of life covering topics such as environmentalism, land art, food art, sustainable practices with art, body art, bio-art. Part lecture, part hands-on workshop, Eco Chic encourages students to redefine and experimentally express their relationships with the varied aspects of everyday living systems and manipulating life.
Offered: Fall term annually.
3 credit hours

ARTS 6400
Experimental Game Design
Experimental Game Design is an upper level studio arts course focusing on the creation of innovation workable game prototypes using a variety of interactive media. Games are considered as a new genre and are analyzed as cultural artifacts. The aesthetics of game design including character development, level design, game play experience, and delivery systems are covered. Flow, game theory, and game play gestalt are considered. Alternate gaming paradigms and emerging forms are encouraged.
Offered: Spring and fall terms annually.
3 credit hours

ARTS 6420
Experimental Telepresence
Research, plan, create and execute portfolio projects involving networked improvisation, composition and performance via Internet and Internet2. Study and use telematic technology such as Lola, JackTrip, SKYPE, mobile and other devices in performances with others in distant locations. Participate in multimedia improvisation ensemble (Tintinnabulate) as a resource for implementing projects.
Offered: Spring term annually.
3 credit hours
ARTS 6570  
Research Methods  
This seminar is an investigation of creative, theoretical and historical research methods in the interdisciplinary arts. Students will be introduced to arts practice-based research discourses and will gain competence in writing and research techniques, conventions, and methods. This course is a requirement for all Arts Department doctoral students.  
Offered: Fall term annually.  
3 credit hours  

ARTS 6900  
Arts Ph.D. Colloquium  
The Ph.D. Arts colloquium provides doctoral discourse and community for Arts at Rensselaer. The Ph.D. students will curate a series of guest speakers representing artists, researchers, theoreticians, historians, and curators to present their work at the colloquium. Related readings and writing assignments will be based on colloquium presentations. Ph.D. students are required to take the colloquium each semester until they have passed their Candidacy Exam.  
Prerequisite: Open to Arts Ph.D. students only.  
Offered: Fall and spring terms annually.  
3 credit hours  

ARTS 6940  
Studies in Electronic Arts  
Individual and collaborative projects and readings adapted to the needs of individual students at the advanced level.  
Offered: Fall and spring terms annually.  
4 to 6 credit hours  

ARTS 6960  
Topics in Electronic Arts  
3 to 6 credit hours  

ARTS 6990  
Master’s Thesis  
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.  
1 to 9 credit hours  

ARTS 9990  
Dissertation  
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  
Offered: Fall and spring terms annually.  
Variable credit, up to 12 hours per semester.  

ASTR Astronomy (SOS)  

ASTR 1510  
Quasars and Cosmology  
An introduction to the origin and large-scale structure of the Universe. Topics to be covered include: the contents and geometry of the Universe, the Big Bang model, particle physics and the formation of the elements, galaxy formation, dark matter, black holes, and active galactic nuclei. If ASTR 1510 is taken as a one-credit course, it will be graded satisfactory/unsatisfactory and it cannot be counted towards the Institute’s baccalaureate requirement of 24 credits in the sciences. If ASTR 1510 is taken as a two-credit course, it will be graded in the conventional manner. If ASTR 1510 and ASTR 1530 are both taken as graded two-credit courses, they may be counted together as one four-credit elective for nonscience majors.  
Offered: Fall term annually.  
1 or 2 credit hours  

ASTR 1530  
Tour of the Solar System  
A survey of the solar system based on recent results from ground-based observations and space probes. Topics to be covered include: the sun, moon, Venus, Mars, the giant planets, comets, and the search for life in the solar system. If ASTR 1530 is taken as a one-credit course, it will be graded satisfactory/unsatisfactory, and it cannot be counted towards the Institute’s baccalaureate requirement of 24 credits in the sciences. If ASTR 1530 is taken as a two-credit course, it will be graded in the conventional manner. If ASTR 1510 and ASTR 1530 are both taken as graded two-credit courses, they may be counted together as one four-credit elective for nonscience majors.  
Offered: Fall term annually.  
1 or 2 credit hours  

ASTR 1960  
Topics in Astronomy and Astrophysics  
1 credit hour  

ASTR 2050  
Introductory Astronomy and Astrophysics  
Astronomy for students with a background of college mathematics and physics. Topics include: astrophysical concepts, solar system basics, stellar astronomy and the interstellar medium, the Milky Way system, galaxies, quasars, and cosmology.  
Corequisite: PHYS 1200.  
Offered: Spring term annually.  
4 credit hours
ASTR 2120  
Earth and Sky  
An introduction to astronomy from an observational perspective. Students will learn the basics of observing the night-time sky, both with the unaided eye and through telescopic observation. Observations of Earth from orbiting satellites will also be discussed. The course is suitable for nonphysics and nonscience majors as well as those committed to specialization in Astronomy. Includes evening laboratory sessions.  
**Offered:** Fall term annually.  
**4 credit hours**

ASTR 2940  
Special Projects in Astronomy  
Study and research in various fields of astronomy to demonstrate interest in and ability for independent work.  
**Prerequisite:** Permission of instructor.  
**Offered:** Fall and spring terms annually.  
**3 credit hours**

ASTR 4120  
Observational Astronomy  
**Prerequisite:** ASTR 2050 or permission of instructor.  
**Offered:** Fall term annually.  
**4 credit hours**

ASTR 4220  
Astrophysics  
A survey course in modern astrophysics with an emphasis on stellar astrophysics and interstellar matter; topics include star formation, the structure and observable properties of normal and degenerate stars; and the composition, dynamics, and stability of the interstellar medium.  
**Prerequisite:** PHYS 2220 and PHYS 4420 or equivalent.  
**Offered:** Fall term annually.  
**4 credit hours**

ASTR 4240  
Gravitation and Cosmology  
Introduction to the physics of gravitation and spacetime. Special relativity, tensor calculus, and relativistic electrodynamics. General relativity with selected applications of Einstein’s field equations (gravitational time dilation; gravitational lensing; frame dragging; gravitational radiation). The physics of nonrotating and rotating black holes. Relativistic models for the large-scale structure of the Universe. Observational constraints on the cosmological parameters. Big Bang nucleosynthesis, the Cosmic Background Radiation.  
**Prerequisite:** PHYS 4330 and MATH 4600.  
**Offered:** Spring term annually.

Cross listed: PHYS 4240. Students cannot receive credit for both ASTR 4240 and PHYS 4240.  
**3 credit hours**

ASTR 4510  
Origin of Life: A Cosmic Perspective  
To understand the origin of life is a fundamental goal of science. We discuss evidence for important prebiotic molecules in the clouds from which new planetary systems are born, and compare cosmic and terrestrial sources of such molecules on the primitive Earth. The course is multidisciplinary, covering topics in physics, astronomy, chemistry, earth sciences, and biology.  
**Prerequisite:** ASTR 2050 or permission of instructor.  
**Offered:** Spring term annually.  
**3 credit hours**

ASTR 4900  
Astrophysics Undergraduate Seminar  
Discussion of topics in the current astrophysical literature. Each student is required to give one oral presentation based on a paper or group of papers.  
**Prerequisite:** Junior standing or higher, or permission of instructor.  
**Offered:** Fall and spring terms annually.  
**1 credit hour**

ASTR 4940  
Special Projects in Astronomy  
Study and research in various fields of astronomy to demonstrate interest in and ability for independent work.  
**Prerequisite:** Permission of instructor.  
**Offered:** Fall and spring terms annually.  
**3 credit hours**

ASTR 4960  
Topics in Astronomy and Astrophysics  
**4 credit hours**

ASTR 6250  
Interstellar Medium  
Thermal structure and dynamics of the interstellar medium. Topics include diffuse nebulae, composition of interstellar dust and relation to extinction and polarization, molecules and interstellar chemistry, physics of star-forming regions.  
**Prerequisite:** ASTR 4220.  
**Offered:** Consult department about when offered.  
**3 credit hours**

ASTR 6900  
Astrophysics Seminar  
Discussion of topics in the current astrophysical literature. Each student is required to give an oral presentation based on a paper or group of papers. For graduate students only.  
**Offered:** Fall and spring terms annually.  
**1 credit hour**
ASTR 6940
Readings in Astronomy and Astrophysics
3 credit hours

ASTR 6960
Special Topics in Astronomy and Astrophysics
Supervised reading and study in various fields of astrophysics.
3 credit hours

ASTR 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

BCBP Biochemistry and Biophysics (SOS)

BCBP 2900
Research in Biochemistry/Biophysics
Hands-on research in a faculty member’s research laboratory.
Prerequisite: Permission of instructor.
Offered: Fall and spring terms annually.
3 to 4 credit hours, 9 to 12 contact hours

BCBP 2930
Out-of-Classroom Experience in Biochemistry/ Biophysics
Credit to be given for an out-of-classroom experience related to biochemistry and/or biophysics (BCBP) having intellectual content relevant to the student's educational or career goals, subject to approval of a written proposal and a final written report. The adviser (for BCBP majors) or, with permission, any BCBP faculty member may serve as evaluator. For each out-of-classroom experience a student may register only once.
1 to 4 credit hours

BCBP 2940
Readings in Biochemistry/Biophysics
Independent study of selected readings in the fields of biochemistry and biophysics, supervised by a faculty member.
Prerequisite: Permission of instructor.
Offered: Fall and spring terms annually.
1 to 4 credit hours

BCBP 4310
Genetic Engineering
In this course, students will explore the molecular methods and applications of recombinant DNA technology and the issues regarding their use through case studies on the effect of genetic engineering in medicine, agriculture, biology, forensics, and various other areas of technology. The course has three major components: 1) techniques used in the generation of recombinant molecules, 2) application of recombinant technology to diagnostics and therapeutics and 3) genetically modified organisms. May be used to fulfill the Culminating Experience requirement in Biology. (Students cannot obtain credit for both this course and BCBP 6310.)
Prerequisites or corequisites: BCBP 4760 and BIOL 4620, or permission of instructor.
Offered: Spring term annually.
4 credit hours

BCBP 4550
Molecular Modeling
This course covers the theory and practice of the structural modeling of proteins and other biomolecules using informatics-driven and energy-based approaches. Topics include template-based comparative modeling, secondary structure prediction, tertiary structure prediction, protein classification, sidechain rotamers, docking, protein design, energy minimization, electrostatics, molecular dynamics, and molecular surfaces. Molecular modeling software will be provided. Laptop computers are required. BIOL 4550, BIOL 6420, BCBP 4550, and BCBP 6420 meet jointly; only one of these courses can be taken for credit.
Prerequisite: MATH 1020, BIOL 4620, BIOL 4760.
Offered: Spring term annually.
Cross listed: BIOL 4550/6420, BCBP 4550/6420.
4 credit hours

BCBP 4640
Proteomics
Characterization of patterns and changes in patterns of protein expression with development, aging, and disease. Protein separation and quantification strategies; mass spectrometry and analysis of spectra; protein profiling, biomarkers, post-translational modifications; current applications; emerging technologies and applications. Individual presentations on relevant topics will be expected. (Students cannot obtain credit for this course and BIOL 4640, BCBP 6640 or BIOL 6640.)
Prerequisite: BCBP 4760 or equivalent.
Offered: Spring term annually.
4 credit hours
BCBP 4710
Biochemistry Laboratory
Major principles of biochemistry are illustrated as students purify and analyze specific proteins. Experience is obtained with various techniques including protein extraction from bacteria and tissues, chromatography, ultracentrifugation, spectrophotometric analysis, and electrophoresis. The course includes extensive hands-on laboratory work, as well as the writing of in-depth reports. (Students cannot obtain credit for both this course and BIOL 4710.) This is a communication-intensive course.
Prerequisite: BIOL 1010, BIOL 2120.
Offered: Spring term annually.
4 credit hours

BCBP 4760
Molecular Biochemistry I
Part I of a two-semester sequence focusing on the chemistry, structure, and function of biological molecules, macromolecules, and systems. Topics covered include protein and nucleic acid structure, enzymology, mechanisms of catalysis, regulation, lipids and membranes, carbohydrates, bioenergetics, and carbohydrate metabolism. (Students cannot obtain credit for both this course and either BIOL 4760 or CHEM 4760.)
Prerequisites or corequisites: CHEM 2250 and BIOL 1010 or BIOL 2120 or equivalents.
Offered: Fall term annually.
Cross listed: BIOL 4760 and CHEM 4760.
4 credit hours

BCBP 4770
Molecular Biochemistry II
The second semester of the molecular biochemistry sequence. Topics include lipids and lipid metabolism, amino acid metabolism and the coenzymes involved in this metabolism, nucleic acid synthesis and chemistry, protein synthesis and degradation, integration of metabolism, photobiology, and photosynthesis. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BIOL 4770 or CHEM 4770.)
Prerequisite: BCBP 4760 or equivalent.
Offered: Spring term annually.
Cross listed: BIOL 4770 and CHEM 4770.
4 credit hours

BCBP 4780
Protein Folding
The biophysical mechanism of protein folding and the role of misfolding in human diseases is explored. The course will introduce principles of protein structure, protein folding in the cell, and thermodynamic and kinetic methods for studying protein folding in vitro. The course will also involve a literature-based discussion of human diseases related to protein folding defects, including Alzheimer's and other amyloid diseases, cystic fibrosis, and Prion-related syndromes.
Prerequisite: BCBP 4760 or equivalent. (Students may not receive credit for both this course and BCBP 6780, CHEM 4780, or CHEM 6780.)
Offered: Spring term even-numbered years.
4 credit hours

BCBP 4870
Protein Structure Determination
X-ray crystallography and nuclear magnetic resonance (NMR) are used to determine 3-D structures of biological macromolecules at atomic resolution. The course will cover crystallographic and NMR methods, their theory and practice, along with thermodynamics of structure formation and molecular dynamics. Students will prepare a poster presentation on a protein of their choice. (Students cannot obtain credit for both this course and BCBP 6870.)
Prerequisites: BCBP 4760, MATH 1020, and PHYS 1200 or equivalents.
Offered: Fall term even-numbered years.
4 credit hours

BCBP 4990
Senior Research Thesis
Independent laboratory research, on or off campus, supervised by a faculty member, culminating in a written thesis; or literature research culminating in the writing of a review article. The thesis research must also be presented in the form of a poster presentation or a talk. This is a communication-intensive course. Limited to students with senior status.
Prerequisite: Permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

BCBP 6170
Advanced Topics in Nuclear Magnetic Resonance
Advanced graduate course covering fundamental aspects of NMR common for application in a broad range of fields. Classical and quantum-mechanical descriptions are utilized to explore information content of NMR pulse sequences. The latter approach includes density matrix theory and proceeds with the product-operator formalism. Practical aspects and data analysis are also described. Subsequent focus is on liquid-state NMR of biological macromolecules, including resonance assignment and determination of molecular structure and dynamics. (Students cannot obtain credit for both this course and CHEM 6170.)
Prerequisite: CHEM 4410 or equivalent.
Offered: Spring term annually.
4 credit hours
BCBP 6310
Genetic Engineering
In this course, students will explore the molecular methods and applications of recombinant DNA technology and the issues regarding their use through case studies on the effect of genetic engineering on medicine, agriculture, biology, forensics, and various other areas of technology. The course has three major components: 1) techniques used in the generation of recombinant molecules, 2) application of recombinant technology to diagnostics and therapeutics and 3) genetically modified organisms. May be used to fulfill the Culminating Experience requirement in Biology.
Prerequisite: Undergraduate course in molecular biology and biochemistry or permission of instructor. (Students cannot obtain credit for both this course and BCBP 4310.)
Offered: Spring term annually.
4 credit hours

BCBP 6420
Molecular Modeling
This course covers the theory and practice of the structural modeling of proteins and other biomolecules using informatics-driven and energy-based approaches. Topics include template-based comparative modeling, secondary structure prediction, tertiary structure prediction, protein classification, sidechain rotamers, docking, protein design, energy minimization, electrostatics, molecular dynamics, and molecular surfaces. Molecular modeling software will be provided. Laptop computers are required. BIOL 4550, BIOL 6420, BCBP 4550, and BCBP 6420 meet jointly; only one of these courses can be taken for credit.
Prerequisite: MATH 1020, BIOL 4620, BIOL 4760.
Offered: Spring term annually.
Cross listed: BIOL 4550/6420, BCBP 4550/6420.
4 credit hours

BCBP 6640
Proteomics
Characterization of patterns and changes in patterns of protein expression with development, aging, and disease. Protein separation and quantification strategies; mass spectrometry and analysis of spectra; protein profiling, biomarkers, post-translational modifications; current applications; emerging technologies and applications. Individual presentations on relevant topics will be expected. (Students cannot obtain credit for both this course and BCBP 4640.)
Prerequisite: BCBP 4760 or equivalent.
Offered: Spring term annually.
3 credit hours

BCBP 6780
Protein Folding
The biophysical mechanism of protein folding and the role of misfolding in human diseases is explored. The course will introduce principles of protein structure, protein folding in the cell, and thermodynamic and kinetic methods for studying protein folding in vitro. The course will also involve a literature-based discussion of human diseases related to protein folding defects, including Alzheimer’s and other amyloid diseases, cystic fibrosis, and Prion-related syndromes. (Students may not receive credit for both this course and BCBP 4780, CHEM 4780, or CHEM 6780.)
Prerequisite: BCBP 4760 or equivalent.
Offered: Spring term even-numbered years.
4 credit hours

BCBP 6870
Protein Structure Determination
X-ray crystallography and nuclear magnetic resonance (NMR) are used to determine 3-D structures of biological macromolecules at atomic resolution. The course will cover crystallographic and NMR methods, their theory and practice, along with thermodynamics of structure formation and molecular dynamics. Students will prepare an oral presentation on a protein of their choice. (Students cannot obtain credit for both this course and BCBP 4870.)
Prerequisites: BCBP 4760, MATH 1020, and PHYS 1200 or equivalents.
Offered: Fall term even-numbered years.
4 credit hours

BCBP 6910
Research Rotation
The student will perform hands on research in the lab of a BCBP faculty to learn basic research methods and techniques, accomplish a small research project and determine whether the lab is a good fit for thesis research.
Prerequisites: Restricted to first year BCBP graduate students.
Offered: Spring and fall terms annually.
2 to 4 credit hours

BCBP 6940
Readings in Biochemistry/Biophysics
Independent study of selected readings in the fields of biochemistry and biophysics, supervised by a faculty member.
Prerequisite: Permission of instructor.
Offered: Fall and spring terms annually.
1 to 4 credit hours

BCBP 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned.
Offered: Spring and fall terms annually.
1 to 4 credit hours
BCBP 6990
Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of S or U are assigned by the adviser each term to reflect the student's research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.

1 to 9 credit hours

BCBP 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.

Variable credit hours

BIOL Biology (SOS)

BIOL 1010
Introduction to Biology
Introduction to biological systems. Discussion of problems associated with biological organization, scaling, and hierarchy. Major topics covered include evolution, genetics, molecular biology and biotechnology, and ecology. The course considers the biological components of various societal and individual problems. Taught in Web-based, interactive studio mode with emphasis on biological simulations, problem solving, and peer teaching methods.

Corequisite: BIOL 1015.
Offered: Fall and spring terms annually.
4 credit hours

BIOL 1015
Introduction to Biology Laboratory
The goal of this laboratory course is to learn about biology through hands-on, project-based lab activities that engage students in actual biology experiments and procedures — learning biology by actually doing biology.

Corequisite: BIOL 1010 Introduction to Biology.
Offered: Fall and spring terms annually.
1 credit hour

BIOL 2120
Introduction to Cell and Molecular Biology
Structural and functional relationships of cells are discussed with regard to similarities among all living organisms. Introduction to cellular biochemistry, metabolism and energy flow, cellular and Mendelian genetics, and the chemical basis of heredity. The laboratory exercises illustrate current concepts in cellular and molecular biology.

Offered: Spring term annually.
4 credit hours, 6 contact hours

BIOL 4200
Biostatistics
An introduction to the concepts and techniques of modern statistics. Computer-based, in-class sessions will emphasize hands-on application of statistical techniques using data and examples drawn from the biological and medical sciences. Pre-class, online exercises will prepare students for in-depth classroom explorations. Topics covered will include sampling, regression, analysis of variance, and factor analysis, MANOVA, maximum likelihood methods, discriminant analysis, time series analysis, and forecasting. The final project requires analysis of a major research-related data set and write-up of results in the format of a scientific paper.

Prerequisite: BIOL 1010, MATH 1010 or permission of the instructor.
Offered: Fall term annually.
4 credit hours

BIOL 2500
Genetics and Evolution
Mechanisms of inheritance in eukaryotes and prokaryotes; genetic mapping, gene expression, cloning and sequencing; quantitative and population genetics, and synthetic theory of evolution.

Prerequisite: BIOL 2120.
Offered: Fall term annually.
4 credit hours

BIOL 2900
Research in Biology
Independent study program for the purpose of developing research skills under the guidance of a faculty member. This course may be repeated and it cannot count as a biology elective.

Prerequisite: Permission of instructor.
Offered: Fall, spring, and summer terms annually.
1 to 4 credit hours, 3 to 12 contact hours

BIOL 2930
Out-of-Classroom Experience in Biology
Credit to be given for an out-of-classroom experience related to biology having intellectual content relevant to the student's educational or career goals, subject to approval of a written proposal and a final report. The adviser (for biology majors) or, with permission, any Biology faculty member may serve as evaluator. For each out-of-classroom experience, a student may register only once for one to four credit hours. This course cannot be used as a biology elective.

Offered: Fall, spring, and summer terms annually.
1 to 4 credit hours
BIOL 4020
Stem Cell Laboratory
This laboratory course will use cell culture and various biochemical techniques to study cultured human stem cells. After learning basic cell culture methods, a class project will be assigned for the class to complete, and each student will be responsible for designing and completing the lab work for a single component of the overall project. May be used to fulfill the Culminating Experience requirement in Biology.
Prerequisite/Corequisite: Completion of Advanced Laboratory Requirement for Biology.
Offered: Fall term annually.
4 credit hours

BIOL 4050
Literature Search Strategies in Biology
Course covers basic library offerings such as ConnectNY, My Rens-Search, and Interlibrary Loan and complex ones such as Sci-Finder Scholar, Web of Science and Medline. Different types of information retrieval including ebooks, journal articles, protocols, patents, and grants are included. Students visit archives, and guest librarians are invited to lecture on their areas of expertise.
Offered: Fall term annually.
1 credit hour

BIOL 4060
Cancer Cell Research
Each student is assigned a specific research problem within the general area of cancer cell interactions with the normal tissue microenvironment. Students will use a wide range of techniques, including cell culture, immunofluorescence microscopy, and Western blotting. This laboratory course can serve as a culminating experience for seniors who have previously been involved in independent research involving in vitro cancer cells. This course can be used to fulfill the Culminating Experience in Biology. This is a communication-intensive course.
Prerequisite: BIOL 4260 or BIOL 4740 and permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

BIOL 4090
Seminal Developments in Biomedical Research
Recent developments in biomedical research will be discussed in a moderator-led classroom discussion. Topics may vary by semester but will all relate scientific discoveries to clinical applications and research. Students will make presentations during the semester. Open to students in the accelerated physician-scientist program only.
Offered: Spring term annually.
2 credit hours

BIOL 4100
From Neuron to Behavior
A detailed survey of important topics in the neurosciences. Some of the topics to be covered in this class are: basic mechanisms of neural signaling (neurophysiology, synaptic transmission, and molecular signaling); understanding of sensation/movement and in particular how it relates to neuroanatomy; neurodevelopment and how the mature brain can change (plasticity), and; complex brainfunctions and neurological disease. Taught together with BIOL 6100. Although there is extra work associated with the 6100 course, both courses may not be taken for credit.
Prerequisite: BIOL 1010, BIOL 2120 or permission of the instructor.
Offered: BIOL 1010, BIOL 2120 or permission of the instructor.
Cross listed: BIOL 6100.
4 credit hours

BIOL 4250
Developmental Biology
Model systems provide the experimental basis for understanding the conserved principles of developmental biology. This class will cover fundamental topics including axis specification, pattern formation, cell fate and determination, cell differentiation, senescence, and apoptosis. Emphasis will be placed on integrating gene function and cell behavior with development. Model systems include vertebrates (e.g. frog and chick) and genetically tractable invertebrates (e.g. fruitflies and roundworms).
Prerequisites: BIOL 2120, BIOL 2500.
Offered: Spring term annually.
4 credit hours

BIOL 4260
Advanced Cell Biology
This course is designed to enable students to understand how an organism functions at the cellular and molecular level, and further, how this functioning is regulated so that cells can adapt to changes in their environment. Students will learn the fundamental components of the cell (from protein to organelle), their characteristics, and how these components function in both normal and diseased cells. Students will also learn biochemical, structural, and mechanical aspects of cell functioning and regulation in normal and diseased cells. In addition, students will learn to critically read current scientific literature. By reading current literature, students will gain knowledge of the practice and presentation of science, as well as learn about new techniques and findings. This course can be used to fulfill the Culminating Experience in Biology. Students cannot receive credit for both this course and BIOL 6260.
Prerequisite: BIOL 2120 and one of the following: BIOL 4620, BIOL 4760.
Offered: Fall term annually.
Cross listed: BIOL 6260.
4 credit hours
BIOL 4270  
Human Physiology  
Fundamental physiological processes and their mechanism of action in human and higher mammalian organisms. Emphasis on the control and interaction of physiological systems. Introduction to the muscle, nervous, circulatory, renal, respiratory, digestive, reproductive, and hormonal systems. Limited to biology, biochemistry and biophysics, bioinformatics and molecular biology majors, and biology accelerated medical students.  
Prerequisites: BIOL 2120 or BIOL 4620, CHEM 2250, PHYS 1100. Not recommended for freshmen and sophomores.  
Offered: Fall term annually.  
4 credit hours

BIOL 4310  
Microbiology  
Microbiology is the study of “microscopic organisms”, including members of all the kingdoms of life. The course has two objectives: 1. Provide an overview of the diversity, genetics, and physiology of microorganisms. 2. Review current topics of investigation in Microbiology in detail. Microbes will be studied from a cellular and molecular perspective. This includes structure, nutrition, growth, control, classification and genetics. This course will provide BIOL-OGY STUDENTS the necessary background in bacterial genetics, pathogenic microbiology, prokaryotic physiology, eukaryotic microbiology, molecular biology and microbial ecology. Students may not obtain credit for both this course and BIOL 6310.  
Prerequisite: Biology 2120 or permission of instructor.  
Offered: Spring term annually.  
Cross listed: BIOL 6310  
4 credit hours

BIOL 4320  
Microbiology Lab  
Microbiology Laboratory will provide hands-on experience for broad training in bacteriology and mycology with emphasis on: microscopy, bacterial growth, and biochemical assays. An investigative component will involve characterization of an unknown bacterium using the analytical tools learned. In addition to laboratory experience and good technique, the course will emphasize written communication with reports in the format of scientific papers. This is a communication-intensive course.  
Prerequisites: BIOL 4310 or permission of instructor  
Offered: Fall semester annually (beginning fall 2014).  
4 credit hours

BIOL 4330  
Cancer Biology  
This course is a comprehensive review of the mechanisms of cancer initiation and progression. The format is student-initiated, round-table discussions and manuscript presentations of a wide range of topics that comprise cancer biology including: tumor viruses, oncogenes and tumor suppressor genes, cell cycle regulation in cancer, growth factors and their receptors, multistep tumorigenesis, genomic instability and cancer, stromal cell-tumor cell interactions, angiogenesis, and metastatic invasion. The technique of concept mapping will be used to allow students to graphically organize their understanding of the cancer field as the course progresses. Students may not obtain credit for both this course and BIOL 6330. May be used to fulfill the Culminating Experience in Biology. Students may not obtain credit for both this course and BIOL 6330.  
Prerequisites: BIOL 2500 and BIOL 4620 or equivalent courses.  
Offered: Fall term annually.  
Cross listed: BIOL 6330.  
4 credit hours

BIOL 4350  
Virology  
This course will provide an exploration of the essential aspects of virology. Introductory examination of viral structure, entry and replication for each of the major classes of viruses serve as a foundation. Case studies will examine virus host interactions and strategies for prevention and intervention of viral infection. Additional topics include: emerging viruses, viral detection, viral extinction, beneficial use of viruses, modified viruses as research tools. A student cannot get credit for both BIOL 4350 and BIOL 6350.  
Prerequisite: BIOL 4620 and BIOL 4310 or permission of instructor.  
Offered: Fall term annually beginning fall 2014.  
Cross listed: BIOL 6350.  
4 credit hours

BIOL 4400  
Bioterrorism, Biowarfare, and Biodefense: A Clear and Present Danger  
Never in the history of civilization is the use of biological weapons against humanity more likely by individuals or groups. Course material will focus on what constitutes biological weaponry. Topics include a history of biological warfare and the basic biological principles involved in the manipulation of biological agents: pathogenic microorganisms (bacteria and viruses), their toxins and their comparative lethality. Modes of environmental dissemination of agents and countermeasures that constitute biological defense will be presented. Course will include class discussion and Internet homework.  
Prerequisite: BIOL 1010 or equivalent.  
Offered: Fall term annually.  
4 credit hours
BIOL 4540
Sequence Analysis
This course covers the theory and practice of biological sequence analysis, including algorithms for pairwise sequence alignment, multiple sequence alignment, phylogenetic analysis, and database searching. Concepts covered include homology, sequence similarity, parsimony, mechanisms and metrics of molecular evolution, biological data bases, database search algorithms (BLAST), and statistical significance. Selected topics include hidden Markov models, bootstrap analysis and gene finding. Modern sequence analysis software will be provided. Laptop computers and programming knowledge are required. Meets jointly with BIOL 6410; both cannot be taken for credit. 
Prerequisites: MATH 1020, BIOL 4620, CSCI 1200, or equivlant. 
Offered: Fall term annually. 
Cross listed: BIOL 6410.
4 credit hours

BIOL 4550
Molecular Modeling
This course covers the theory and practice of the structural modeling of proteins and other biomolecules using informatics-driven and energy-based approaches. Topics include template-based comparative modeling, secondary structure prediction, tertiary structure prediction, protein classification, sidechain rotamers, docking, protein design, energy minimization, electrostatics, molecular dynamics, and molecular surfaces. Molecular modeling software will be provided. Laptop computers are required. BIOL 4550, BIOL 6420, BCBP 4550, and BCBP 6420 meet jointly; only one of these courses can be taken for credit. 
Prerequisite: MATH 1020, BIOL 4620, BIOL 4760. 
Offered: Spring term annually. 
Cross listed: BIOL 4550/6420, BCBP 4550/6420. 
4 credit hours

BIOL 4620
Molecular Biology
Nucleotide biosynthesis; structure, replication, transcription, and translation of nucleic acids; reassociation of nucleic acids; molecular cloning, sequencing, and endonuclease mapping of DNA; control of gene expression in bacteria and higher organisms. 
Prerequisites: BIOL 2120 and BIOL 2500 or permission of the instructor. 
Offered: Spring term annually. 
4 credit hours

BIOL 4630
Molecular Biology II
Students will use a variety of tools (textbooks, scientific journals, and Internet resources including molecular databases and data mining tools) to increase understanding of genes, their expression, their products, and their inter-relatedness. (Meets together with BIOL 6690. Both cannot be taken for credit.) 
Prerequisite/Corequisite: BIOL 4620 and BIOL 4760. 
Offered: Fall term annually. 
Cross listed: BIOL 6690. 
4 credit hours

BIOL 4640
Proteomics
Characterization of patterns and changes in patterns of protein expression with development, aging, and disease. Protein separation and quantification strategies; mass spectrometry and analysis of spectra; protein profiling, biomarkers, post-translational modifications; current applications; emerging technologies and applications. Individual presentations on relevant topics will be expected. (Students cannot obtain credit for this course and BCBP 4640, BCBP 6640 or BIOL 6640.) 
Prerequisite: BCBP 4760 or equivalent. 
Offered: Spring term annually. 
4 credit hours

BIOL 4680
Applied and Environmental Microbiology
Examination of how microorganisms interact with each other and with their environment. Microbial distribution and activities in natural systems, and their importance to ecosystem function and environmental quality. Field work and laboratory experience with both classical and modern molecular microbiological techniques including sampling and chemical and physical site characterization; enrichment techniques, fluorescence in situ hybridization, 16S rDNA amplification, sequence analysis, and probe design. Current literature regarding manipulation and regulation of microbial activities will be discussed. This course will be taught at the Darrin Fresh Water Institute at Lake George. A nominal fee will be charged for housing. The course includes extensive hands-on laboratory work as well as the writing of in-depth reports. This is a communication-intensive course. 
Prerequisite: BIOL 4310 or permission of instructor. 
Offered: Fall term annually. 
Contact hours: A total of three hours of lecture/class time and three hours laboratory time is required per week. 
4 credit hours

BIOL 4700
Freshwater Ecology
Freshwater ecology is the quantitative examination of major biological fresh water communities. Course discussions will delineate the physical and chemical regimes under which aquatic organisms exist. Basic limnological processes are studied to define aquatic systems of natural water bodies. The course includes extensive hands-on laboratory work with various locations in the Adirondacks. The course includes extensive hands-on laboratory work, as well as the writing of in-depth reports. This is a communication-intensive course. 
Prerequisite: BIOL 1010 or equivalent and permission of instructor. 
Offered: Fall term annually. 
Cross listed: BIOL 6700. 
4 credit hours
**BIOL 4710**  
Biochemistry Laboratory  
Major principles of biochemistry are illustrated, as students purify and analyze specific proteins. Experience is obtained with various techniques including protein extraction from bacteria and tissues, chromatography, ultracentrifugation, spectrophotometric analysis, and electrophoresis. The course includes extensive hands-on laboratory work, as well as the writing of in-depth reports. (Students cannot obtain credit for both this course and BCBP 4710.) This is a communication-intensive course.  
**Prerequisite:** BIOL 1010, BIOL 2120.  
**Offered:** Spring term annually.  
**Cross listed:** BCBP 4710.  
4 credit hours

**BIOL 4720**  
Molecular Biology Laboratory  
The techniques of gel electrophoresis, restriction enzyme mapping, PCR, and use of a molecular biology software program are applied to the study of bacterial plasmids and mammalian genes. The course includes extensive hands-on laboratory work, as well as the writing of in-depth reports. This is a communication-intensive course.  
**Prerequisite:** BIOL 2120, BIOL 4620.  
**Offered:** Fall term annually.  
4 credit hours

**BIOL 4740**  
Cell and Developmental Biology Laboratory  
Students will learn a variety of modern cell and developmental biology techniques such as cell culture, genetic analysis, immunocytochemistry, fluorescence microscopy, and live cell imaging. Using these techniques, students will investigate the function of genetically manipulated proteins in cells and developing embryos. In the last third of the semester, students will develop independent experimental research plans to address questions of interest to the student. This is a communication-intensive course.  
**Prerequisite:** BIOL 2120, BIOL 2500.  
**Offered:** Fall term annually.  
4 credit hours

**BIOL 4750**  
Cell-Extracellular Matrix Interactions  
Comprehensive examination of cellular interactions with the extracellular matrix (ECM), as well as analysis of the structure and function of the ECM in a variety of tissues. Topics to be covered include: ECM proteins, cell-matrix interactions, ECM signaling, mechanics of the ECM, ECM pathology, and recent advances in ECM research.  
**Prerequisite:** There are no formal prerequisites, but students should have a rudimentary knowledge of cell biology and protein structure (readings to provide this background can be requested from the instructor). Limited to students with junior or senior standing. Graduate students must enroll in BIOL 6750; both courses BIOL 4750 and BIOL 6750 may not be taken for credit. May be used to fulfill the Culminating Experience requirement in Biology.  
**Offered:** Spring term even-numbered years.  
4 credit hours

**BIOL 4760**  
Molecular Biochemistry I  
Part I of a two-semester sequence focusing on the chemistry, structure, and function of biological molecules, macromolecules, and systems. Topics covered include protein and nucleic acid structure, enzymology, mechanisms of catalysis, regulation, lipids and membranes, carbohydrates, bioenergetics, and carbohydrate metabolism. (Students cannot obtain credit for both this course and either BCBP 4760 or CHEM 4760.)  
**Prerequisites:** CHEM 2250 and BIOL 1010 or BIOL 2120 or equivalent.  
**Offered:** Fall term annually.  
**Cross listed:** BCBP 4760 and CHEM 4760.  
4 credit hours

**BIOL 4770**  
Molecular Biochemistry II  
The second semester of the molecular biochemistry sequence. Topics include lipids and lipid metabolism, amino acid metabolism and the coenzymes involved in this metabolism, nucleic acid synthesis and chemistry, protein synthesis and degradation, integration of metabolism, photobiology, and photosynthesis. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BCBP 4770 or CHEM 4770.)  
**Prerequisite:** BIOL 4760 or permission of instructor.  
**Offered:** Spring term annually.  
4 credit hours

**BIOL 4850**  
Principles of Ecology  
A study of the fundamental principles of the ecology of plants and animals. Interrelationships between organisms and their environments are discussed as well as material and energy balances in the ecosystem. Emphasis on the biology of populations (producers, consumers, and decomposers).  
**Prerequisite:** BIOL 2120 or BIOL 1010.  
**Offered:** Spring term annually.  
4 credit hours

**BIOL 4860**  
Evolution  
Phylogeny and the patterns of evolution in the fossil record, geography of evolution, biodiversity, origin of genetic variation, genetic drift, natural selection and adaptation, genetic theory of natural selection, evolution of phenotypic traits, conflict and cooperation, speciation, fitness, coevolution, genomic evolution, evolution and development, macroevolution, evolutionary science and society. May be used to fulfill the Culminating Experience requirement in Biology. Lectures, student presentations, and peer learning.  
**Prerequisite:** BIOL 2500.  
**Offered:** Fall term annually.  
4 credit hours
BIOL 4900
Team Research
Independent research by teams under the supervision of a faculty member, including literature search, brief proposal of project design, conduct of project to completion, and writing of a formal report in the form of a scientific paper and presentation of a seminar or poster on the project. May be used to fulfill the Culminating Experience in Biology.
Prerequisite: Restricted to Biology majors who have completed BIOL 1010, BIOL 2120, and BIOL 2500, or equivalents and who have permission of the instructor to register.
Offered: Fall and spring terms annually.
4 credit hours

BIOL 4940
Readings in Biology
Selected readings in the biological literature to supplement the scientific background of undergraduate students. May be used as a biology elective with approval of Biology Department Curriculum Committee. With four credits, may be acceptable as fulfilling the Culminating Experience requirement in Biology, subject to approval of academic adviser.
Prerequisite: Permission of instructor.
Offered: Fall, spring, and summer terms annually.
1 to 4 credit hours

BIOL 4970
Non-thesis Research
Independent study program for the purpose of developing research skills under the guidance of a faculty member. This course may be repeated once, and it can count as a biology elective. It may not meet the culminating experience requirement except by special permission of the Biology Department.
Prerequisite: Permission of instructor.
Offered: Fall, spring, and summer terms annually.
1 to 4 credit hours, 3 to 12 contact hours.

BIOL 4980
Biomedical Research
Independent research in health sciences, supervised by a faculty member, for the purpose of developing research skills. Such skills include defining a research project, both as a written and oral exercise for a scientific and general audience, and gathering preliminary research data enabling both a written and oral description of the project in the form of a research proposal and an oral defense. Open to students in the accelerated physician-scientist curriculum only. This course is the Culminating Experience for students in this program. This is a communication-intensive course.
Prerequisite: Permission of instructor.
Offered: Spring term annually.
4 credit hours

BIOL 4990
Senior Research Thesis
Independent research, supervised by a faculty member, culminating in a written thesis and oral presentation. This is a communication-intensive course.
Prerequisite: Permission of instructor.
Offered: Fall, spring, and summer terms annually.
4 credit hours

BIOL 6100
From Neuron to Behavior
A detailed survey of important topics in the neurosciences. Some of the topics to be covered in this class are: basic mechanisms of neural signaling (neurophysiology, synaptic transmission, and molecular signaling; understanding of sensation/movement and in particular how it relates to neuroanatomy; neurodevelopment and how the mature brain can change (plasticity), and; complex brain functions and neurological disease. Students prepare analyses and make a presentation of a paper in the original literature. Since there is overlap associated with the 4100 course, both courses may not be taken for credit.
Prerequisites: BIOL 1010, BIOL 2120 or permission of the instructor.
Offered: Spring term annually.
4 credit hours

BIOL 6260
Advanced Cell Biology
This course is designed to enable students to understand how an organism functions at the cellular and molecular level, and further, how this functioning is regulated so that cells can adapt to changes in their environment. Students will learn the fundamental components of the cell (from protein to organelle), their characteristics, and how these components function in both normal and diseased cells. Students will also learn biochemical, structural, and mechanical aspects of cell functioning and regulation in normal and diseased cells. In addition, students will learn to critically read current scientific literature. By reading current literature, students will gain knowledge of the practice and presentation of science, as well as learn about new techniques and findings. Students cannot receive credit for both this course and BIOL 4260.
Prerequisites: An undergraduate “Introduction to Cell Biology” course (BIOL 2120 equivalent). Coursework in Biochemistry and Molecular Biology will be helpful, as well.
Offered: Fall term annually.
4 credit hours
BIOL 6310  
**Microbiology**  
Microbiology is the study of “microscopic organisms including members of all the kingdoms of life. The course has two objectives: 1. Provide an overview of the diversity, genetics, and physiology of microorganisms. 2. Review current topics of investigation in Microbiology in detail. Microbes will be studied from a cellular and molecular perspective. This includes structure, nutrition, growth, control, classification and genetics. This course will provide BIOLOGY STUDENTS the necessary background in bacterial genetics, prokaryotic physiology, eukaryotic microbiology, molecular biology and microbial ecology. Students may not obtain credit for both this course and BIOL 4310.  
*Offered:* Spring term annually.  
*Cross listed:* BIOL 4310.  
*4 credit hours, 6 contact hours*  

BIOL 6330  
**Cancer Biology**  
This course is a comprehensive review of the mechanisms of cancer initiation and progression. The format is student-initiated, roundtable discussions and manuscript presentations of a wide range of topics that comprise cancer biology including: tumor viruses, oncogenes and tumor suppressor genes, cell cycle regulation in cancer, growth factors and their receptors, multistep tumorigenesis, genomic instability and cancer, stromal cell-tumor cell interactions, angiogenesis, and metastatic invasion. The technique of concept mapping will be used to allow students to graphically organize their understanding of the cancer field as the course progresses. May be used to fulfill the Culminating Experience in Biology. Students may not obtain credit for both this course and BIOL 4330.  
*Prerequisites:* BIOL 2500 and BIOL 4620 or equivalent courses.  
*Offered:* Fall term, even-numbered years.  
*Cross listed:* BIOL 4330.  
*4 credit hours*  

BIOL 6350  
**Virology**  
This course will provide an exploration of the essential aspects of virology. Introductory examination of viral structure, entry and replication for each of the major classes of viruses serve as a foundation. Case studies will examine virus host interactions and strategies for prevention and intervention of viral infection. Additional topics include: emerging viruses, viral detection, viral extinction, beneficial use of viruses, modified viruses as research tools. A student cannot get credit for both BIOL 4350 and BIOL 6350.  
*Prerequisites:* BIOL 4620 and BIOL 4310 or permission of instructor.  
*Offered:* Fall term annually beginning fall 2014.  
*Cross listed:* BIOL 4350.  
*4 credit hours*  

BIOL 6410  
**Sequence Analysis**  
This course covers the theory and practice of biological sequence analysis, including algorithms for pairwise sequence alignment, multiple sequence alignment, phylogenetic analysis, and database searching. Concepts covered include homology, sequence similarity, parsimony, mechanisms and metrics of molecular evolution, biological data bases, database search algorithms (BLAST), and statistical significance. Selected topics include hidden Markov models, bootstrap analysis, and gene finding. Modern sequence analysis software will be provided. Laptop computers are required. Knowledge of a programming language is strongly suggested. Meets jointly with BIOL 4540; both cannot be taken for credit.  
*Prerequisites:* MATH 1020, BIOL 4620, CSCI 1200 or equivalent, or permission of the instructor.  
*Offered:* Fall term annually.  
*4 credit hours*  

BIOL 6420  
**Molecular Modeling**  
This course covers the theory and practice of the structural modeling of proteins and other biomolecules using informatics-driven and energy-based approaches. Topics include template-based comparative modeling, secondary structure prediction, tertiary structure prediction, protein classification, sidechain rotamers, docking, protein design, energy minimization, electrostatics, molecular dynamics, and molecular surfaces. Molecular modeling software will be provided. Laptop computers are required. BIOL 4550, BIOL 6420, BCBP 4550, and BCBP 6420 meet jointly; only one of these courses can be taken for credit.  
*Prerequisites:* MATH 1020, BIOL 4620, BIOL 4760.  
*Offered:* Spring term annually.  
*Cross listed:* BIOL 4550/6420, BCBP 4550/6420.  
*4 credit hours*  

BIOL 6510  
**Biology Core Course 1**  
An intensive course designed to provide instruction and stimulate discussion on important topics in biological research. It is loosely divided into 4 modules: 1) ethics, writing, and basic computational biology tools; 2) structural and computational biology; 3) protein and carbohydrate structure and function; 4) microbiology, ecology, and evolution. Students will gain a fundamental understanding of major topics in biology through formal didactic instruction and selected readings from the primary literature.  
*Prerequisite:* Completed bachelor’s degree or permission of instructor.  
*Offered:* Fall term annually.  
*4 credit hours*
BIOL 6520
Biology Core Course II
An intensive course designed to provide instruction and stimulate discussion on important topics in biological research. It is loosely divided into three modules: 1) molecular biology and genetics; 2) cell biology; and 3) entrepreneurship/leadership. Students will gain a fundamental understanding of major topics in biology through formal didactic instruction and selected readings from the primary literature.
Prerequisite: This is a continuation of the fall course BIOL 6510. Completed bachelor’s degree or permission of instructor.
Offered: Spring term annually.
4 credit hours

BIOL 6550
Ethical Issues in Biotechnology
This course reviews the principles of ethical behavior and responsible conduct of research and discusses specific areas of biotechnology research, medical research and societal issues in the context of these principles. Representative topics include genetic engineering, stem cell research, assisted reproduction, human subjects, animal research and nanotechnology. Active student participation is expected.
Prerequisite: Undergraduate registration only with permission of instructor.
Offered: Fall term annually.
Cross listed: BIOL 6700. Students may not receive credit for both BIOL 6550 and BMED.
3 credit hours

BIOL 6640
Proteomics
Characterization of patterns and changes in patterns of protein expression with development, aging, and disease. Protein separation and quantification strategies; mass spectrometry and analysis of spectra; protein profiling, biomarkers, post-translational modifications; current applications; emerging technologies and applications. Individual presentations on relevant topics will be expected. (Students cannot obtain credit for this course and BCBP 4640, BIOL 4640, or BCBP 6640.)
Prerequisite: BCBP 4760 or equivalent.
Offered: Spring term annually.
Cross listed: BIOL 4640, BCBP 4640, BCBP 6640
3 credit hours

BIOL 6660
Muscle Mechanics and Modeling
This graduate/advanced undergraduate hybrid course examines the structural and physiologic properties of muscle, as well as its force production and overall biomechanical function. Muscle structure and function will be explored at the protein, single fiber and whole tissue levels. Discussions will focus primarily on skeletal muscle, and topics will include muscle morphology, cross-bridge theory, molecular motor and actomyosin interaction, Hill-type and Huxley-type models, electromyography, fatigue, muscle inhibition, history-dependent phenomena, in vitro and in vivo muscle function, and the response to injury. Each topic will be introduced and developed utilizing seminal articles in the literature as well as excerpts from texts, and further discussion on current problems and state-of-the-art experimental techniques will draw on the current scientific literature. A student may receive credit for only one of BIOL 6660 or BMED 4660/6660.
Prerequisites: Senior standing or permission of instructor.
Offered: Spring term annually.
Cross listed: BMED 4660/6660.
3 credit hours

BIOL 6680
Applied and Environmental Microbiology
A survey of applied aspects of microbiology including the application of microorganisms in industrial processes and the roles played by microorganisms in the environment. Emphasis is placed on ways in which microorganisms can be manipulated and controlled for human advantage. Current literature regarding manipulation and regulation of microbial activities is discussed.
Prerequisite: BIOL 4310 or permission of instructor.
Offered: Spring term even-numbered years.
3 credit hours

BIOL 6690
Advanced Molecular Biology
Students will use a variety of tools (textbooks, scientific journals, and Internet resources including molecular databases and data mining tools) to increase understanding of genes, their expression, their products, and their inter-relatedness. (Meets together with BIOL 4630. Both cannot be taken for credit.)
Prerequisite: Undergraduate course in molecular biology, molecular genetics, and/or molecular biochemistry.
Offered: Fall term annually.
Cross listed: BIOL 4630.
3 credit hours

BIOL 6700
Freshwater Ecology
Freshwater ecology is the quantitative examination of major biological fresh water communities. Course discussions will delineate the physical and chemical regimes under which aquatic organisms exist. Basic limnological processes are studied to define aquatic systems of differing physical characteristics. Nutrient chemistry analyses of waters of varying acidity, alkalinity, and chemical loadings are related to their trophic status. Lecture and Laboratory are taught at the Darrin Fresh Water Institute at Lake George with field activities at various locations in the Adirondacks. The course includes extensive hands-on laboratory work, as well as the writing of in-depth reports.
Prerequisites: BIOL 4850 Principles of Ecology or equivalent or permission of instructor.
Offered: Fall term annually.
Cross listed: BIOL 4700. A student cannot get credit for both this course and BIOL 4700.
4 credit hours
BIOL 6750
Cell-Extracellular Matrix Interactions
Comprehensive examination of cellular interactions with the extracellular matrix (ECM), as well as analysis of the structure and function of the ECM in a variety of tissues. Topics to be covered include: ECM proteins, cell-matrix interactions, ECM signaling, mechanics of the ECM, ECM pathology, and recent advances in ECM research. May be used to fulfill the Culminating Experience requirement in Biology.
Prerequisite: There are no formal prerequisites, but students should have a rudimentary knowledge of cell biology and protein structure (readings to provide this background can be requested from the instructor). Limited to students with junior or senior standing. Graduate students must enroll in BIOL 6750; both courses BIOL 4750 and BIOL 6750 may not be taken for credit.
Offered: Spring term even-numbered years.
Cross listed: BIOL 4750.
4 credit hours

BIOL 6900
Seminar in Biology
Weekly discussion of selected topics in biology by graduate students and staff.
Offered: Fall and spring terms annually.
1 credit hour

BIOL 6910
Research Rotation I
The students take active part in research, under the supervision of a Biology faculty adviser by mutual agreement.
Prerequisites: Restricted to first year Biology graduate student.
Offered: Fall term annually.
4 credit hours

BIOL 6920
Research Rotation II
The student will perform hands-on research in the lab of a Biology faculty to learn basic research methods and techniques, accomplish a small research project and determine whether the lab is a good fit for thesis research.
Prerequisites: Restricted to first year Biology graduate students.
Offered: Spring term annually.
2 credit hours

BIOL 6930
Research Rotation III
The student will perform hands-on research in the lab of a Biology faculty to learn basic research methods and techniques, accomplish a small research project and determine whether the lab is a good fit for thesis research.
Offered: Spring term annually.
2 credit hours

BIOL 6940
Readings in Biology
Readings in the current literature designed to supplement the background of the student and provide greater depth in the area of his or her specialty.
Prerequisite: Permission of instructor.
Offered: Fall, spring, and summer terms annually.
1 to 4 credit hours

BIOL 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.
1 to 9 credit hours

BIOL 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
2 to 9 credit hours

BIOL 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
Variable credit hours
BMED Biomedical Engineering (SOE)

BMED 2100
Biomedical Engineering (SOE)
Presents structure-property relationships of implant materials including metals, polymers, ceramics, and composites, with an emphasis on mechanical and surface properties in the broader context of implant design. Biological performance of biomaterials, case studies of traditional implants — as well as emerging, tissue-engineered materials — are emphasized.
Offered: Spring term annually.
4 credit hours

BMED 2200
Introduction to Biomedical Engineering
Introduction of mathematical and computational methods to model physiological systems in biomedical engineering. Mathematical methods include solution techniques for systems of algebraic equations, systems of differential, and partial differential equations. Computational methods include finite difference, finite element, and lumped parameter methods. Computational methods are programmed using commercial programming and finite element software.
Prerequisites: MATH 2400, PHYS 1200.
Corequisite: CSCI 1190.
Offered: Fall term annually.
4 credit hours

BMED 2300
Bioimaging and Bioinstrumentation
This course serves as an introduction to biomedical instrumentation and imaging with focus on the acquisition and monitoring of vital signals. Basic principles for the selection and appropriate use of instruments for solving bioengineering and medical problems such as microscopy, magnetic resonance imaging, and ultrasounds, among others are addressed.
Prerequisites: Physics 1200 Physics II.
Offered: Spring term annually.
4 credit hours

BMED 2940
Studies in Biomedical Engineering
Offered: Fall and spring terms annually.
1 to 4 credit hours

BMED 2960
Topics in Biomedical Engineering
Offered: Fall and spring terms annually.
1 to 4 credit hours

BMED 4010
Biomedical Engineering Laboratory
Theory and practice of biomedical measurements. An introduction to instruments and procedures for measurement of pressure, flow, bioelectrical potentials, cell counting, biomechanical and biomaterial properties, using invasive and noninvasive techniques. Transducers studied include strain gauge, differential transformer, spectrophotometer, biopotential electrodes, microscope with camera, mechanical testing machine, piezoelectric transducer (or sensor). Also studied are instruments for determination of material properties.
Prerequisites: BMED 2200, BIOL 4290, or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

BMED 4240
Tissue Biomaterial Interactions
Relationships between structure and properties of synthetic implant materials, including metals, polymers, ceramics, and composites. The emphasis is on mechanical, corrosion, and surface properties of materials. Detailed review of blood-material interactions. An introduction to biocompatibility with special emphasis on the interaction of biomaterials with cells and tissues in the context of implant surface design and tissue engineering.
Corequisite: BMED 2100.
Offered: Spring term annually.
3 credit hours

BMED 4410
BioMEMs
This course discusses state-of-the-art techniques in patterning biomolecules, biosensors, machining three-dimensional microstructures, and building microfluidic devices (Lab-on-a-Chip). Seminal and current literature will be used to discuss topics in BioMEMs ranging from device fabrication to applications in cell biology and medicine. Students cannot get credit for both BMED 4410 and BMED 6410.
Prerequisite: Junior/senior standing.
Offered: Spring term annually.
3 credit hours

BMED 4420
Clinical Orthopaedics and Contemporary Research
An in-depth review of the underlying science, engineering, medicine and contemporary research related to the nation's highest priorities for musculoskeletal diseases and care. Musculoskeletal anatomy, pathophysiology, epidemiology, and contemporary treatments are covered. Special topics will be presented relating state-of-the-art biomedical research to clinical practice. The clinical perspective of each topic will be presented by practicing clinicians with case studies. Topics conclude with live webcasts or recorded surgery from Albany Medical Center or the Capital Region Bone and Joint Center. Students cannot get credit for both BMED 4420 and BMED 6420.
Prerequisites: BMED 4500 and senior standing or permission from instructor.
Offered: Fall term annually.
4 credit hours
BMED 4440
Biophotonics
Biophotonics, or biomedical optics, is a newly developing field, dealing with the application of optical science and technology to biomedical problems, including clinical applications. The course introduces students to the fundamentals in modern and classical optics, light-matter interaction and provides them with a broad overview of current topics and contemporary research in the area of optics and lasers in medicine and biology.
Prerequisite: PHYS 1200.
Offered: Fall term annually.
Cross listed: With 6940. Students cannot receive credit for both courses.
3 credit hours

BMED 4450
Drug and Gene Delivery
The course presents several aspects of drug and gene delivery including: 1) definitions of what drugs or gene are; 2) pharmacokinetics and pharmacodynamics; 3) biomaterial selection considerations; 4) bioactivity considerations; 5) physiological and biochemical barriers to drug delivery; 6) diffusion controlled, dissolution controlled, and osmotic controlled drug delivery systems; 7) polymeric delivery systems; 8) ligand-based targeting and physical targeting; 9) viral mediated gene delivery; 10) non-viral gene delivery; 11) polymers in gene delivery.
Prerequisites: BMED 2100 or equivalent, senior standing, or instructor permission.
Offered: Fall term annually.
3 credit hours

BMED 4500
Advanced Systems Physiology
Applications of control theory and systems techniques to physiology. Emphasis is on entire systems and their interactions rather than isolated phenomena. Areas covered include cardiovascular, respiratory, renal, and gastrointestinal systems. Includes laboratory on the application of engineering techniques in the study of physiological systems.
Prerequisite: BIOL 2120 or equivalent.
Offered: Spring term annually.
4 credit hours

BMED 2540
Biomechanics
Application of mechanics to the study of normal, diseased, and traumatized musculo-skeletal system. Areas covered include determination of joint and muscle forces, mechanical properties of biological tissues, and structural analysis of bone-implant systems. Case studies are discussed to illustrate the role of biomechanics and biomaterials in the design of implants.
Prerequisite: ENGR 2050.
Offered: Fall term annually.
4 credit hours

BMED 4510
Mechanobiology
Mechanical regulation of biological systems. Topics include principles and concepts of mechanobiology; evolution, embryogenesis and histogenesis of tissues with particular references to skeletal system; mechanical regulation of cellular behavior, tissue growth and organ development; concept and application of strain energy regulation in biology; application of mechanobiology to tissue regeneration; limits of mechanical regulation.
Prerequisites: BMED 2450 (Biomechanics) or permission from instructor (non-BME students).
Offered: Spring term annually.
3 credit hours

BMED 4540
Biomechanics II
Examines biomechanics of human body movement through developing various models (e.g., lumped mass, planar rigid body, 3D) and exploring current techniques in Forward and Inverse Dynamic approaches. Topics are developed on a classical mechanics foundation, and simulations are constructed using software (e.g., OpenSIM) to describe normal movements, and investigate possible sources of abnormalities due to injury, disease or dysfunction.
Prerequisites: BMED 2540 or equivalent, junior/senior standing or instructor permission.
Offered: Fall term annually.
3 credit hours

BMED 4560
Biomaterial Applications in Medicine
This is an advanced senior undergraduate course where biomaterials and regenerative medicine is explored with attention to therapies for medical conditions. Regenerative medicine is an interdisciplinary field that brings the promise of repairing and replacing tissues damaged from disease and trauma. In this course the contributions of biomaterials used in tissue and organ replacement will be investigated. Topics will include applications to implant design, tissue engineering, regenerative medicine, stem cells, and drug delivery.
Prerequisites: BMED 2100 Biomaterials Science and Engineering.
Offered: Fall term annually.
3 credit hours
**BMED 4580**  
**Biomedical Fluid Mechanics**  
This course covers the dynamics of fluid flow in human physiological system. Engineering principles and fluid dynamic concepts will be taught in the context of cardiovascular system. Topics include: pulsatile flow in arteries, vascular compliance and wave propagation, impedance, cardiac mechanics, dynamic coupling of ventricle and systemic circulation, blood flow in vein, coronary circulation, microcirculation, blood flow at complex geometries, imaging techniques in clinical hemodynamic assessment, fluid mechanics in designing and testing circulatory implants.  
**Prerequisite:** ENGR 2250 and a basic knowledge of human physiology.  
**Offered:** Fall term annually.  
**Cross listed:** BMED 6480. Students cannot receive credit for both courses.  
**3 credit hours**

**BMED 4600**  
**Biomedical Engineering Design**  
A guided approach to development of design skills. Students work individually and in teams to tackle a biomedical design problem using methods drawn as necessary from engineering and from the physical and mathematical sciences. Discussion sessions involve students in presentations of work. This is a communication-intensive course.  
**Prerequisite:** Senior standing.  
**Offered:** Spring term annually.  
**3 credit hours**

**BMED 4650**  
**Intro to Cell and Tissue Engineering**  
The principles and practice of tissue engineering are taught in this course. The principles underlying strategies for employing selected cells, biomaterial scaffolds, soluble regulators or their genes, and biomechanical loading and culture conditions, for the regeneration of tissues and organs in vitro and in vivo are addressed. Bioreactors, enabling technology and biomimetic approach for fabricating tissue-engineered products and devices for implantation are taught.  
**Prerequisites:** A basic course in mechanics (ENGR 2530 or BMED 2540), and a basic course in transport phenomena or fluid dynamics (ENGR 2250 or equivalent), or permission of instructor.  
**Offered:** Spring term annually.  
**3 credit hours**

**BMED 4660**  
**Muscle Mechanics and Modeling**  
This graduate/advanced undergraduate hybrid course examines the structural and physiologic properties of muscle, as well as its force production and overall biomechanical function. Muscle structure and function will be explored at the protein, single fiber, and whole tissue levels. Discussions will focus primarily on skeletal muscle, and topics will include muscle morphology, cross-bridge theory, molecular motor and actomyosin interaction, Hill-type and Huxley-type models, electromyography, fatigue, muscle inhibi-

- **BMED 4940**  
  **Studies in Biomedical Engineering**  
  **Offered:** Fall and spring terms annually.  
  **1 to 4 credit hours**

- **BMED 4960**  
  **Topics in Biomedical Engineering**  
  **Offered:** Fall and spring terms annually.  
  **1 to 4 credit hours**

- **BMED 6410**  
  **BioMEMs**  
  This course discusses state-of-the-art techniques in patterning biomolecules, biosensors, machining three-dimensional microstructures and building microfluidic devices (Lab-on-a-Chip). Seminal and current literature will be used to discuss topics in BioMEMs ranging from device fabrication to applications in cell biology and medicine. Students cannot get credit for both BMED 4410 and BMED 6410.  
  **Offered:** Spring term annually.  
  **3 credit hours**

- **BMED 6420**  
  **Clinical Orthopaedics and Contemporary Research**  
  An in-depth review of the underlying science, engineering, medicine and contemporary research related to the nation’s highest priorities for musculoskeletal diseases and care. Musculoskeletal anatomy, pathophysiology, epidemiology, and contemporary treatments are covered. Special topics will be presented relating state-of-the-art biomedical research to clinical practice. The clinical perspective of each topic will be presented by practicing clinicians with case studies. Topics conclude with live Webcasts or recorded surgery from Albany Medical Center or the Capital Region Bone and Joint Center. Students can not get credit for both BMED 4420 and BMED 6420.  
  **Prerequisites:** BMED 4500 and senior standing or permission from Instructor  
  **Offered:** Fall term annually.  
  **4 credit hours**
**Biophotonics**

Biophotonics, or biomedical optics, is a newly developing field, dealing with the application of optical science and technology to biomedical problems, including clinical applications. The course introduces students to the fundamentals in modern and classical optics, light-matter interaction and provides them with a broad overview of current topics and contemporary research in the area of optics and lasers in medicine and biology.

**Prerequisite:** PHYS 1200.

**Offered:** Spring term annually.

**Cross listed:** With 4440. Students cannot receive credit for both.

3 credit hours

**Drug and Gene Delivery**

The course presents several aspects of drug and gene delivery including: 1) definitions of what drugs or gene are; 2) pharmacokinetics and pharmacodynamics; 3) biomaterial selection considerations; 4) bioactivity considerations; 5) physiological and biochemical barriers to drug delivery; 6) diffusion controlled, dissolution controlled, and osmotic controlled drug delivery systems; 7) polymeric delivery systems; 8) ligand-based targeting and physical targeting; 9) viral mediated gene delivery; 10) non-viral gene delivery; 11) polymers in gene delivery.

**Prerequisites:** BMED 2100 or equivalent, senior standing, or instructor permission.

**Offered:** Fall term annually.

3 credit hours

**Biomedical Fluid Mechanics**

This course covers the dynamics of fluid flow in human physiological system. Engineering principles and fluid dynamic concepts will be taught in the context of cardiovascular system. Topics include: pulsatile flow in arteries, vascular compliance and wave propagation, impedance, cardiac mechanics, dynamic coupling of ventricle and systemic circulation, blood flow in vein, coronary circulation, microcirculation, blood flow at complex geometries, imaging techniques in clinical hemodynamic assessment, fluid mechanics in designing and testing circulatory implants.

**Prerequisite:** ENGR 2250 and a basic knowledge of human physiology.

**Offered:** Fall term annually.

**Cross listed:** BMED 4580. Students cannot receive credit for both courses.

3 credit hours

**Mechanobiology**

Mechanical regulation of biological systems will be discussed. Topics include principles and concepts of mechanobiology; embryogenesis and histogenesis of tissues with particular references to skeletal system; physical forces at cellular, tissue and organ level; mechanical regulation of cellular behavior, tissue growth, and organ development; limits of mechanical regulation; biochemical influences; application of mechanobiology to tissue regeneration.

**Prerequisite:** BMED 2540 or ENGR 2530 with permission from the instructor. Graduate course.

**Offered:** Spring term even-numbered years.

3 credit hours

**Cell Biomechanics**

The mechanics of single cells and cells in a continuum are discussed in the context of the modulation of cell function by mechanical stresses. Topics include: mechanical forces in the natural environment of various mammalian cells (erythrocytes, leukocytes, osteoblasts, and epithelial cells), mathematical formulations of force distribution and force transmission, cell motility, models of cell membrane skeleton, cell deformability and elasticity, mechanical properties of cell membranes, and role of mechanical forces in cell structure/function.

**Prerequisite:** BMED 2540 or ENGR 2530 with permission from the instructor.

**Offered:** Fall semester annually.

3 credit hours

**Biomaterial Applications in Medicine**

This is an advanced senior graduate course where biomaterials and regenerative medicine is explored with attention to therapies for medical conditions. Regenerative medicine is an interdisciplinary field that brings the promise of repairing and replacing tissues damaged from disease and trauma. In this course the contributions of biomaterials used in tissue and organ replacement will be investigated. Topics will include applications to implant design, tissue engineering, regenerative medicine, stem cells, and drug delivery.

**Prerequisites:** BMED 2100 Biomaterials Science and Engineering.

**Offered:** Fall term annually.

3 credit hours

**Intro to Cell and Tissue Engineering**

The principles and practice of tissue engineering are taught in this course. The principles underlying strategies for employing selected cells, biomaterial scaffolds, soluble regulators or their genes, and biomechanical loading and culture conditions, for the regeneration of tissues and organs in vitro and in vivo are addressed. Bioreactor, enabling technology, and biomimetic approach for fabricating tissue-engineered products and devices for implantation are taught.

**Prerequisites:** A basic course in mechanics (ENGR 2530 or BMED 2540), and a basic course in transport phenomena or fluid dynamics (ENGR 2250 or equivalent) or permission of instructor.

**Offered:** Spring term annually.

3 credit hours
BMED 6660
Muscle Mechanics and Modeling
This graduate/advanced undergraduate hybrid course examines the structural and physiologic properties of muscle, as well as its force production and overall biomechanical function. Muscle structure and function will be explored at the protein, single fiber and whole tissue levels. Discussions will focus primarily on skeletal muscle, and topics will include muscle morphology, cross-bridge theory, molecular motor and actomyosin interaction, Hill-type and Huxley-type models, electromyography, fatigue, muscle inhibition, history-dependent phenomena, in vitro and in vivo muscle function, and the response to injury. Each topic will be introduced and developed utilizing seminal articles in the literature as well as excerpts from texts, and further discussion on current problems and state-of-the-art experimental techniques will draw on the current scientific literature.
Prerequisites: Senior standing or permission of instructor.
3 credit hours

BMED 6700
Ethical Issues in Biotechnology
This discussion course reviews the principles of ethical behavior and responsible conduct of research and then discusses specific areas of biotechnology research, medical research, and societal issues in the context of these principles. Representative topics include genetic engineering, stem cell research, assisted reproduction, human subjects, animal research, and nanotechnology. Class performance is dependent on active participation and discussion, student presentations, and the submission of analytical essays.
Offered: Fall term annually.
3 credit hours

BMED 6940
Studies in Biomedical Engineering
Offered: Fall and spring terms annually.
1 to 4 credit hours

BMED 6960
Topics in Biomedical Engineering
New courses or special course offerings are given under this number from time to time. Graduate students in biomedical engineering may pursue special interests under this number when sponsored by a biomedical engineering faculty member and with the permission of the department.
Offered: By individual arrangement.
1 to 4 credit hours

BMED 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

BMED 6980
Master's Project
Active participation in a master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the Master's Project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.
1 to 9 credit hours

BMED 6990
Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of S or U are assigned by the adviser each term to reflect the student's research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library. 
1 to 9 credit hours

BMED 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
Variable credit hours

CHEM Chemistry (SOS)

CHEM 1100
Chemistry I
Principles of chemistry, with particular focus on atomic and molecular structure and bonding, periodicity, basic thermodynamic principles, introduction to acid-base chemistry and elementary chemical equilibrium, and introduction to organic chemistry. Students cannot get credit for both this course and CHEM 1110.
Offered: Fall term annually.
4 credit hours
CHEM 1110  
Chemistry I with Advanced Lab  
Covers the same lecture material as CHEM 1100, but laboratory experiments will be more technique-oriented to provide better preparation for students who plan to take future laboratory courses in chemistry. Students cannot get credit for both this course and CHEM 1100.  
Offered: Fall term annually.  
4 credit hours

CHEM 1200  
Chemistry II  
Continued examination of the principles of chemistry in more depth, considering thermodynamics, advanced concepts in chemical equilibrium and acid-base chemistry, kinetics of chemical reactions and electrochemistry.  
Prerequisite: CHEM 1100 or CHEM 1110.  
Offered: Spring term annually.  
4 credit hours

CHEM 2030  
Inorganic Chemistry I  
Descriptive chemistry of the elements. Properties, structures, and typical reactions of the elements of the periodic table and their compounds; basic principles of inorganic chemistry.  
Prerequisite: CHEM 1200 or ENGR 1600.  
Offered: Spring term annually.  
4 credit hours

CHEM 2110  
Equilibrium Chemistry and Quantitative Analysis  
This course will cover principles of equilibrium chemistry (particularly solubility and acid-base chemistry) and its application to chemical analysis. Applications of equilibrium chemistry in the fields of geology, environmental science, biology, and biochemistry will be included.  
Prerequisite: CHEM 1200 or CHEM 4530.  
Offered: Fall term annually.  
3 credit hours

CHEM 2120  
Experimental Chemistry I: Analytical Techniques  
A laboratory course dealing with wet and instrumental techniques of chemical analysis.  
Corequisite: CHEM 2110.  
Offered: Fall term annually.  
2 credit hours

CHEM 2230  
Organic Chemistry Laboratory I  
Laboratory experiments dealing with basic techniques used in the synthesis and characterization of organic compounds.  
Prerequisite or Corequisite: CHEM 2250 or a similar course in organic chemistry.  
Offered: Fall term annually.  
1 credit hour

CHEM 2240  
Organic Chemistry Laboratory II  
A continuation of CHEM 2230, which is a prerequisite.  
Prerequisite: CHEM 2230 and CHEM 2260 or a similar course in organic chemistry should be taken with or prior to this course.  
Offered: Spring term annually.  
1 credit hour

CHEM 2250  
Organic Chemistry I  
Structure and chemical behavior of organic molecules with particular emphasis on reaction mechanisms as pathways for understanding their reactions. Stereochemistry, synthesis, and spectroscopic methods for the identification of organic functional groups are among the topics included.  
Prerequisite: CHEM 1100 or 1110 or equivalent.  
Offered: Fall term annually.  
3 credit hours

CHEM 2260  
Organic Chemistry II  
A continuation of CHEM 2250, which is a prerequisite.  
Prerequisite: CHEM 2250.  
Offered: Spring term annually.  
3 credit hours

CHEM 2290  
Experimental Chemistry II: Synthesis and Characterization  
Laboratory experiments dealing with the synthesis and characterization of chemical compounds and practical experience in accessing the chemistry literature. Primary emphasis is organic chemistry. Intended for chemistry majors.  
Corequisite: CHEM 2260.  
Offered: Spring term annually.  
2 credit hours

CHEM 2360  
Chemistry Laboratory: Selected Experiments  
A selection of experiments taken primarily from other chemistry laboratory courses. Intended to permit an individualized laboratory course to be set up to enable transfer students to make up deficiencies in their laboratory background, to allow students from other departments to obtain experience in areas of interest to them, and to provide a course that students from other schools can use to fulfill laboratory requirements of their home institution on a transfer basis. Selection of experiments and credits determined by individual consultation with the academic adviser and instructor.  
Offered: Fall and spring terms annually.  
Arranged credit hours
CHEM 2440
Physical Chemistry for Life Sciences
Topics in physical chemistry that are important for understanding processes in biological systems. Included are: thermodynamics as applied to phase and chemical equilibria in chemical and biochemical systems; passive transport models for diffusion and electrical conductivity in electrolyte solutions; kinetic models for simple and complex chemical reactions, including enzyme mechanisms; quantum mechanical models used in spectroscopy.
Prerequisites: CHEM 1200 and MATH 1010.
Offered: Fall term annually.
4 credit hours

CHEM 2540
Introduction to Geochemistry
An introduction to the application of chemistry to the understanding of problems in the earth and environmental sciences. Topics include thermodynamics and phase equilibria as applied to mineral stability, rock evolution, and water chemistry; stable isotope systematics; radiogenic isotope systematics, trace element geochemistry, organic geochemistry, and geochemical cycles.
Prerequisites: ERTH 1100 and/or ERTH 1200 or permission of instructor.
Offered: Spring term annually.
Cross listed: ERTH 2140. Students cannot receive credit for both this course and ERTH 2140.
4 credit hours

CHEM 2930
Out-of-Classroom Experience in Chemistry
Students may obtain credit for chemistry-related experience in nonclassroom situations. For credit to be awarded, a brief proposal outlining the nature of the experience to be undertaken must be given to the department in advance for approval of its suitability. A written report is required at the end of the experience. A maximum of four credits is allowed, but this may be made up in more than one experience. Graded Satisfactory/Unsatisfactory.
1 to 4 credit hours

CHEM 2940
Special Projects in Chemistry
Study and experimental work in various fields of chemistry to develop an interest in and ability for independent study and investigation.
Prerequisite: Permission of instructor.
Offered: Fall and spring terms annually.
1 to 4 credit hours

CHEM 2950
Undergraduate Research
Hands-on research in a faculty research laboratory.
Prerequisite: Permission of instructor.
Offered: Fall and spring terms annually.
1 to 4 credit hours

CHEM 4010
Inorganic Chemistry II
A course dealing with more advanced topics of inorganic chemistry, including molecular symmetry, application of symmetry concepts to molecular orbital descriptions of polyatomic molecules, solid state and non-stoichiometric compounds, coordination chemistry, spectral and magnetic properties, organometallic chemistry, and bioinorganic chemistry.
Prerequisite: CHEM 2030; it is recommended that CHEM 4410 be taken concurrently.
2 credit hours

CHEM 4020
Experimental Chemistry III: Inorganic and Physical Methods
Laboratory exploration including synthesis and characterization of several types of inorganic compounds, with emphasis on the use of physical methods in inorganic chemistry. Communication of results in written and oral form is an integral part of the course. This is a communication-intensive course.
Corequisites: CHEM 4010 and CHEM 4410.
Offered: Fall term annually.
2 credit hours

CHEM 4110
Instrumental Methods of Analysis
This course will introduce advanced instrumental physicochemical methods of chemical analysis and will include such topics as separations (chromatography), atomic spectroscopy, molecular spectroscopy, and electroanalytical chemistry. Non-majors, particularly those in Biochemistry and Engineering (Biomedical, Environmental, etc. except Chemical Engineering) are encouraged to take this course. Chemistry majors should register for CHEM 4120 concurrently.
Prerequisites: CHEM 2110 and CHEM 2120 or permission of the instructor.
Offered: Fall term annually.
2 credit hours

CHEM 4120
Experimental Chemistry IV: Physical and Instrumental Methods
A laboratory course emphasizing the hands-on use of modern instrumental methods in analytical and physical chemistry applications, and the interpretation and discussion of the results obtained from them. This is a communication-intensive course. Experiments depend on the theoretical material in CHEM 4110 and CHEM 4420, which are corequisites.
Offered: Spring term annually.
2 credit hours
Chem 4160
Nuclear Magnetic Resonance Spectroscopy
A lecture-laboratory course that begins by establishing a knowledge base in the fundamental physical principles of NMR and then provides an understanding of basic and some advanced NMR experiments. This understanding extends to the actual performance of many of these experiments in the laboratory portion of the course. The use of NMR as a powerful tool to solve chemical problems will be explored. Topics included will be: Relaxation, Coupling and NOE, Multinuclear NMR, Spectral Editing, Multidimensional NMR, Solid State NMR, and the special challenges of Macromolecular NMR. Enrollment limited to advanced undergraduates.
Prerequisite: Permission of instructor.
Offered: Spring term even-numbered years.
Cross listed: Students cannot get credit for both this course and CHEM 6160.
3 credit hours

Chem 4300
Medicinal Chemistry
Organic and medicinal chemistry play a crucial role in the discovery of agents used to treat human disease. The basis of this course is the study of the drug discovery process from the perspective of these chemical disciplines. Concepts to be studied are molecular targeted drug discovery, lead compound identification and optimization, biophysical and molecular modeling tools, biological barriers to drug action and ways chemistry can overcome them, and the biotech industry. Topics pertinent to drug development such as drug metabolism and clinical research will also be discussed.
Prerequisite: CHEM 2260 or permission of instructor.
4 credit hours

Chem 4310
Bioorganic Mechanisms
The study of mechanisms of organic reactions in biochemical processes on a molecular level. Enzyme active sites, mechanisms of enzymatic transformations, catalysis, cofactors, enzyme kinetics, environmental toxicology. Strong emphasis on the design and mechanism of action of pharmaceutical agents. Meets with CHEM 6310; both courses cannot be taken for credit.
Prerequisite: CHEM 2260 or permission of instructor.
Offered: Fall term annually.
4 credit hours

Chem 4330
Drug Discovery
This course will examine how bioinformatics, functional genomics, and other modern biotechnologies are used to speed the discovery of new drugs, especially those small organic molecules to treat human diseases with large unmet therapeutic need. Special emphasis will be placed on molecular target identification and validation as well as high-throughput screening to identify a lead. Topics to be discussed will include transgenic mice, RNA interference, DNA and protein microarrays, homogenous time-resolved fluorescence bioassays, phage-display, combinatorial chemistry, and parallel synthesis. Students cannot receive credit for both this course and CHEM 6330.
Prerequisite: CHEM 2260 or permission of instructor.
Offered: Fall term annually.
3 credit hours

Chem 4340
Drug Discovery Laboratory
In this laboratory associated with CHEM 4330, students will reduce to practice the chemical and biological aspects of high-throughput screening used to discover lead molecules. Colorimetric and fluorescence plate readers will be used in 96-well plate format to generate enzyme inhibition data for small libraries of organic molecules. Students will use these inhibition data and published X-ray structural data to develop a pharmacophore model and rationalize a structure-activity relationship.
Prerequisite: CHEM 4330 or concurrent with CHEM 4330.
Offered: Fall term annually.
1 credit hour

Chem 4410
Macroscopic Physical Chemistry
A course dealing with physicochemical properties of substances on a macroscopic scale. Chemical thermodynamics, electrochemistry, electric and magnetic phenomena, transport properties, and surface and colloid chemistry.
Offered: Fall term annually.
4 credit hours

Chem 4420
Microscopic Physical Chemistry
A course dealing primarily with physicochemical properties of substances on a molecular basis. Chemical kinetics, quantum chemistry, spectroscopy, and statistical mechanics.
Prerequisite: CHEM 4410, CHEM 2440, or CHME 2020.
Offered: Spring term annually.
3 credit hours

Chem 4470
Theoretical Chemistry
Introduction to quantum mechanics and applications in chemical systems. Atomic and molecular spectra and structure. Statistical thermodynamics.
Prerequisite: CHEM 4410.
Offered: Fall term annually.
3 credit hours
CHEM 4530  
**Modern Techniques in Chemistry**  
A lecture/laboratory course for Chemical Engineering students. Discusses the principles and applications of modern instrumental methods of chemical analysis and provides laboratory experience in their use along with other chemical techniques. Principles of analytical, organic, and physical chemistry will be illustrated throughout the course.  
**Prerequisites:** Chem 2250.  
**Offered:** Fall and spring terms annually.  
**4 credit hours**

CHEM 4620  
**Introduction to Polymer Chemistry**  
This course will introduce synthetic and kinetic aspects of various polymerization reactions that have been employed to produce commodity and specialty plastic materials. Control and prediction of the molecular weight distribution for different polymerization mechanisms will be discussed along with various characterization techniques of molecular weight distribution and its relation to properties. Thermal/solution properties, chemical/physical properties, and uses of polymers also will be discussed.  
**Prerequisite:** CHEM 2260 or permission of instructor.  
**Offered:** Spring term annually.  
**3 credit hours**

CHEM 4640  
**Experimental Techniques in Macromolecular Chemistry**  
Laboratory techniques and experiments in synthesis, characterization, physical and mechanical properties of synthetic and natural macromolecules. Some commercial macromolecules as well as those synthesized in the laboratory are investigated. Techniques for predicting the engineering and physical properties of macromolecules from their molecular structures are introduced. Lectures provide a state-of-the-art description of synthesis and characterization methods.  
**Corequisite:** CHEM 4620 or equivalent.  
**Offered:** Spring term annually.  
**3 credit hours, 6 contact hours**

CHEM 4690  
**Aqueous Geochemistry**  
Fundamentals of aqueous chemistry as applied to the evolution of natural waters. The course covers principles of chemical equilibrium, activity models for solutes, pH as a master variable, concentration and Eh-pH diagrams, mineral solubility, aqueous complexes, ion exchange, and stable isotopes. The carbonate system, weathering reactions, and acid rain are examined in detail. Emphasis is on the chemical reactions that control surface and groundwater evolution in natural and engineered (treatment plant) settings. Students learn theory, computation methods, and the use of computer programs for calculation of speciation and mass balance.  
**Prerequisite:** Permission of instructor.  
**Offered:** Fall term annually.  
**Cross listed:** ENVE 4110 and ERTH 4690. Students cannot receive credit for both this course and either ERTH 4690 or ENVE 4110.  
**4 credit hours**

CHEM 4760  
**Molecular Biochemistry I**  
Part I of a two-semester sequence focusing on the chemistry, structure, and function of biological molecules, macromolecules, and systems. Topics covered include protein and nucleic acid structure, enzymology, mechanisms of catalysis, regulation, lipids and membranes, carbohydrates, bioenergetics, and carbohydrate metabolism. (Students cannot obtain credit for both this course and either BIOL 4760 or BCBP 4760.)  
**Prerequisite:** CHEM 2250 and BIOL 1010 or BIOL 2120 or equivalents.  
**Offered:** Fall term annually.  
**Cross listed:** BCBP 4760, BIOL 4760.  
**4 credit hours**

CHEM 4770  
**Molecular Biochemistry II**  
The second semester of the Molecular Biochemistry sequence. Topics include lipids and lipid metabolism, amino acid metabolism and the coenzymes involved in this metabolism, nucleic acid synthesis and chemistry, protein synthesis and degradation, integration of metabolism, photobiology, and photosynthesis. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BIOL 4770 or BCBP 4770.)  
**Prerequisite:** CHEM 4760 or equivalent.  
**Offered:** Spring term annually.  
**4 credit hours**

CHEM 4810  
**Chemistry of the Environment**  
Chemical processes important in the environment from naturally occurring and man-induced systems. Thermodynamic and chemical considerations of fuels; the thermodynamics of the atmosphere; atmospheric photochemistry; chemistry of natural water systems; chemistry of pesticides, fertilizers, and other important environmental contaminants; aspects of the carbon, nitrogen, and sulfur cycles.  
**Prerequisites:** CHEM 1200 and one prior or concurrent course in analytical, organic, and physical chemistry.  
**Offered:** Spring term annually.  
**Cross listed:** ERTH 4810. Students cannot obtain credit for both this course and ERTH 4810.  
**4 credit hours**

CHEM 4900  
**Professional Development Seminar**  
Weekly seminars on topics of concern to students who are about to embark on their professional careers in Chemistry. Topics will include employment and career opportunities; graduate school; ethical requirements and expectations in the profession; patent considerations; new directions in research and other topical matters. Restricted to senior Chemistry majors.  
**Offered:** Fall term annually.  
**1 credit hour**
CHEM 4950
Senior Experience
An independent project that utilizes the student’s education as a Chemistry professional and results in the preparation of a formal report. Examples are a laboratory research project or an in-depth, critical literature review in a specific area of chemistry. Students intending research should arrange this with a faculty member well before the beginning of the semester to allow time to plan for a proper project. Students who have performed research in earlier semesters may continue or extend their original project. To be graded S/U. Chemistry seniors only.

CHEM 4960
Selected Topics in Chemistry
1 to 4 credit hours

CHEM 4970
Advanced Research Project
An independent research project in a faculty research laboratory for junior and senior students with prior research experience. Requires permission of the instructor.
Offered: Fall and spring terms annually.
1 to 4 credit hours

CHEM 4990
Senior Thesis
A two-semester spring-fall or fall-spring course dealing with an advanced level independent research project supervised by a faculty member and requiring the presentation of a thesis. First term registration is limited to second semester juniors and first semester seniors.
Prerequisite: Permission of instructor. The grade for the first semester will be listed as “in progress.”
3 credits each semester

CHEM 6010
Perspectives in Chemistry
The objective of this course is to prepare graduate students for research in chemistry. Topics will include general and universal aspects of research in science, such as the written and oral presentation of scientific findings and the ethical considerations involved in the publication of these findings, and a survey of the current research topics of the department including emphasis on the fundamental science that underlies these topics.
Offered: Fall term annually.
3 credit hours

CHEM 6020
Advanced Inorganic Chemistry I
Structure and bonding in inorganic molecules and crystals; stabilities of inorganic compounds; coordination chemistry and organometallic compounds; acid-base concepts; nonstoichiometry and phase relationships.
Offered: Fall term annually.
3 credit hours

CHEM 6140
Introduction to Mass Spectrometry
Graduate course covering fundamental aspects and applications of Mass Spectrometry (MS). Quasi-equilibrium theory, isotope effects, and gas phase chemistry will serve to describe ion formation, excitation, and fragmentation. Methods of ionization (electron impact, electrospray, matrix-assisted laser desorption ionization) and instrumentation (quadrupole, ion trap, time-of-flight, ion cyclotron resonance) will be introduced. Practical aspects regarding application of MS (sample preparation, gas chromatography, liquid chromatography) to biological mixtures and data analysis will also be discussed.
Offered: Spring term annually.
2 credit hours

CHEM 6160
Nuclear Magnetic Resonance Spectroscopy
An introductory course to nuclear magnetic resonance spectroscopy that begins by establishing a knowledge base in the fundamental physical principles of NMR and then provides an understanding of basic and some advanced NMR experiments. The use of NMR as a powerful tool to solve chemical problems will be explored. Topics included will be: Relaxation, Coupling and NOE, Multinuclear NMR, Spectral Editing, Multidimensional NMR, Solid State NMR, and the special challenges of Macromolecular NMR. Students cannot get credit for both this course and CHEM 4160.
Offered: Spring term annually.
2 credit hours

CHEM 6170
Advanced Topics in Nuclear Magnetic Resonance
Advanced graduate course covering fundamental aspects of NMR common for application in a broad range of fields. Classical and quantum-mechanical descriptions are utilized to explore information content of NMR pulse sequences. The latter approach includes density matrix theory and proceeds with the product-operator formalism. Practical aspects and data analysis are also described. Subsequent focus is on liquid-state NMR of biological macromolecules, including resonance assignment and determination of molecular structure and dynamics. (Students cannot obtain credit for both this course and BCBP 6170.)
Prerequisite: CHEM 4410 or equivalent.
Offered: Spring term annually.
4 credit hours

CHEM 6210
Advanced Organic Chemistry I
An introduction to the organic chemical literature. A consideration of reactions of synthetic importance to the organic chemist with emphasis on the influence of structure on the behavior of organic molecules.
Offered: A fall-spring sequence annually.
3 credit hours
CHEM 6250  
**Glycochemistry, Glycobiology and Glychotechnology**  
This is an advanced graduate level course on carbohydrates covering their physicochemical properties, chemical and biochemical synthesis and analysis. The biological activity of polysaccharides, glycoproteins, proteoglycans and glycolipids and the role of glycomics in development and disease will be discussed. The application of glycotechnology and glycoengineering for the preparation of therapeutic glycans and glycan-coated materials will be covered.  
**Prerequisite:** A working knowledge of organic chemistry and biochemistry is required  
*3 credit hours*

CHEM 6300  
**Medicinal Chemistry**  
The organic chemistry of drug discovery and synthesis will be the focus of this course. Starting with the basic concepts of molecular-targeted drug discovery, the process of lead identification will be explored with special emphasis on drug screening and combinatorial chemistry. The roles of computational chemistry, molecular modeling, and biophysical methods in the understanding of the relationship between structure and biological activity will be studied. The chirality of drugs from both the biological and synthetic perspectives will also be explored.  
**Prerequisite:** CHEM 6210 or permission of instructor.  
*3 credit hours*

CHEM 6310  
**Biorganic Mechanisms**  
The study of mechanisms of organic reactions in biochemical processes on a molecular level. Enzyme active sites, mechanisms of enzymatic transformations, catalysis, cofactors, enzyme kinetics, environmental toxicology. Strong emphasis on the design and mechanism of action of pharmaceutical agents. Meets with CHEM 4310; both courses cannot be taken for credit.  
**Prerequisite:** CHEM 6210 or permission of instructor.  
**Offered:** Spring term odd-numbered years.  
*3 credit hours*

CHEM 6330  
**Drug Discovery**  
This course will examine how bioinformatics, functional genomics, and other modern biotechnologies are used to speed the discovery of new drugs, especially those small organic molecules to treat human diseases with large unmet therapeutic need. Special emphasis will be placed on molecular target identification and validation as well as high-throughput screening to identify a lead. Topics to be discussed will include transgenic mice, RNA interference, DNA and protein microarrays, homogenous time-resolved fluorescence biosassays, phage-display, combinatorial chemistry, and parallel synthesis. Students cannot receive credit for both this course and CHEM 4330.  
**Prerequisite:** A knowledge of organic chemistry is required.  
*3 credit hours*

CHEM 6450  
**Nonlinear Laser Spectroscopy**  
An introduction to the theory and practice of multiphoton or nonlinear laser spectroscopic and nonlinear optical phenomena. Emphasis is placed on the spectroscopic applications of nonlinear optical phenomena such as harmonic generation, sum and difference frequency generation, stimulated Raman scattering, multiphoton absorption and ionization, and four-wave mixing methods such as coherent anti-Stokes Raman scattering. There are no prerequisites, but a background in molecular spectroscopy is recommended.  
**Offered:** Spring term odd-numbered years.  
*3 credit hours*

CHEM 6490  
**Chemical Thermodynamics**  
The principles of thermodynamics, with their applications to homogeneous and heterogeneous equilibria.  
**Prerequisite:** Permission of instructor.  
**Offered:** Upon sufficient demand.  
*3 credit hours*

CHEM 6510  
**Computational Chemistry**  
This course is designed to cover the history and application of modern computational chemistry techniques to chemical problems. It will provide familiarity with the various methods and tools presently in use and the assumptions and limitations inherent in each approach. The format involves both lecture and studio modes of instruction and meets in a classroom where each student has a modern workstation.  
**Offered:** Spring term even-numbered years.  
*3 credit hours*

CHEM 6520  
**Advanced Analytical Chemistry**  
A course in the principles of analytical chemistry emphasizing the role of equilibrium chemistry in chemical analysis and the statistical design of experiments. Topics covered include equilibrium chemistry, electrochemistry, chromatographic separations, thermal methods, and chemometrics/experimental design.  
**Offered:** Spring term annually.  
*3 credit hours*

CHEM 6530  
**Quantum Chemistry**  
Postulates of quantum mechanics. Solution of the particle in a box, harmonic oscillator, and the hydrogen atom via series solutions and ladder operator techniques. Development of atomic and molecular orbital theories with applications to structure and spectra.  
**Offered:** Fall term annually.  
*3 credit hours*
CHEM 6540  
**Equilibrium Statistical Mechanics** 
Principles of classical and quantum statistical mechanics with applications to thermodynamics, gases, and crystals. Included are topics related to phase and chemical equilibria, chemical kinetics, imperfect crystals, surface layers, and electrolyte solutions.  
**Prerequisite:** CHEM 6530 or permission of instructor.  
**Offered:** Fall term odd-numbered years.  
3 credit hours

CHEM 6630  
**Synthesis of High Polymers I**  
This course deals with the synthesis of high molecular weight polymers that proceed by condensation polymerization mechanisms. Detailed descriptions of characteristics and mechanisms of condensation polymerizations leading to various classes of polymeric materials will be provided. Discussion will center on the factors that are important for the control and commercial application of these polymerization techniques.  
**Offered:** Fall term even-numbered years.  
3 credit hours

CHEM 6650  
**Synthesis of High Polymers II**  
This course deals with the synthesis of high molecular weight polymers that proceed by addition polymerization mechanisms. Detailed descriptions of characteristics of free radical, cationic, anionic and coordination-catalyzed polymerizations will be provided. Discussion will center on the factors that are important for the control and commercial application of these polymerization techniques.  
**Offered:** Fall term odd-numbered years.  
3 credit hours

CHEM 6660  
**Polymer Analysis and Characterization**  
The objective of this course is to provide the student with a broad survey of methods of analysis and characterization of polymers. Thermal analysis, molecular weight characterization, spectroscopy, and mechanical property determination will be reviewed with an emphasis on method of measurement, quantities measured, and quantities derived from the measurements. Select applications will be used to convey the usefulness of these methods for characterizing polymers and their properties.  
**Offered:** Spring term even-numbered years.  
3 credit hours

CHEM 6670  
**Chemical Biology**  
This course introduces the fundamentals of protein structure and function with an emphasis on chemical concepts and small molecule-protein interactions. This course focuses on the basic biochemical concepts required for advanced studies in biochemistry and biotechnology and is intended for first year graduate students.  
**Offered:** Fall term annually.  
2 credit hours

CHEM 6800  
**Chemical Information Sources**  
An introduction to chemical information science for chemistry graduate students, providing a survey of printed and electronic sources and their effective use. Students will do literature searches and prepare a bibliography on potential or actual research topics.  
**Offered:** Spring term annually.  
1 credit hour

CHEM 6900  
**Chemistry Seminar**  
1 credit hour

CHEM 6910  
**Chemistry Teaching Seminar**  
Discussions and seminars on how to deal with the various aspects of teaching and related problems encountered by teaching assistants in chemistry. Seminar topics will include: cognitive theories of learning; several models of teaching; educational psychology; attitude and motivational factors; communication and presentation skills; leadership; time management; how to write an exam; grading problems; ethics; group problem solving skills; and cultural diversity. Seminars will be led by a senior, experienced teaching assistant along with participating faculty. Graded satisfactory/unsatisfactory only.  
**Offered:** Fall term annually.  
1 credit hour

CHEM 6940  
**Readings in Chemistry**  
1 to 3 credit hours

CHEM 6950  
**Introduction to Research**  
A course for first semester Chemistry graduate students that involves rotations of four weeks each through three research groups to become familiar with research in the department. Students will participate in various research-related activities, including group meetings, reading papers, exploring potential thesis projects, and shadowing or assisting graduate students working in the lab. The main goal of the course is to assist graduate students in their selection of a research adviser.  
3 credit hours

CHEM 6960  
**Selected Topics in Chemistry**  
1 to 3 credit hours
CHEM 6970  
**Professional Project**  
Active participation in a semester-long project, under the supervision of a faculty adviser. A professional project often serves as a culminating experience for a professional master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one professional project. Professional projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.  
*3 to 4 credit hours*  

CHEM 6990  
**Master’s Thesis**  
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library. May be used interchangeably with CHEM 9990 for students presenting a doctoral dissertation.  

CHEM 9990  
**Dissertation**  
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.  
*Variable, Up to 9 credit hours can be used in place of CHEM-6990 for students submitting a master’s thesis.*  

CHME 2010  
**Material, Energy, and Entropy Balances**  
Development of the ability to apply and solve equations of balance for chemical-process systems, laying the foundation for subsequent chemical engineering courses in unit operations and process design. Topics include process flowsheeting, mass and mole balances for nonreactive and reactive systems, properties of fluids, and the first and second laws of thermodynamics.  
*Offered: Fall term annually.  
*4 credit hours*  

CHME 2020  
**Energy, Entropy, and Equilibrium**  
A continuation of CHME 2010. Topics include process flowsheeting, solution thermodynamics, phase equilibria, chemical-reaction equilibria, and applications of thermodynamics to problems in chemical-process design. One credit hour of this course is devoted to Professional Development.  
*Prerequisite: CHME 2010.  
Offered: Spring term annually.  
*4 credit hours*  

CHME 2940  
**Readings in Chemical Engineering**  
*1 to 3 credit hours*  

CHME 2960  
**Topics in Chemical Engineering**  
*3 credit hours*  

CHME 2980  
**Senior Project**  
*1 to 3 credit hours*  

CHME 4010  
**Transport Phenomena I**  
An introductory course in transport phenomena covering fluid statics, and one-dimensional diffusive processes including laminar flow, heat conduction, and mass diffusion. Course focuses on developing the equations of change, introducing sum-of-resistance concepts and couple fluid flow, heat transfer, and mass transfer problems. The concept of extended surfaces as a means of enhancing transport process is included. The course introduces numerical simulation concepts for solving simple, one-dimensional transport problems. Credit not allowed for both this course and ENGR 2250.  
*Prerequisite: MATH 2400.  
Offered: Fall term annually.  
*4 credit hours*  

## CHME Chemical Engineering (SOE)

CHME 1010  
**Introduction to Chemical Engineering**  
This is an elective course suitable for first-year students interested in chemical engineering. It introduces students to the profession, including the technical content, career opportunities, and societal impact.  
*Offered: Fall term annually.  
*1 credit hour*  

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**407 COURSE DESCRIPTIONS**
CHME 4020
Transport Phenomena II
A continuation of CHME 4010. Course includes topics on multi-dimensional transport processes, potential, boundary layer and turbulent fluid flows, convective heat and mass transfer processes, friction factors and drag in and around solid objects, heat and mass exchangers, and radiation heat transfer. The course extends the use of numerical methods to apply to multidimensional problems, convective heat and mass transfer problems and the simulation of more complicated fluid flows including turbulence approximations. Credit not allowed for both this course and ENGR 2250.
Prerequisite: MATH 2400 and CHME 4010.
Offered: Spring term annually.
4 credit hours

CHME 4030
Chemical Process Dynamics and Control
Introduction to modeling and control of dynamic chemical processes. Topics include the development of first-principles models, linearization and state space form, input/output (transfer function) form, design and tuning of PID controllers, model-based control, frequency response for robustness analysis, case studies in multiple-variable control, numerical analysis, and simulation.
Prerequisite: MATH 2400.
Offered: Fall term annually.
4 credit hours

CHME 4040
Chemical Engineering Separations
The application of the fundamentals of chemistry, thermodynamics, mathematics, and transport phenomena to the design and evaluation of stage-wise and continuous contacting apparatus and systems for separating and purifying chemical materials. Steady-state and transient processes are studied.
Prerequisites: CHME 4010 and CHME 4020. Corequisite or prerequisite: CHME 2020.
Offered: Fall term annually.
3 credit hours

CHME 4050
Chemical Process Design
The design of equipment, processes, and systems of interest in chemical engineering through application of scientific, technological, and economic principles. The concepts of product design, design for the environment, and the ethical and safety issues of design are introduced. Emphasis is placed on problem formulation and the conceptual, analytical, and decision aspects of open-ended design situations. The work integrates knowledge and skills gained in previous and concurrent courses. This is a communication-intensive course.
Prerequisites: CHME 4040 and CHME 4500.
Offered: Spring term annually.
4 credit hours

CHME 4150
Chemical Engineering Laboratory I
A two-term laboratory course on experimental analysis of the operations and processes of chemical engineering. Emphasis is placed on planning of experiments, data evaluation, and report writing.
Prerequisites: CHME 4010, CHME 4020, and CHME 2020.
Offered: Fall and spring terms annually.
3 credit hours

CHME 4160
Chemical Engineering Laboratory II
A two-term laboratory course on experimental analysis of the operations and processes of chemical engineering. Emphasis is placed on planning of experiments, data evaluation, and report writing.
Prerequisites: CHME 4150, CHME 4040, and CHME 4500.
Offered: Fall and spring terms annually.
3 credit hours

CHME 4170
Bioprocessing Laboratory Course
A one-term laboratory course covering the fundamentals of biotechnology and bioprocessing including molecular biology, fermentation, and protein purification.
Prerequisite: Senior standing in chemical and biological engineering. CHME 4430 strongly recommended.
Offered: Spring term annually.
3 credit hours

CHME 4400
Chromatographic Separation Processes
Theory and practice of chromatographic separation processes. Topics include chromatographic dispersion, adsorption isotherms, solute movement analysis, chromatographic techniques (reversed-phase, HIC, ion exchange, affinity, and size exclusion), modes of operation (gradient, elution, displacement, and continuous systems), novel morphologies and chromatographic applications in biotechnology. Includes critical reviews of the current literature and computer simulations. Suitable for graduate students in chemical engineering, chemistry, biology, and biomedical engineering. Students cannot receive credit for both CHME 4400 and CHME 6440.
Prerequisite: Senior or graduate standing in chemical engineering or permission of instructor.
Offered: Spring term annually.
3 credit hours
CHME 4430
Introduction to Biochemical Engineering
Description, fundamentals, and engineering features of processes using microbial, plant, or animal cells or their enzymes. Topics include review of biochemistry, review of microbiology, computer simulation, growth, death, aseptic techniques, continuous culture, fermenter design, sterilization, mixed cultures, process scale up, immobilized cells and enzymes, recovery of products, and process economics. Weekly exercises requiring personal computers.
Prerequisite: Background in chemical engineering or microbiology. Biochemistry strongly recommended.
Offered: Fall term annually.
3 credit hours

CHME 4460
Biomolecular Engineering
This course will focus on 1) designing, engineering, and selecting proteins and other biomolecules with desired functional and biophysical properties (high thermal stability, high solubility, low propensity to aggregate), and 2) characterizing thermodynamic and kinetic properties (folding, oligomerization, and self-association) of these biomolecules. (Students may not receive credit for both this course and CHME 6460.)
Prerequisites: BIOL 1010 or BIOL 2120 or equivalent, and CHME 2020 or ENGR 2250 or equivalent.
Offered: Spring term odd-numbered years.
3 credit hours

CHME 4480
Single Molecules Complex Fluid
This course will focus on the connections between the behavior of single molecules and their interacations and macroscopic non-Newtonian behavior. We will discuss microscopic models of these systems, techniques for measuring and manipulating the microstructure, and the impact on macroscopic behavior. Students may not receive credit for both this course and CHME 6480.
Prerequisites: CHME 4020 or equivalent. Co-current registration with CHME 4020 or equivalent allowed with permission of instructor.
Offered: Spring term even-numbered years.
3 credit hours

CHME 4500
Chemical Reactor Design
Principles of kinetics, reactor design, and analysis for both homogeneous and heterogeneous (catalytic) systems. Topics include design for multiple reaction networks (optimum selectivity), analysis of simple reactor combinations, and design of isothermal, adiabatic, and optimum temperature profile reactor.
Prerequisites: CHME 2010, CHME 4010, and CHME 4020.
Offered: Fall term annually.
3 credit hours

CHME 4600
Introduction to Semiconductor Processing
The basic processes of fabrication of silicon-based semiconductor devices with emphasis on the chemical principles and systems involved. Topics include materials preparation, oxide growth, lithography, diffusion, ion implantation, epitaxial growth, chemical-vapor deposition, vacuum deposition, reactive ion etching, and packaging technologies. Fabrication of both bipolar and FET devices is discussed with emphasis on manufacturing process flow and control. Process design methodology.
Prerequisite: Senior standing in chemical engineering or permission of instructor.
Offered: Fall term annually.
3 credit hours

CHME 4940
Readings in Chemical Engineering
1 to 3 credit hours

CHME 4960
Topics in Chemical Engineering
3 credit hours

CHME 6410
Advanced Membrane Concepts
Prerequisite: A general knowledge of transport phenomena.
Offered: Fall term even-numbered years.
3 credit hours

CHME 6420
Separation and Recovery Processes
The application of theoretical and fundamental principles and pilot plant data to the design and operation of biochemical separation processes and advanced waste treatment systems. Topics covered include characterization and dispersion, coagulation and flocculation, sedimentation, filtration, adsorption, ion exchange, membrane processes, aeration and gas transfer, centrifugation, and related subjects.
Offered: Spring term annually.
3 credit hours
CHME 6430  
Biochemical Engineering  
Engineering aspects of microbial processes and of conversions with immobilized enzymes. Topics are mixed-culture processes, sterilization, aseptic techniques, mass transfer, bioprocess control, product isolation, enzyme technology, bioprocess development. There are heavy emphases on continuous fermentation and on chemicals from biomass.  
Prerequisite: Microbiology or assigned reading.  
Offered: Fall term annually.  
3 credit hours

CHME 6440  
Chromatographic Separations  
Theory and practice of chromatographic separation processes. Topics include chromatographic dispersion, adsorption isotherms, solute movement analysis, chromatographic techniques (reversed-phase, HIC, ion exchange, affinity, and size exclusion), modes of operation (gradient, elution, displacement, and continuous systems), novel morphologies and chromatographic applications in biotechnology. Includes critical reviews of the current literature and computer simulations. Suitable for graduate students in chemical engineering, chemistry, biology, and biomedical engineering. Students cannot receive credit for both CHME 4400 and CHME 6440.  
Offered: Spring term annually.  
3 credit hours

CHME 6450  
Advanced Biochemical Engineering  
Selected topics beyond the scope of CHME 6430. Particular emphasis on the current literature and the applications of computers and graphics. Extensive coverage is given to purification and separation technology, kinetic analysis, design of bioreactors, exploitation of genetic engineering, and bioprocess development. An individual project is required.  
Prerequisite: CHME 6430 or permission of instructor.  
Offered: Summer term annually.  
3 credit hours

CHME 6460  
Biomolecular Engineering  
This course will focus on 1) designing, engineering, and selecting proteins and other biomolecules with desired functional and biophysical properties (high thermal stability, high solubility, low propensity to aggregate), and 2) characterizing thermodynamic and kinetic properties (folding, oligomerization, and self-association) of these biomolecules. (Students may not receive credit for both this course and CHME 4460.)  
Prerequisites: BIOL 1010 or BIOL 2120 or equivalent, and CHME 2020 or ENGR 2250 or equivalent.  
Offered: Spring term odd-numbered years.  
3 credit hours

CHME 6470  
Downstream Processing in Biochemical Engineering  
The course focuses on the concentration, recovery, and isolation of biological molecules relevant in biotechnology. The characteristics of biological molecules such as proteins and biological fluids such as blood, fermentation, and cell culture broth, are discussed. The principles, advantages, and limitations of centrifugation, membranes, cell-disruption, two-phase extraction, precipitation crystallization, and electrical processes are discussed. Integrated bioseparation schemes are presented and many specific applications are discussed in detail.  
Prerequisite: A course in biochemical engineering or permission of instructor.  
Offered: Fall term odd-numbered years.  
3 credit hours

CHME 6480  
Single Molecules Complex Fluid  
This course will focus on the connections between the behavior of single molecules and their interactions and macroscopic non-Newtonian behavior. We will discuss microscopic models of these systems, techniques for measuring and manipulating the microstructure, and the impact on macroscopic behavior. Students may not receive credit for both this course and CHME 4480.  
Prerequisite: CHME 4020 or equivalent. Co-current registration with CHME 4020 or equivalent allowed with permission of instructor.  
Offered: Spring term even-numbered years.  
3 credit hours

CHME 6510  
Advanced Transport Phenomena I  
Prerequisite: CHME 4010.  
Offered: Spring term annually.  
3 credit hours

CHME 6520  
Advanced Transport Phenomena II  
A continuation of CHME 6510. Treats irrotational flow, flow around bubbles, and other free surface problems, turbulent flow, jets, and wakes. Presumes an understanding of continuum mechanics, viscous flow, and boundary layer flow.  
Prerequisite: CHME 6510 or permission of instructor.  
Offered: Fall term odd-numbered years.  
3 credit hours
CHME 6540
Convective Heat Transfer
A review of basic concepts of mass, momentum, and energy conservation as related to convective heat transfer. The analysis of laminar and turbulent forces and free convection problems in both internal and external flows. Also a study of the current state of the art in boiling and condensation heat transfer.
Offered: Spring term annually.
3 credit hours

CHME 6570
Chemical and Phase Equilibria
Classical solution thermodynamics, equations of state, and topics in chemical reaction and phase equilibria. Emphasis is on the rigorous formulation of equilibrium problems, and on the measurement, reduction, correlation, and interpretation of experimental data.
Offered: Fall term annually.
3 credit hours

CHME 6610
Mathematical Methods in Chemical Engineering I
Development and application of mathematical methods for the solution of chemical engineering problems. Classical solution methods for ordinary and partial differential equations. Major emphasis is given to the mathematical implications of describing and solving representation of chemical reactors and other systems. Case studies relevant to other departmental graduate courses and ongoing research activities are discussed. The mathematical methods include ordinary solutions, special function representations, boundary-value problems, and operational calculus.
Prerequisite: MATH 2400.
Offered: Fall term annually.
3 credit hours

CHME 6620
Mathematical Methods in Chemical Engineering II
Modern solution techniques including semi-analytical, approximation, and numerical methods are introduced and applied to linear and nonlinear transport phenomena problems and chemical engineering systems. Similarity theory and integral methods, perturbation techniques, and orthogonal collocation, indispensable to chemical engineering, are discussed.
Prerequisite: CHME 6610 or permission of instructor.
Offered: Spring term annually.
3 credit hours

CHME 6640
Advanced Chemical Reactor Design
Analysis of ideal and nonideal chemical reactor operation with simple and multiple homogeneous, heterogeneous, and catalytic reactions. Interplay of chemical and mass, energy and momentum transport processes in model reactors and catalytic particles. Topics include transient and steady-state operation, residence time distribution, multiplicity, stability, selectivity control, and catalyst deactivation.
Prerequisite: CHME 4500 or permission of instructor.
Offered: Spring term annually.
3 credit hours

CHME 6650
Advanced Process Control
Application of modern control theory to chemical processes. Introduction to on-line data acquisition and computer control. Real-time process optimization and optimal control theory. Estimation theory and adaptive control. Introduction to stochastic control and to the control of large-scale distribution systems. Case studies via computer-aided design programs.
Prerequisite: CHME 4030 or equivalent.
Offered: Upon sufficient demand.
3 credit hours

CHME 6670
Advanced Process Design
Process synthesis with applications to heat exchange networks, energy-integrated separation sequences, and reactor networks. Analysis, design, and optimization of large-scale systems.
Prerequisite: Chemical engineering degree or permission of instructor.
Offered: Upon sufficient demand.
3 credit hours

CHME 6830
Combustion
Review of fundamentals of thermodynamics, chemical kinetics, fluid mechanics, and modern diagnostics. Discussion of flame propagation, thermal and chain explosions, stirred reactors, detention, droplet combustion, and turbulent jet flames.
Prerequisite: Permission of instructor.
Offered: Spring term odd-numbered years.
Cross listed: MANE 6830. Students cannot receive credit for both this course and MANE 6830.
3 credit hours

CHME 6840
An Introduction to Multiphase Flow and Heat Transfer I
This course is intended to give students a state-of-the-art understanding about single and multicomponent boiling and condensation heat transfer phenomena. Applications include the analysis of nuclear reactors, oil wells, and chemical process equipment. Students satisfactorily completing this course are expected to be able to thoroughly understand the current thermal-hydraulics literature on multiphase heat and mass transfer and be able to conduct independent research in this field.
Prerequisite: A working knowledge of fluid mechanics and heat transfer.
Offered: Fall term annually.
Cross listed: MANE 6840. Students cannot obtain credit for both this course and MANE 6840.
3 credit hours
CHME 6850  
An Introduction to Multiphase Flow and Heat Transfer II  
This course is intended to give students a state-of-the-art understanding in multicomponent flow phenomena. Applications in the chemical process, petroleum recovery, and fossil/nuclear power industries will be given. Specific areas of coverage include two-phase: fluid mechanics, pressure drop, modeling and analysis, stability analysis, critical flow and dynamic waves, flow regime analysis, and phase separation and distribution phenomena.  
Prerequisite: CHME 6840 or MANE 6840.  
Offered: Spring term annually.  
Cross listed: MANE 6850. Students cannot obtain credit for this course and MANE 6850.  
3 credit hours

CHME 6940  
Readings in Chemical Engineering  
1 to 3 credit hours

CHME 6960  
Topics in Chemical Engineering  
State-of-the-art formal courses in specialized areas suitable for master’s and doctoral programs. Usually two topics offered per term.  
Typical topics include colloidal dynamics, dispersion and mixing, fluidization, heterogeneous catalysis, polymer reaction engineering, stochastic processes, and statistical mechanics.  
Offered: Fall and spring terms annually.  
1 to 3 credit hours

CHME 6970  
Professional Project  
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

CHME 6990  
Master’s Thesis  
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.  
1 to 9 credit hours

CHME 9990  
Dissertation  
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  
1 to 16 credit hours

CISH Computer Science at Hartford (SOS)

CISH 4010  
Discrete Mathematics and Computer Theory*  
This course covers foundations of discrete mathematics and fundamentals of computer theory. Topics include propositional logic, truth tables, quantifiers, sets, set operations, sequences, complexity of algorithms, divisibility, matrix manipulations, proofs, induction, recursion, counting and the pigeonhole principle, permutations, combinations, repeated trials, expectation, relations (properties, representation, equivalence, Warshall’s algorithm), Boolean algebra, functions, logic gates, minimizing, Finite State Machines, Turning machines, Regular expressions, context-free grammars, language recognizers, derivation trees, pushdown automata.  
Offered: H and G, fall term annually; H, spring and summer term.

CISH 4020  
Object Structures*  
A study of object oriented software component design. This course introduces the object oriented paradigm and its use in organizing software structures including arrays, stack, queues, lists, trees, graphs, and recursion. Programming assignments require the use of an object oriented language.  
Prerequisite: CISH 4010 or equivalent and knowledge of an imperative programming language (C, PASCAL, etc.).  
3 credit hours

*This is an “immigration” course which will not count towards the M.S. in Computer Science, M.S. in Information Technology, or M.Eng. in Computer and Systems Engineering degrees. Such courses may count towards other degrees but consult your adviser before registering.
CISH 4030
Structured Computer Architecture
Introduction to computer architecture; the structure and function of a computer system consisting of processors, memory, I/O modules, and its internal interconnections. Primary focus on the attributes of a system visible to an assembly level programmer. Topics include: digital logic, VLSI components, instruction sets, addressing schemes, memory hierarchy, cache and virtual memories, integer and floating point arithmetic, control structures, buses, RISC vs. CISC, multiprocessor and vector processing (pipelining) organizations. Examples are drawn from contemporary (e.g., Intel Pentium, PowerPC) microcomputers.

CISH 4210
Operating Systems
Discussion of various aspects of computer operating systems design and implementation. Topics include: I/O programming, concurrent processes and synchronization problems, process management and scheduling of processes, virtual memory management, device management, file systems, deadlock problems, system calls, and interprocess communication. Programming projects are required.
Prerequisite: CISH 4020 and CISH 4030.
Offered: H, fall, spring annually; G, on sufficient demand.
3 credit hours

CISH 4380
Database Systems
Discussion of the state of practice in modern database systems with an emphasis on relational systems. Topics include database design, database system architecture, SQL, normalization techniques, storage structures, query processing, concurrency control, recovery, security, and new direction such as object oriented and distributed database systems. Students gain hands-on experience with commercial database systems and interface building tools. Programming projects are required.
Prerequisite: CISH 4020 or equivalent.
Offered: H, spring, summer annually; G, on sufficient demand.
3 credit hours

CISH 4940
Readings in Computer and Information Sciences
1 to 4 credit hours

CISH 4960
Topics in Computer and Information Sciences
1 to 4 credit hours

CISH 6010
Object Oriented Programming and Design
An introduction to the theory and practice of object oriented programming and design. Encapsulation, inheritance, genericity, dynamic binding, and polymorphism. Students use these concepts to design and implement a modest-sized system. One object oriented language (chosen by the instructor) is studied in detail and required for the project. Other languages are covered briefly.
Prerequisite: CSCI 4210.
3 credit hours

CISH 6050
Software Engineering Management
Introduction to the current issues in software engineering management. Topics include the origin of the software crisis, current state-of-the-practice, modeling the software engineering process, the relationship of methods and tools to process, software validation, risk mitigation, and software engineering economics.
3 credit hours

CISH 6110
Object Oriented Database Systems
Presents concepts and architectures of object oriented database systems. Provides the object oriented view of data models, query languages, versioning evolution, authorization, transaction control, storage management, indexing techniques, distributed data, and parallelism. Current object oriented database systems are reviewed and compared. A programming project or research paper may be required.
Prerequisites: CSCI 4380 and the object oriented portion of either CISH 4020 or CISH 6010.
3 credit hours

CISH 6120
Distributed Database Systems
Examines client/server DBMS and considers how a client-server architecture can be used to implement the requirements of a DDBMS. Topics include DDBMS taxonomies, case studies, design considerations, transaction management, and global query optimization. Concludes with an examination of multibase database systems.
Prerequisite: CSCI 4380.
3 credit hours

CISH 6150
Artificial Intelligence and Heuristics
Survey of machine implementation of processes as foundation to thinking and perceiving. Modeling and representation of knowledge. AI systems and languages, reasoning and problem solving. Current literature is discussed. Applications are chosen from computer game playing programs, English dialogue, theorem proving, computer vision, robot implementation, and automatic programming. Limitations and performances of techniques. Certain topics are programmed.
Prerequisite: CISH 4030.
Offered: H, spring, even years; G, on sufficient demand.
3 credit hours
CISH 6210
Computer Network Analysis and Design
Theoretical and empirical analysis of algorithms; tools for on-line monitoring of the algorithm’s performance. Advanced algorithms for polynomial problems; randomized heuristic and approximate algorithms. Problems include computation in discrete mathematics, number theory, linear algebra, graph theory, numerical and symbolic computing. It is suggested that students take CSCI 6050 before taking this course.
3 credit hours

CISH 6220
LANs, MANs, and Internetworking
Explores the current capabilities and trends in LANs and MANs with additional focus on issues of Internetworking network systems or subsets. Topics include topologies and transmission media, Local and Metropolitan Area Network (LAN and MAN) architectures and performance. LAN standards IEEE 802.x, and ANSI Standard FDDI. Circuit switched local area networks, e.g., ATM, Fibre Channel. Internetworking alternatives, bridges, network switches, routers and gateways. General LAN management tools.
Prerequisite: ECSE 4670 or equivalent.
3 credit hours

CISH 6230
Network Management
Introduction to methods, techniques, and tools for the management of telecommunication systems and networks. Major topics covered in the course are: Simple Network Management Protocol (SNMPv2, SNMPv3), Remote Monitoring (RMON1, RMON2), Standard Management Information (MIBs), and Telecommunications Management (TMN, CMIS/CMIP); configuration and name management; fault and performance management; security; accounting management; and Web-based network management.
Prerequisite: ECSE 4670 or equivalent basic concept computer and communication networks course.
3 credit hours

CISH 6510
Web Application Design and Development
Students will learn approaches to the design, development, and maintenance of Web sites. Students will study software and information architectures for the Web, design techniques for distributed Web-based applications, and methods and tools for the creation and maintenance of Web sites. Study will encompass the major components of a Web site, including browsers and client applications, Internet protocols that link the client to the server, and server applications. Issues of performance, security, and usability will be examined.
Prerequisites: CISH 4020 or CSCI 2300, prior experience with HTML and Java, ECSE 4670 and CSCI 4380 recommended.
Offered: Fall and spring terms annually.
3 credit hours

CISH 6900
Computer Science Seminar
For students near the end of their program, a two semester course that meets once per month from September through March and one Saturday in April when students give their presentations. Registration is accepted during fall registration only. Students are required to attend all eight meetings in order to fulfill the Seminar requirement. This course, combined with two additional graduate credit hours, will be the equivalent of one advanced three-credit-hour elective.

CISH 6902
Computer Science Seminar
For students following the Applied path, who were admitted after summer 2004. Registration is allowed only after acceptance of an approved project plan by a faculty adviser. Students are required to attend guest speaker sessions and give a formal presentation of their own research results.
3 credit hours

CISH 6940
Readings in Computer and Information Sciences
1 to 3 credit hours

CISH 6960H09
Research Methods
Course will review the major considerations and tasks involved in conducting scientific research, particularly in the area of computer science. It introduces the essential aspects of designing, supporting, and conducting a research project. Those who successfully complete the course will be able to: produce a well-developed research proposal; select an appropriate methodology with which to conduct the research and defend the methodology of their selection; understand the various tasks required to carry out the research; find the resources needed to guide them through the research process and the documentation of its findings.
Offered: H, spring annually; G, on sufficient demand.

CISH 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A professional project often serves as a culminating experience for a professional master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one professional project. Professional projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.
3 to 4 credit hours
CISH 6980
Master's Project
Details may be obtained from the Department of Engineering and Science.
3 to 6 credit hours

CISH 6990
Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of S or U are assigned by the adviser each term to reflect the student's research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
1 to 9 credit hours

CISH or CSCI 6960
Topics in Computer and Information Sciences
1 to 3 credit hours

CIVL Civil Engineering (SOE)

CIVL 1100
Introduction to Civil and Environmental Engineering
Deals with the practice of Civil and Environmental Engineering. Not a highly analytical course, as the course is primarily intended for first year students. Some topics: history of Civil Eng.; present practice; typical employers; typical projects; design philosophy; professional topics including organizations, registrations, ethics. Discuss case histories, bring in outside speakers. Students attend CE Capstone presentations.
Offered: Spring term annually.
1 credit hour

CIVL 1200
Engineering Graphics for Civil Engineers
An introduction to the elements of computer aided design for Civil and Environmental Engineers using AutoCAD Civil 3D. Students will be introduced to basic AutoCAD drafting techniques as well as learn the key features of Civil 3D that aid site development design and analysis. Topics covered will include general AutoCAD techniques, existing conditions development and analysis using field collected survey data and GIS information, pipe network design, grading design, and roadway corridor layout.
Corequisite: ENGR 2050 Intro to Engineering Design.
Offered: Fall term annually.
1 credit hour

CIVL 2030
Introduction to Transportation Engineering
Introduction to basic concepts in transportation engineering including planning, design, and operations. Introduces the challenges and issues in modeling transportation problems. Studies of various concepts related to the design of highway facilities, level of service, and demand for transportation services. Concepts related to signal optimization. Policy implications. Basics of transportation planning.
Prerequisite: MATH 2400.
Offered: Fall term annually.
4 credit hours

CIVL 2040
Professional Practice
Contract essentials; types of contracts for construction and for engineering services. Bidding procedure, surety bonds, insurance, litigation. Standard contract documents, the compilation of specifications. Engineering ethical principles and codes.
Offered: Full term odd-numbered years.
3 credit hours

CIVL 2630
Introduction to Geotechnical Engineering
The application of the basic laws and phenomena of science to particulate matter, specifically soils. Basic physical and mechanical structural characteristics of soil. Equilibrium and movement of water. Flow through porous media. Effective stress. Stress-strain-time relations. Basic laboratory work as related to practice.
Prerequisite: ENGR 2530.
Offered: Fall term annually.
4 credit hours, 6 contact hours

CIVL 2670
Introduction to Structural Engineering
Prerequisite: ENGR 2530 or equivalent.
Offered: Fall term annually.
4 credit hours

CIVL 2940
Readings in Civil Engineering
1 to 3 credit hours

CIVL 4010
Foundation Engineering
Subsurface investigation. The application of the principles of soil mechanics to the design of footings, retaining walls, pile foundations, bulkheads, cofferdams, bridge piers and abutments, and underpinnings.
Prerequisites: ENGR 2530 and CIVL 2630 or equivalent.
Offered: Fall term annually.
3 credit hours
CIVL 4020
Bedford Seminar
The seminar will be interdisciplinary with students from both architecture and civil engineering departments. The content of the lectures bears direct relation to practical experience and is considered to be supplementary to the other courses in the respective engineering and architecture schools. Specific types of structures will be examined with the help of suitable existing project examples clarifying and critically analyzing the basic engineering principles behind them. Students will be exposed to the collaborative methods inherent within the architect/engineer relationship.
Corequisite: CIVL 4450 Conceptual Structural Systems.
Offered: Fall and spring terms annually.
3 credit hours

CIVL 4070
Steel Design
Prerequisite: CIVL 2670.
Offered: Fall term annually.
3 credit hours

CIVL 4080
Concrete Design
Prerequisite: CIVL 2670.
Offered: Spring term annually.
3 credit hours

CIVL 4140
Geoenvironmental Engineering
The application of geotechnical engineering to the environmental area. Deals with waste disposal, waste containment systems, waste stabilization, and landfills. Emphasis on design of such facilities. Includes related topics necessary for design, e.g. geosynthetics, groundwater, contaminant transport, and slurry walls. Some field trips are possible. (Students cannot receive credit for both this course and CIVL 6550.)
Offered: Fall term annually.
3 credit hours

CIVL 4150
Experimental Soil Mechanics
Second course in geotechnical engineering, emphasizing experimental aspects of soil behavior. Laboratory experiments to measure the following soil properties: consolidation, compressibility, shear strength, permeability, various moduli, and bearing capacity. Theory, practical applications of theory, and laboratory.
Prerequisite: CIVL 2630 or equivalent.
Offered: Spring term annually.
3 credit hours

CIVL 4240
Introduction to Finite Elements
An introductory course in use of the Finite Element Method (FEM) to solve one- and two-dimensional problems in fluid mechanics, heat transfer, and elasticity. The methods are developed using weighted residuals. Algorithms for the construction and solution of the governing equations are also covered. Students will be exposed to the use of commercial finite element software.
Prerequisites: ENGR 2250 or ENGR 2530 or ECSE 4160 and senior standing.
Offered: Fall and spring terms annually.
Cross listed: MANE 4240. Students cannot obtain credit for both this course and MANE 4240.
3 credit hours

CIVL 4270
Construction Management
Application of engineering principles to planning construction operations. Network scheduling (CPM, PERT), resource allocation. Cost engineering and control.
Prerequisite: Senior standing.
Offered: Spring term annually.
3 credit hours

CIVL 4440
Advanced Structural Analysis
Computer analysis of structures. Advanced topics in the behavior of structural components. Buckling of columns and frames. Beam-columns. Inelastic behavior and limit analysis of structures. Students cannot receive credit for both this and CIVL 6440.
Prerequisite: CIVL 2670.
Offered: Spring term even-numbered years.
3 credit hours

CIVL 4450
Conceptual Structural Systems
This course covers concepts of structural systems. The course is aimed at understanding behavior of different structural systems and how they respond to various loading conditions. The concept of load transfer, shaping, and form finding is of particular interest. This concept is reinforced through analytical, digital, and physical modeling intended to foster intuitive thinking. The course includes the following: approximate analyses of statically indeterminate beams, rigid frames, and vierendeel frames; cable suspended structures; arch supported structures; masonry structures, space frame, and folded plate structures; spherical, cylindrical, and hyperbolic shells; net and tent structures; air-supported and air-inflated structures, and hybrid structural systems. The course includes guest lectures, project, computer simulation, and testing physical models.
Prerequisite: CIVL 2670. Corequisite: CIVL 4020.
Offered: Spring term annually.
3 credit hours
CiVl 4570  
Analytical Methods in Civil Engineering Systems  
This course is an applications-oriented course covering basic analytical tools for modeling and optimization of large-scale civil engineering systems. Application domains in civil engineering that will be discussed include: scheduling in large systems, pipeline systems, transportation and logistics planning, as well as other civil engineering systems. An overview of different optimization techniques, with a particular focus on network flow problems and introductory stochastic analysis will be provided. Software to solve these problems will be used throughout the class.  
Prerequisite: CIVL 2030, ENGR 2600, and ENGR 4760.  
Offered: Fall term even-numbered years.  
3 credit hours

CiVl 4620  
Mass Transit Systems  
The basic concepts of planning, design, and operation of urban mass transit systems. Topics include travel demand, network configurations, communication and control systems, power systems, vehicle technology, guideway and vehicle support and guidance technology, routing and scheduling, operating practice, marketing and financing of transit service, interface design, and implementation. These topics are discussed with relation to bus transit systems, guided transit systems, and several new systems. Several case studies examined.  
Prerequisite: CIVL 2030.  
Offered: Upon availability of instructor.  
3 credit hours

CiVl 4640  
Transportation System Planning  
Introduction to the analysis and planning of transportation systems. Study of the basic interaction between transportation supply and demand. Role of transportation systems analysis in the social, environmental, and policy making. Trip generation. Trip distribution. Mode split. Traffic Assignment. Computer applications. (Meets with CIVL 6250 Transportation System Planning.) Students cannot obtain credit for this course and CIVL 6250.  
Prerequisite: CIVL 2030.  
Offered: Fall term odd-numbered years.  
3 credit hours

CiVl 4660  
Traffic Engineering  
Basic characteristics of traffic flow, including driver, vehicle, volume, speed, delay, capacity, and accidents; traffic regulation and control, signs, markings, signals, and signal systems; basic traffic flow theory; study methods and analysis procedures to solve traffic engineering and control problems.  
Prerequisite: CIVL 2030.  
Offered: Spring term annually.  
3 credit hours

CiVl 4670  
Highway Engineering  
Principles of geometric design of highways, intersections, interchanges, and terminals. Practical issues of vertical and horizontal curvature, highway evaluation, driver and vehicle dynamics, and traffic safety are also addressed. Computer-aided design and modeling.  
Prerequisite: CIVL 2030.  
Offered: Upon availability of instructor.  
3 credit hours

CiVl 4920  
Civil Engineering Capstone Design  
Open-ended design project in which students work in teams. Oral presentations and written reports cover alternates considered, design assumptions, cost, safety, and feasibility. This is a communication-intensive course.  
Prerequisite: Senior status and CIVL 4070 and CIVL 4080, or CIVL 4010 and CIVL 4150, or CIVL 4660, or CIVL 4640 or ENVE 2110, and either ENVE 4200, ENVE 4350, ENVE 4310 or ENVE 4340.  
Offered: Spring term annually.  
3 credit hours

CiVl 4940  
Readings in Civil Engineering  
1 to 3 credit hours

CiVl 4960  
Topics in Civil Engineering  
3 credit hours

CiVl 6170  
Mechanics of Solids  
Introduction to Cartesian tensors, infinitesimal strain kinematics, equations of motion. Models of material behavior: isothermal linear isotropic and anisotropic elasticity, thermoelasticity, linear viscoelasticity, and rate-independent plasticity. General principles in elasticity: minimum potential and complementary energy, reciprocal theorem. Formulation of linear elastic boundary value problems, methods of solutions for 2-D and 3-D elasticity problems. Correspondence principle of linear viscoelasticity, applications to simple structural components. Use of symbolic computations in the solution of BVP.  
Offered: Spring term annually.  
Cross listed: MANE 6170. Students cannot obtain credit for both this course and MANE 6170.  
3 credit hours

CiVl 6180  
Mechanics of Composite Materials  
Prerequisite: One graduate course in mechanics of solids.  
Offered: Fall term annually.  
Cross listed: MANE 6180. Students cannot obtain credit for both this course and MANE 6180.  
3 credit hours
CIVL 6190  
**Advanced Transportation Models**  
This graduate level course will introduce two types of advanced models related to travel demand forecasting: the land use models and the activity-based models. This project-based course will allow students to obtain sound knowledge of advanced modeling techniques, and to have some preliminary experience with building, estimating and applying advanced transportation models.  
**Offered:** Fall term even-numbered years.  
3 credit hours

CIVL 6200  
**Plates and Shells**  
**Offered:** Upon availability of instructor.  
**Cross listed:** MANE 6200. Students cannot obtain credit for both this course and MANE 6200.  
3 credit hours

CIVL 6210  
**Structural Stability**  
Concepts of stability pertaining to structural and mechanical systems. Static and dynamic theories of stability. Configurations include bars, plates, shells, and structural complexes.  
**Offered:** Upon availability of instructor.  
**Cross listed:** MANE 6210. Students cannot obtain credit for both this course and MANE 6210.  
3 credit hours

CIVL 6220  
**Critical Issues in Transportation**  
To provide the students with a broad understanding of cutting edge methodologies in transportation modeling and economics not thoroughly covered in other courses, and emerging issues pertaining to transportation research and practice.  
**Prerequisite:** CIVL 2030 or equivalent.  
**Offered:** Upon availability of instructor.  
3 credit hours

CIVL 6230  
**Transportation Economics**  
**Prerequisites:** CIVL 2030 or equivalent.  
**Offered:** Spring term even-numbered years.  
3 credit hours

CIVL 6240  
**Intelligent Transportation Systems**  
The course discusses Intelligent Transportation Systems (ITS) technologies and its application areas. ITS Architecture, ITS applications. A number of outside speakers will complement the lectures. The students are expected to give at least two technical presentations and write a final paper on an ITS topic of their choosing.  
**Prerequisite:** CIVL 2030 or equivalent.  
**Offered:** Fall term even-numbered years.  
3 credit hours

CIVL 6250  
**Transportation Systems Planning**  
The analysis and planning of transportation systems. Study of the basic interaction between transportation supply and demand. Role of transportation systems analysis in social, environmental, and policy making. Trip generation. Trip distribution. Mode split. Traffic Assignment. Computer applications. Students cannot obtain credit for this course and CIVL 4640.  
**Prerequisite:** CIVL 2030 or equivalent.  
**Offered:** Fall term odd-numbered years.  
3 credit hours

CIVL 6260  
**Transportation Network Analysis**  
Fundamentals of transportation network analysis, including graph representations of transportation networks, shortest path search algorithms, static traffic assignment and user equilibrium, and dynamic traffic assignment. Focus on how basic mathematical analysis tools such as linear and nonlinear programming can be used to analyze transportation network problems. The objective of this course is to introduce students to transportation network analysis fundamentals so that they are equipped with basic skills to analyze related problems in this area.  
**Prerequisites:** CIVL 2030; MATH 2400.  
**Offered:** Upon availability of instructor.  
3 credit hours

CIVL 6270  
**Traffic Control and Simulation**  
Topics on traffic control systems such as signals and ramp metering; sensor-aided and data-oriented traffic modeling; fundamentals and applications of microscopic traffic simulation. State of the art signal design and traffic simulation tools will be used throughout the class.  
**Prerequisite:** CIVL 2030, CIVL 4660 or their equivalents.  
**Offered:** Fall term odd-numbered years.  
3 credit hours
**CIVL 6280**  
**Dynamic Traffic Models**  
The fundamentals of dynamic equilibrium with applications to planning and real-time operations in transportation systems. A network optimization approach to dynamic models including time-dependent shortest path algorithms, analytical and simulation models for dynamic traffic assignment. Applications of these approaches to network-wide real-time control. Emphasis on implementation of algorithms using programming languages.  
**Prerequisite:** CIVL 6260.  
**Offered:** Spring term even-numbered years.  
3 credit hours

**CIVL 6290**  
**Freight Transportation Systems**  
**Prerequisite:** CIVL 6250.  
**Offered:** Spring term odd-numbered years  
3 credit hours

**CIVL 6300**  
**Transportation Statistical Modeling**  
This graduate level course will introduce a number of econometric models to analyze transportation data, ranging from count of crash occurrence to household trip frequency. Students will learn to specify, estimate, and interpret models to study various transportation issues.  
**Offered:** Fall term odd-numbered years  
3 credit hours

**CIVL 6310**  
**Advanced Concrete Structures**  
**Prerequisite:** CIVL 4080 or equivalent.  
**Offered:** Fall term annually.  
3 credit hours

**CIVL 6320**  
**Advanced Steel Design**  
Advanced analysis and design of complex metal structures. Flexible, semi-rigid, and rigid connections. Plate girders, torsional design. Effects of semi-rigid connections on structural stability.  
**Prerequisite:** CIVL 4070 or equivalent.  
**Offered:** Spring term annually.  
3 credit hours

**CIVL 6340**  
**Bedford Design Studio**  
Open-ended design project in which students work in teams of four (two engineers and two architects) to replicate the Architecture/Structural Engineering integrated design of buildings. Oral presentations and written reports and studio critics cover alternatives considered, design assumptions, and cost estimates. This is a communication-intensive course.  
**Prerequisites:** CIVL 4020 Bedford Seminar, CIVL 6310 Advanced Concrete, CIVL 6320 Advanced Steel.  
**Offered:** Fall and spring terms annually.  
3 credit hours

**CIVL 6380**  
**Advanced Concrete Mechanics**  
**Offered:** Fall term even-numbered years.  
3 credit hours

**CIVL 6390**  
**Wind Engineering**  
This course will develop understanding and integrate skills across the fields of fluid mechanics, meteorology, climatology, bluff-body aerodynamics, structural dynamics, code provisions for design, wind tunnel testing, and damage documentation.  
**Prerequisite:** ENVE 4310.  
**Offered:** Spring term odd-numbered years.  
3 credit hours

**CIVL 6440**  
**Advanced Structural Analysis**  
Computer analysis of structures. Advanced topics in the behavior of structural components. Buckling of columns and frames. Beam-columns. Inelastic behavior and limit analysis of structures. Student cannot receive credit for both this course and CIVL 4440.  
**Prerequisite:** CIVL 2670.  
**Offered:** Spring term even-numbered years.  
3 credit hours
CIVL 6450  
**Structural Dynamics**  
*Prerequisite:* CIVL 2670.  
*Offered:* Fall term annually.  
3 credit hours

CIVL 6460  
**Advanced Structural Dynamics**  
Stochastic response of lumped parameter and continuous systems to random excitation, wave propagation, power spectral densities, covariance and cross covariance functions, transfer functions, application of procedure to wind and earthquake engineering. Review of current literature.  
*Prerequisite:* CIVL 6450.  
*Offered:* Upon availability of instructor.  
3 credit hours

CIVL 6480  
**Designing with Geosynthetics**  
Civil Engineering applications of geosynthetics including geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geosynthetic, and geocomposites. Designing by function, including separation, reinforcement, filtration, drainage, liquid barrier, and combined functions. Applications in the areas of landfills, groundwater drains, geotextile reinforced walls and slopes, roadways, and other civil engineered type structures.  
*Prerequisite:* CIVL 2630 or equivalent.  
*Offered:* Upon availability of instructor.  
3 credit hours

CIVL 6490  
**Earthquake Engineering**  
Seismology concepts including plate tectonics, fault mechanisms, quantification of earthquake size, and wave propagation. Dynamic sensors for earthquake ground motion measurement. Estimation of ground motion parameters using attenuation relationships. Linear and nonlinear dynamic analyses for evaluation of the seismic response of structures. Code-based approach to the seismic analysis and design of structural systems. Seismic design considerations for various construction materials. Base isolation and energy dissipation systems for seismic protection of structures.  
*Prerequisite:* CIVL 6450.  
*Offered:* Upon availability of instructor.  
3 credit hours

CIVL 6510  
**Advanced Soil Mechanics**  
An intensive study of the fundamentals of soil mechanics at the graduate level. Transmission of stresses between particles. Soils in which the pore water is either stationary or flowing under steady conditions. Soils in which pore pressures are influenced by applied loads, and hence the pore water is flowing under transient conditions.  
*Prerequisite:* CIVL 4150.  
*Offered:* Fall term annually.  
3 credit hours

CIVL 6520  
**Advanced Foundations and Earth Structures**  
The applications of the principles of soil mechanics to the design of foundations, at the graduate level. Subsurface investigation. Design of footings, retaining walls, pile foundations, flexible retaining structures, anchor tie-backs, bridge piers, abutments, embankments, and natural slopes. Slope stability analysis and landslide prevention. Earthquake effects. Case studies.  
*Prerequisites:* CIVL 4010, CIVL 4150.  
*Offered:* Spring term annually.  
3 credit hours

CIVL 6530  
**Seepage, Drainage, and Groundwater**  
Introduction to groundwater hydrology, well hydraulics, permeability, seepage, flow nets, filter criteria, dewatering, slope stabilization, practical applications.  
*Prerequisite:* CIVL 2630 or equivalent.  
*Offered:* Upon availability of instructor.  
3 credit hours

CIVL 6540  
**Dynamics of Soil and Soil-Foundation Systems**  
Basics of dynamic response of soil and soil-foundation systems, including applications to earthquake engineering and machine foundations. Systems studies include shallow and deep foundations, buried structures, earth structures, slopes, and earthquake site response.  
*Prerequisite:* CIVL 6450.  
*Offered:* Spring term annually.  
3 credit hours

CIVL 6550  
**Advanced Geoenvironmental Engineering**  
An intensive study of the application of geotechnical engineering to the environmental area. Deals with waste disposal, waste containment systems, waste stabilization and landfills. Emphasis on design of such facilities. Includes related topics necessary for design, e.g., geosynthetics, groundwater, contaminant transport, and slurry walls. Some field trips are possible. This course meets concurrently with CIVL 4140. CIVL 6550 students are required to do a term paper and/or project, read additional professional papers and publications, and do additional laboratory experiments. (Students cannot receive credit for both this course and CIVL 4140.)  
*Offered:* Fall term annually.  
3 credit hours
CIVL 6660
Fundamentals of Finite Elements
Graduate-level course on the fundamental concepts and technologies underlying finite element methods for the numerical solution of continuum problems. The course emphasizes the construction of integral weak forms for elliptic partial differential equations and the construction of the elemental level matrices using multi-dimensional shape functions, element level mappings, and numerical integration. The basic convergence properties of the finite element method will be given. This course serves as preparation for students working on finite element methods.
Prerequisite: Differential equations.
Offered: Fall term annually.
Cross listed: MANE 6660. Students cannot receive credit for both this course and MANE 6660.
3 credit hours

CIVL 6670
Nonlinear Finite Element Methods
The formulations and solution strategies for finite element analysis of nonlinear problems are developed. Topics include the sources of nonlinear behavior (geometric, constitutive, boundary condition), derivation of the governing discrete equations for nonlinear systems such as large displacement, nonlinear elasticity, rate independent and dependent plasticity and other nonlinear constitutive laws, solution strategies for nonlinear problems (e.g., incrementation, iteration), and computational procedures for large systems of nonlinear algebraic equations.
Prerequisite: CIVL 6660 or MANE 6660.
Offered: Fall term odd-numbered years.
Cross listed: MANE 6670. Students cannot obtain credit for both this course and MANE 6670.
3 credit hours

CIVL 6680
Finite Element Programming
Examines the implementation of finite element methods. Consideration is first given to the techniques used in classic finite element programs. Attention then focuses on development of a general geometry-based code which effectively supports higher order adaptive technique. Technical areas covered include: effective construction of element matrices for p-version finite elements, ordering of unknowns, automatic mesh generation, adaptive mesh improvement, program and database structures. Implementation of automated adaptive techniques on parallel computers is also covered.
Prerequisites: CIVL 6660, MANE 6660, CSCI 6860, or MATH 6860.
Offered: Spring term odd-numbered years.
Cross listed: MANE 6680. Students cannot obtain credit for both this course and MANE 6680.
3 credit hours

CIVL 6690
Advanced Finite Element Formulations
This course focuses on generalized weighted residual methods and multifield variational principles for constructing approximate solutions to sets of governing differential equations and associated boundary conditions. Topics include hybrid and mixed methods, boundary element formulations, p-version finite elements, global/local procedures, and penalty methods. Problem areas include solid mechanics (nearly incompressible solids, plates, and shells), fluid mechanics including compressible flows, and heat transfer.
Prerequisite: CIVL 6660 or MANE 6660.
Offered: Spring term even-numbered years.
Cross listed: MANE 6690. Students cannot obtain credit for both this course and MANE 6690.
3 credit hours

CIVL 6700
Finite Element Methods in Structural Dynamics
Solutions to the free vibration and transient dynamic responses of two- and three-dimensional structures by the finite element method are considered. The governing finite element matrix equations are derived and numerical aspects of solving these time-dependent equations considered. Topics include the formulation of the eigenvalue problem, algorithms for eigenvalue extraction, time integration methods including stability and accuracy analysis, and finite elements in time. Modal analysis and direct time integration techniques are compared for a variety of two-and three-dimensional problems.
Prerequisite: CIVL 6660 or MANE 6660.
Offered: Fall term odd-numbered years.
Cross listed: MANE 6700. Students cannot obtain credit for both this course and MANE 6700.
3 credit hours

CIVL 6780
Numerical Modeling of Failure Processes in Materials
State-of-the-art in computational modeling of failure processes in materials. Topics include numerical modeling of discrete defects, distributed damage, and multiscale computational techniques including multiple scale perturbation techniques, boundary layer techniques, and various global-local approaches.
Prerequisite: CIVL 6660 or MANE 6660.
Offered: Spring term even-numbered years.
Cross listed: MANE 6780. Students cannot receive credit for both this course and MANE 6780.
3 credit hours

CIVL 6900
Civil Engineering Graduate Seminar
Civil engineering graduate students present seminars about their research to an audience composed of students and faculty and participate in discussions about the research of others. The course consists of one-hour weekly meetings. The faculty member in charge of the course helps the students develop their presentation skills. This course is required to be taken once by M.S. and Ph.D. students who are doing a thesis or project. For ME students not doing a thesis or project this course is not required.
Offered: Spring term annually.
0 credit hours
CIVL 6910
Colloquium Series
Seminars by distinguished guest speakers. All undergraduates and graduates are strongly encouraged to attend as many lectures as possible.
Offered: Fall and spring terms annually.
0 credit hours

CIVL 6940
Readings in Civil Engineering
1 to 3 credit hours

CIVL 6960
Topics in Civil Engineering
3 credit hours

CIVL 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

CIVL 6980
Master’s Project
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the Master’s Project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.
1 to 9 credit hours

CIVL 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presentend, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
1 to 9 credit hours

CIVL 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
Variable credit hours

COGS Cognitive Science (HSSH)

COGS 2120
Introduction to Cognitive Science
This course is an introduction to the new and quickly growing field of cognitive science. Cognitive Science is a highly interdisciplinary field of study of mind at the intersection of philosophy, psychology, computer science, neuroscience, linguistics, and anthropology. This is a communication-intensive course.
Offered: Spring term annually.
Cross listed: PHIL 2120 and PSYC 2120. Students cannot obtain credit for both this course and PHIL 2120 and PSYC 2120.
4 credit hours

COGS 2520
Introduction to Game Design
This course looks at the mathematics of game theory from a psychological perspective and serves as a primer in video game design. The psychology of players and designers are discussed, as well as the cognitive processes that people use when solving game-related puzzles. Additional topics include logic, human frailty, role playing, artificial intelligence, kinesics, theater, and human-computer interaction.
Offered: Fall term annually.
4 credit hours

COGS 4210
Cognitive Modeling I
This is an undergraduate level course that introduces the student to computational cognitive modeling. Cognitive modeling is the simulation of human cognitive, perceptual and motor processes based on a cognitive architecture. The benefit of cognitive modeling is that it facilitates the testing of ideas about human processes through comparison of model data with empirical data. This course covers ACT-R, a symbolic architecture and LEABRA, a neural-level architecture.
Prerequisite: COGS 4410 or permission of instructor.
Offered: Spring term annually.
Cross listed: COGS 6210. Students cannot obtain credit for both this course and COGS 6210.
4 credit hours
COGS 4220
Cognitive Modeling II
This is an undergraduate level course that extends the objectives of Cognitive Modeling I to additional cognitive architectures. The first part of the course is a survey of cognitive modeling paradigms. The second part will be a more in depth coverage of two or three architectures and will be done by teams of students. Each team will study one architecture including the development of a model.

Prerequisite: COGS 4210.
Offered: Fall term annually.
Cross listed: COGS 6220. Students cannot obtain credit for both this course and COGS 6220.
4 credit hours

COGS 4320
Game Mechanics
This is an iterative game prototyping class. The focus is on designing and tuning games from a rules-based perspective. Topics include cooperation and competition, risk and reward, probability, and game balance.

Prerequisite: COGS 2520.
Offered: Spring term annually.
4 credit hours

COGS 4330
Introduction to Cognitive Neuroscience
This survey course is intended as an introduction to Cognitive Neuroscience. Prerequisites are PSYC 1200, or equivalent, or permission of instructor. The topics covered will focus on exploring the neural underpinnings for cognitive processes, such as sensation, language, attention, motor control, executive functions, social communication, emotions, consciousness, and learning/memory. Basic aspects of nervous system function and neuroanatomy, brain development/evolution, structural and functional imaging techniques, and other research methods used in Cognitive Neuroscience will be discussed.

Prerequisites: PSYC 1200 or permission of instructor.
Offered: Spring term annually.
Cross listed: PSYC 4330.
4 credit hours

COGS 4410
Programming for Cognitive Science and Artificial Intelligence
This course is an undergraduate course that teaches Cognitive Science and Artificial Intelligence concepts by enabling the student to develop and understand computer programs that implement them. It covers data collection and analysis, task environments, natural language, cognitive architectures, and learning. Some previous programming experience is very beneficial but not required.

Prerequisite: CSCI 2300 or permission of instructor.
Offered: Fall term annually.
Cross listed: COGS 6410. Students cannot obtain credit for both this course and COGS 6410.
4 credit hours

COGS 4520
Game Development
This class is a practical primer for anyone interested in a career in the rapidly evolving industry of video gaming. It is an intense, team-based, project-based course in which students will closely follow the actual game development cycle, with each team producing a complete PC game. Students cannot get credit for both this course and CSCI 4520.

Prerequisite: COGS 2520 or CSCI 2300.
Offered: Spring term annually.
4 credit hours

COGS 4540
Game Development II
This course follows Game Development I. Students work in interdisciplinary teams to create one large-scale 3D game, working from concept to public release. Projects may include games, educational games, serious games and simulations, and interactive artworks, and will focus on creative design, technical execution, and use of game design principles. The course builds on skills and knowledge in previous courses in the GSAS core, including game design, game mechanics, game programming, art, and narrative.

Prerequisites: Game Development I or consent of the instructor.
Offered: Spring term annually.
Cross listed: ARTS 4960, CSCI 4969.
4 credit hours

COGS 4610
Stress on the Brain
This seminar course is a detailed examination of the mind-brain relationship, through study of the stress response. Stress is simply defined as any challenge to an individual’s homeostasis, or balance. This course will explore the neurobiological underpinnings of the stress response, with particular focus on how stressors can alter perception, affective and cognitive processing in the individual, which can in turn feedback to alter the general health of the individual (body and mind/brain).

Prerequisites: PSYC 1200 or permission of instructor.
Cross listed: PSYC-4XXX.
4 credit hours
COGS 4620
Cognitive Engineering
Covers cognitive theory from an applied perspective to understand and predict the interactions among human cognition, artifact (i.e., tools), and task. Cognitive task analysis techniques will be taught and used throughout the course, as will techniques for collecting and analyzing fine-grained behavioral data. Topics covered may include visual search and visual attention, cognitive skill and its acquisition, hard and soft constraints on interactive behavior, human error, soft constraints on judgment and decision-making, and experts and expertise.
Prerequisites: PSYC/PHIL 2120 or PSYC 4310 or PSYC 4370 or permission of instructor.
Offered: Fall term annually.
Cross listed: PSYC 4620. Students cannot obtain credit for both courses.
4 credit hours

COGS 4640
Intelligent Virtual Agent
This course introduces various computational approaches for creating intelligent conversational agents. This course will take the form of a combination of lectures, presentations by students, class discussions, and independent study.
Prerequisites: CSCI 1200 and CSCI 2300.
Offered: Fall term annually.
4 credit hours

COGS 4940
Readings in Cognitive Science
An individually arranged independent study course under the supervision of a member of the Cognitive Science Department.
The topic is selected by consultation between student and faculty member.
1 to 4 credit hours

COGS 4960
Topics in Cognitive Science
An advanced course concerned with selected topics in cognitive science.
1 to 4 credit hours

COGS 4990
Undergraduate Thesis
Students conduct original scholarly projects: original research, theoretical or analytical reviews of the literature, or computer simulations. Students prepare written reports relating to this project, under the supervision of a faculty member. This is a communication-intensive course.
Prerequisite: Permission of a supervising faculty member (completion of the thesis/project/dissertation registration form).
Offered: Fall, spring, and summer terms annually.
3 to 6 credit hours

COGS 4940
Readings in Cognitive Science
An individually arranged independent study course under the supervision of a member of the Cognitive Science Department.
The topic is selected by consultation between student and faculty member.
1 to 4 credit hours

COGS 6100
Seminar in Cognitive Engineering
Integrated cognitive systems comprise human cognitive, perception, and motor subsystems in coordinated action with interactive devices. Examples may be as simple as a human using a VCR or as complex as the behavior exhibited by Air Force pilots. This course will introduce students to the cognitive theory behind integrated cognitive systems, the techniques for collecting and analyzing data such as eye movements and action protocols, as well as the software tools available for the representation of interactive behavior.
Prerequisite: Admission to doctoral program.
Offered: Fall and spring terms annually.
4 credit hours

COGS 6200
Cognition
This course covers reasoning, decision making, and behavioral game theory, which are major domains in human higher order cognition. Each topic begins with normative theories and continues through formal and mathematical models, and the introduction of empirical studies. The course emphasizes integrations of competing approaches within a domain, integration between reasoning and decision making, and integration between individual decision making and game-theoretic interactions. Each year, the course has a theme. The theme for this year is quantum cognition, which applies quantum theory in cognitive modeling. This course is designed as self-contained, and has no prerequisites. A middle term presentation and a final term paper are required for each student.
Graduate students only.
Offered: Fall term annually.
4 credit hours

COGS 6210
Cognitive Modeling I
This is a graduate level course that introduces the student to computational cognitive modeling. Cognitive modeling is the simulation of human cognitive, perceptual and motor processes based on a cognitive architecture. The benefit of cognitive modeling is that it facilitates the testing of ideas about human processes through comparison of model data with empirical data. This course covers ACT-R, a symbolic architecture and LEABRA, a neural-level architecture.
Offered: Spring term annually.
Cross listed: COGS 4210. Students cannot obtain credit for both this course and COGS 4210.
4 credit hours

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COGS 6220  
Cognitive Modeling II  
This is a graduate level course that extends the objectives of Cognitive Modeling I to additional cognitive architectures. The first part of the course is a survey of cognitive modeling paradigms. The second part will be a more in depth coverage of two or three architectures and will be done by teams of students. Each team will study one architecture including the development of a model.  
Offered: Fall term annually.  
Cross listed: COGS 4220. Students cannot obtain credit for both this course and COGS 4220.  
4 credit hours

COGS 6240  
Logic and Artificial Intelligence  
This course is about the connection between logic and artificial intelligence (AI). It may be partitioned into three general sections: 1) the straightforward application of first order logic (FOL) in AI; 2) the broadening of FOL to enable a robot to reason in a commonsense way (nonmonotonic reasoning, induction, etc.) and to formalize a robot agent’s belief and knowledge system (modal logics, etc.); and 3) using a logical approach to the Frame Problem and to building a planner.  
Offered: Spring term annually.  
4 credit hours

COGS 6410  
Programming for Cognitive Science and Artificial Intelligence  
This course is a graduate course that teaches Cognitive Science and Artificial Intelligence concepts by enabling the student to develop and understand computer programs that implement them. It covers data collection and analysis, task environments, natural language, cognitive architectures, and learning. Some previous programming experience is very beneficial but not required.  
Offered: Fall term annually.  
Cross listed: COGS 4410. Students cannot obtain credit for both this course and COGS 4410.  
4 credit hours

COGS 6420  
Perception and Action  
This course is a graduate level introduction to the topic of perception and action, and will focus on the significance of perception, motor control, and perceptual-motor learning as they relate to the performance of routine and skilled tasks. It will explore perception and action from information processing, computational, dynamical systems, and ecological perspectives, review current empirical and computational research, and consider some applications, including training, rehabilitation, human-machine interaction, and robotics.  
Prerequisite: Graduate status or permission of instructor.  
Offered: Fall term even-numbered years.  
4 credit hours

COGS 6570  
Advanced Behavioral Statistics  
An accelerated course covering important behavioral statistical concepts including probability, sampling distributions, hypothesis testing, ANOVA, and multiple regression. Course requires usage of statistical software package and is taught using the general linear model framework.  
Prerequisite: Graduate status and one course in undergraduate statistics.  
Offered: Fall term annually.  
4 credit hours

COGS 6640  
Intelligent Virtual Agent  
This course introduces various computational approaches for creating intelligent conversational agents. This course will take the form of a combination of lectures, presentations by students, class discussions, and independent study.  
Prerequisites: CSCI 1200 and CSCI 2300.  
Offered: Fall term annually.  
4 credit hours

COGS 6690  
Seminar in Research Design  
An in-depth study of quasi-experimental and experimental design of behavioral research. Topics include test construction and development, factor analysis, meta-analysis, repeated measures, and MANOVA.  
Prerequisite: COGS 6570 or permission of instructor.  
Offered: Spring term annually.  
4 credit hours

COGS 6940  
Readings in Cognitive Science  
An individually arranged independent study course under the supervision of a member of the Cognitive Science Department. The topic is selected by consultation between student and faculty member.  
Prerequisite: Graduate status and permission of supervising faculty member.  
Offered: Fall and spring terms annually.  
1 to 4 credits credit hours

COGS 6960  
Topics in Cognitive Science  
An advanced course concerned with selected topics in cognitive science.  
Prerequisite: Permission of instructor.  
Offered: Fall and spring terms annually.  
1 to 4 credits credit hours
COGS 6980  
Master's Project  
Active participation in a master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will be listed as S.  
Offered: Fall and spring terms annually.  
1 to 9 credits credit hours

COGS 6990  
Master's Thesis  
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of S or U are assigned by the adviser each term to reflect the student's research progress for the given semester. Once the thesis has been presentend, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.  
Offered: Fall and spring terms annually.  
1 to 9 credits credit hours

COGS 9990  
Doctoral Thesis  
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of S or U are assigned by the adviser each term to reflect the student's research progress for the given semester. Once the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.  
Offered: Fall and spring terms annually.  
Variable credit hours

COMM Communication (HSSH)

COMM 1510  
Introduction to Communication Theory  
This course introduces students to basic topics in communication theory, including interpersonal, small group, organizational, and mass communication. Students will study a variety of theories related to these topics and will also study the cultural impact of new communication technologies and contemporary media systems.  
Offered: Spring term annually.  
4 credit hours

COMM 1600  
History and Culture of Games  
This course surveys 5000 years of game history, from ancient Sumeria to the latest next-generation consoles and MMOGs. In parallel with this historical tour, several major theories will be examined about the nature of play and the nature of games. Along the way we will also look at how games and play influence the cultures they are found in, and how culture in turn influences how people structure their leisure time will also be considered. This is a communication-intensive course.  
Offered: Fall and spring terms annually.  
4 credit hours

COMM 2210  
Web and Database Programming  
This course introduces the fundamentals for creating dynamic Web page content generated using relational databases. This course is structured around Microsoft Visual Studio.NET and modern object-oriented programming languages like C#. Fundamental technologies like ADO.NET database connectivity, ASP.NET active page technology, XML, SOAP, and Web Services are examined. Students will construct actual non-trivial working Web sites that employ databases from which dynamic content is generated.  
Offered: Fall and spring terms annually.  
4 credit hours

COMM 2390  
Formations of Race  
This course explores the historical development and social production of race as an essentialized aspect of human difference, followed by contemporary constructions of race, racial orders and lived racial experience in the U.S. and other countries. Topics include: race, biology and anthropology; racial classification; the critical concept of whiteness; the language of new racism; the post-racial paradigm; and representations of race and ethnicity in entertainment media past and present.  
Offered: Spring term annually.  
4 credit hours

COMM 2410  
Perspectives on Photography  
This course helps students understand the meaning and emotional complexity of visual images in our culture. Students examine photographic imagery through three perspectives. The first—formal—addresses the design components of the image, such as vantage point and contrast. The second—psychodynamic—concerns the emotional dynamics of viewing. The third—social political—explores photographs as instruments for preserving or challenging cultural values. No technical knowledge of photography is needed.  
Offered: Fall and spring terms annually.  
4 credit hours

COMM 2440  
Documentary Film  
Does documentary film depict reality, or is it just another form of storytelling? This course takes a broad, historical look at documentary media, exposing students to a wide range of works that in some sense stand on claims to truth. Students are invited to develop a critical stance toward documentary modes of social representation, through viewing and analyzing colonial photography and cinema, ethnographic, propaganda, cinema verite, experimental, and even “fake” documentaries. This is a communication-intensive course.  
Offered: Spring term annually.  
4 credit hours
COMM 2610
Introduction to Visual Communication
This course is an introduction to basic principles of visual communication and an exploration of the graphic design process. The study approach is through laboratory work utilizing software applications currently used in the field. Topics include type and image; logo design and application; foundation statement creation; and print production methods.
Offered: Fall and spring terms annually.
4 credit hours

COMM 2620
Color Theory
Color – the most relative of all visual attributes – is explored in this studio course through a series of exercises and graphic design problems. Investigations will include: recollection (i.e. visual memory), reading and contexture, relativity and subjectivity, color and light, color and communication, and “cultural” color. An emphasis on the work and theories of Joseph Albers will be examined.
Prerequisite: COMM 2610.
Offered: Fall term odd-numbered years.
4 credit hours

COMM 2940
Communication Studies
Readings and projects adapted to the needs of individual students.
4 credit hours

COMM 2960
Topics in Communication
Experimental courses tried out in one or two terms.
4 credit hours

COMM 4180
Studio Design in Human-Computer Interaction
In this course, students work on collaborative projects to design human-computer interactions (HCIs) aimed at transforming people’s everyday practices. Students work with activity analysis, object-oriented modeling, and UI prototyping. Additional assignments required for students at the 6000 level.
Prerequisite: COMM 4420, COMM 4770, or COMM 4710.
Offered: Spring term annually.
Cross listed: COMM 6810; students cannot obtain credit for both courses.
4 credit hours

COMM 4210
Designing Interactive Characters for Digital Games
This course takes a multi-disciplinary approach to teaching the design of interactive characters for games. Students learn and apply principles from psychology, traditional media, and best practices from the games industry to the crafting of engaging characters. Students develop critical analysis and design skills, as well as team-based project skills. The course includes industry guest speakers, and culminates with the creation of concept prototypes.
Prerequisite: COGS 2520 or permission of instructor.
Offered: Fall term annually.
4 credit hours

COMM 4230
Psychological and Social Effects of Games
This course will address issues related to the psychological and social effects of games. How video games can change personal experience and catalyze social change will be discussed from a broad, critical perspective. The course will draw upon comparative historical, psychological, and sociological domains of knowledge to evaluate existing game influences and consider future possibilities for impact. This course is communication-intensive.
Prerequisite: Any HASS undergraduate course or permission of instructor.
Offered: Fall term annually.
4 credit hours
COMM 4300
Communication Internship
This course is designed for communication majors who wish to incorporate field experience in their educational programs. Students work with local business, industrial, civic, or educational organizations in positions where they can observe communication processes and apply written, interpersonal, and public communication skills to the solution of real problems.
Prerequisite: Undergraduate major in communication at junior or senior level.
Offered: Fall and spring terms annually.
Cross listed: COMM 6300.
4 credit hours

COMM 4310
Sustainable Graphic Design
This course is designed to introduce students to ideas and practices of sustainability in visual communications. Sustainable graphic design is the consideration of environmental, cultural and physical impacts of graphic design products throughout their lifecycle. Designers engaged in sustainable practice use techniques, processes and materials to reduce the detrimental environmental, social and economic impacts of their designs. They raise awareness and act as exemplars of sustainable practice for their clients, their peers and their community.
Prerequisites: COMM 2610 or permission of instructor.
Offered: Spring term annually.
4 credit hours

COMM 4320
Visual Poetic and Narrative
This studio course explored new directions in art and design that include visual poetry (visual expression in which the shape an arrangement of text, images, symbols convey the message) and interactive narrative. Visual poetics and narrative appear in advertisement, music videos, and other forms of communication. Students will experiment with these forms of communication and learn how these concepts apply in artistic and commercial contexts. The class format includes lectures, discussions, and studio work.
Prerequisites: One of the following courses: ARTS 1020, COMM 1510, COMM 4460, COMM 4570, or permission of instructor.
Offered: Annually.
4 credit hours

COMM 4340
Creative Seminar I
This course is for senior for EMAC and EART majors and is the core creative forum for the development and presentation of the senior thesis. The course is the first part of a two-semester study provided in two seminar courses. The focus of the course is to develop a proposal for a written thesis and a creative project that students will execute in the second seminar and exhibit in an exhibition.
Prerequisites: Senior EMAC and EART majors only.
Offered: Fall term annually.
4 credit hours

COMM 4350
Creative Seminar II
This course is for senior EMAC and EART majors. The goal of the Creative Seminar II is to develop and formulate ideas from Creative Seminar I into unique project for the artist/communicator that will demonstrate his/her independent ideas, research, writing and design skills. Students will develop a written thesis, creative project (e.g., art, graphic design, interaction design, music, performance), prepare and present their project in a public exhibition, and design the publicity for the show.
Prerequisites: COMM 4340 Creative seminar I, Senior EMAC and EART majors only.
Offered: Spring term annually.
4 credit hours

COMM 4380
Writing and Response
This course explores effective strategies for talking with others about oral presentations and written texts. Practice in consulting is grounded in theory and research in composition studies, reader-response, and tutoring. Students also study their own writing and reading processes through reflection and discussion. Those who complete the course with a grade of A- or A may apply to work as writing consultants in the Center for Communication Practices. This is a communication-intensive course.
Offered: Spring term annually.
Cross listed: COMM 6380. Students cannot receive credit for both courses.
4 credit hours

COMM 4400
Cross-Cultural Media: Analysis and Application
What role does culture play in visual communication across media? This course surveys perspectives from interdisciplinary discourse on what constitutes culture and its impact on meaning. Through readings on theory and criticism and analyses of existing media and research-generated data students gain an understanding of what constitutes cultural difference and how to communicate visually across cultures.
Prerequisite: Any graphics course.
Offered: Fall term annually.
Cross listed: COMM 6400. Students cannot obtain credit for both courses.
4 credit hours
COMM 4420
Foundations of HCI Usability
In this course, students will consider methods of gathering users' requirements for product functions and information, ways to test products and information for usability and suitability, and procedures for incorporating the results learned through testing. Students will design and conduct usability tests on products, documents, and interfaces of interest.
Prerequisite: One HASS course.
Offered: Fall term annually.
Cross listed: COMM 6420; an additional assignment is required for COMM 6420. Students cannot obtain credit for both courses.
4 credit hours

COMM 4460
Visual Design: Theory and Application
This course introduces students to the theoretical and practical use of graphics as a form of visual communication. Discussions include topics such as the psychology of visual perception, design theory, creative process, formatted text, and graphics. Students have an opportunity to put theory into practice using computer graphics.
Prerequisite: COMM 2610 or permission of instructor.
Offered: Fall term annually.
Cross listed: COMM 6560. Students cannot obtain credit for both courses.
4 credit hours

COMM 4470
Information Design
This course examines methods of graphic representation of data. Course work requires graphing of information derived from researched databases. Visual presentations of historic data will be examined to determine the most efficient way to represent complex information without distorting the data within. Information designers clarify these displays and enrich our understanding of our modern world.
Prerequisite: COMM 2610.
Offered: Fall term annually.
4 credit hours

COMM 4520
Information Architecture
This course examines theoretical and empirical issues in the field of Information Architecture, aiming to identify and utilize principles of information organization, collect and interpret empirical data on human information behavior, and develop and apply methods of information design all in the service of creating usable architectures of information. Focus is on developing experience for professional information architecture projects.
Prerequisite: Any 4000-level COMM course or permission of instructor.
Offered: Spring term annually.
Cross listed: COMM 6620. Students may not obtain credit for both courses.
4 credit hours

COMM 4540
Visual Culture
Humans inhabit a culture of visual images. Images bombard them on television, the internet and in films; they surround everyone as architecture and fashion; they provide essential resource data in science, engineering, and business. This course will help students better understand how images communicate information, arouse emotions, and shape values. Students will primarily do readings in cultural history/theory, with some viewing of films.
Prerequisite: One 2000-level HASS undergraduate course of permission of instructor.
Offered: Fall term annually.
4 credit hours

COMM 4550
Religion in the Media
How are religious fundamentalists using new media? Can religious conversion take place in a theme park? How are religious "cross-over" films transforming political and popular cultural landscapes? This course maps the complex intersections of religion, culture, and media in the global transformations of religious traditions and explores, through a media frame, the "the return of religion" within the secular consensus of modernity.
Prerequisite: COMM 1510 or permission of instructor.
Offered: Fall term annually.
4 credit hours

COMM 4560
Media and Popular Culture
A survey of the historical origins and cultural impact of several mass media, including television, film, radio, the Internet, and print media. The course aims to increase media literacy through analysis of specific media products as well as discussion of broad topics such as: advertising and commercialization; politics and censorship; gender, race, and social identity.
Prerequisites: Any COMM or LITR course, graduate standing, or permission of instructor.
Offered: Spring term annually.
4 credit hours

COMM 4570
Typography
This course teaches the principles of typesetting text effectively for hypothetical and real-world communication. Students practice selecting typefaces, point-sizes, leading, line-length, color, justification, layouts, kerning and tracking for printed and digitized type. An RPI-sponsored, entrepreneurial component allows student teams to conduct typographic makeovers for real-world clients and individual students to explore typography innovation for real-world audiences.
Prerequisite: COMM 2610.
Offered: Spring term annually.
Cross listed: COMM 6570. Students cannot obtain credit for both courses.
4 credit hours
**COMM 4580**  
*Advertising and Culture*  
An examination of the cultural impact of advertising in various media: TV, radio, print, and the Web. How does advertising inform human experience and identity? How has it shaped the culture? Who pays for it and why? Note: This is not a How-To course. The focus is critical analysis, not acquiring skills for producing advertising.  
**Prerequisite:** Any COMM or LITR course or permission of instructor.  
**Offered:** Fall term annually.  
4 credit hours

**COMM 4610**  
*Rhetorical Analysis*  
A study of the persuasive use of language. Some basic theories of argument and style are explored as a means of improving the students’ ability to both analyze and create rhetorical discourse.  
**Prerequisite:** WRIT 2110 or permission of instructor.  
**Offered:** Upon availability of instructor.  
4 credit hours

**COMM 4620**  
*Language and Culture*  
This course examines the role that language plays in the production of social identities and cultural assumptions about the world. Course topics include: language and worldview; linguistic contact and change, language ideology and nationalism, religious language, “politically correct” speech, and the key role that language plays in structuring race, gender and class-based systems of social inequality. Guest lectures from the Languages faculty.  
**Prerequisites:** COMM 1510 or Language Minor, or permission from instructor.  
**Offered:** Spring term annually.  
4 credit hours

**COMM 4650**  
*Marketing Communication Design*  
This course examines communication design for marketing purposes. It evaluates the effectiveness of designs for information, persuasion, education, and administration. Discussions on denotation and connotation, gestalt theory, and semiotics aim to investigate how theory influences design and the political, social, and cultural dimensions of visual language. In a term-long project, students analyze how design from an entrepreneurial perspective can provide marketable solutions to communication problems.  
**Prerequisites:** COMM 2610 and COMM 4570.  
**Offered:** Spring term annually.  
4 credit hours

**COMM 4660**  
*Visual Literacy*  
This course examines the notion of visual literacy — the ability to create effective visual layouts and analyze visual language for meaning. Through readings, discussions, and praxis exercises, students learn the lexicon of visual communication, how to critically evaluate a visual argument, and how to apply visual literacy theory to practice.  
**Prerequisite:** COMM 2610.  
**Offered:** Fall term annually.  
4 credit hours

**COMM 4660**  
*Visual Literacy*  
This course examines the notion of visual literacy — the ability to create effective visual layouts and analyze visual language for meaning. Through readings, discussions, and praxis exercises, students learn the lexicon of visual communication, how to critically evaluate a visual argument, and how to apply visual literacy theory to practice.  
**Prerequisite:** COMM 2610.  
**Offered:** Fall term annually.  
4 credit hours

**COMM 4670**  
*Advanced Typography*  
This advanced design studio course will explore individual approaches to typographic problems in both print and digital mediums. Projects will investigate typographic metaphor and illustration, designing typography for texts, and typography in motion. Emphasis will be on communication and typographic hierarchy while encouraging experimentation to create your own typographic voice. This is an advanced course and students will be expected to work independently.  
**Prerequisite:** COMM 4570.  
**Offered:** Fall term even-numbered years.  
4 credit hours

**COMM 4680**  
*Electronic Portfolio Development*  
This course is designed to introduce students to the research, design, production and distribution of an electronic portfolio of their own work. Through reading, class discussions, and class projects focusing on use of Photoshop, Illustrator, Dreamweaver and Flash, the course will explore concepts and techniques in the design and publication of networked digital material. The course will help students develop the ability to create and present a networked portfolio of their work.  
**Prerequisites:** COMM 2610 or permission of instructor.  
**Offered:** Spring term annually.  
4 credit hours

**COMM 4690**  
*Interface Design: Hypermedia Theory and Application*  
This course focuses on the design theory and research behind effective interface design for hypermedia programs (multimedia computer programs with interactive inks). These interactive programs are the standard form of communication on the WWW, CDs, and DVDs. Students apply theory and research by designing and developing an interactive multimedia program (for WWW or CD).  
**Prerequisites:** 1) an introductory course in communication or another social science course or permission of the instructor; and 2) knowledge of authoring software for multimedia or Web development.  
**Offered:** Spring term annually.  
4 credit hours
COMM 4710
Communication Design for the WWW
In this course, students will examine the design and use of Web sites from initial gathering of user requirement, through design, development, and evaluation of a site’s graphic and textual content and the assessment of customer satisfaction with the site.
Prerequisites: COMM 4420.
Offered: Fall term annually.
Cross listed: COMM 6750. Students cannot obtain credit for both courses.
4 credit hours

COMM 4730
Graphic Design for Corporate Identity
This course examines historical and modern visual communication symbols in relationship to a company’s overall industry and marketplace identity. The course focuses on design processes relative to the dissemination of consistent visual information. Projects will include an identity program for a fictitious company. The course study is structured as a design studio and is aimed at exploring unique methodologies of ever-changing media marketing tools.
Prerequisites: COMM 2610 and COMM 4570 or permission of instructor.
Offered: Spring term annually.
4 credit hours

COMM 4740
Principles of Web Advertising
This course covers fundamental economic and communication issues in advertising, economics, measurement of audience demographics and psychographics, advertising effectiveness, applied persuasion techniques. Technical issues in Web advertising are outlined, and unique characteristics of Web advertising are addressed. Design of cost-effective Web advertising, privacy vs. personalization issues, control of content by advertisers, junk Web advertising and information clutter, and other relevant topics are discussed.
Prerequisites: COMM 2610 and permission of instructor.
Offered: Fall term annually.
4 credit hours

COMM 4770
User-Centered Design
Explore how users get involved in design: as specifiers of requirements, as evaluators, as sounding boards, and as collaborators. Students will gather requirements, design to meet those requirements, and evaluate their success.
Prerequisites: COMM 4420 or permission of instructor.
Offered: Spring term annually.
Cross listed: COMM 6770; students taking COMM 6770 will be assigned an additional project. Students cannot obtain credit for both courses.
4 credit hours

COMM 4780
Interactive Narrative
Lectures and class discussions will analyze narrative theory and interactive narratives in a variety of genres such as oral story-telling, literature, poetry, film, radio programs, artists’ books, historical narrative, hypertext fiction, Net Art, and computer games. Students will have the opportunity to apply theory by designing and developing an interactive electronic program OR completing a research paper on interactive narrative.
Prerequisites: Knowledge of interactive authoring software and either COMM 2610 or COMM 4460.
Offered: Fall term annually.
Cross listed: COMM 6780. Students may not receive credit for both courses. Extra assignments are required in the graduate course.
4 credit hours

COMM 4790
Social Impact of Electronic Media
An exploration of the effects of electronic media such as the Internet, multimedia, computers, pop music, and television. The effects examined include changes in social and work relationships, time displacement, audience aggression, child socialization, education, and consumer behavior.
Prerequisite: Any communication course or permission of the instructor.
Offered: Upon availability of instructor.
4 credit hours

COMM 4800
Media and Memory
Most memories of the past are stories that circulate in the present through a variety of media. To probe the rhetorical mechanism of collective memory, this course combines exploration of several visual media with case studies that interpret the rhetorical potential of specific photographs, films, museums, and monuments.
Prerequisites: COMM 2610 or WRIT 1110.
Offered: Fall term annually.
Cross listed: COMM 6800. Students cannot obtain credit for both courses.
4 credit hours

COMM 4820
Usability Testing
In this course, students will examine and practice several methods of formal usability testing. Classes will consist of classroom discussion of scenario-based testing methods and statistical analysis of data collected and of laboratory sessions in which students develop, conduct, record, and analyze usability tests.
Prerequisites: COMM 4420, COMM 4770, or ITWS 2210.
Offered: Spring term annually.
Cross listed: COMM 6820. For COMM 6820, additional statistical analysis and a literature-based paper on a usability topic are required. Students cannot receive credit for both this course and COMM 4820.
4 credit hours
COMM 4830
Organizational Communication
Focuses on the central role of communication in organizations by exploring the way that communication is used in exercising authority, power, and control. Organizations with hierarchical and nontraditional structures are considered. The course also examines the role of communication in the social construction of organizational life.
Prerequisite: An introductory course in the social sciences or management or permission of instructor.
Offered: Spring term annually.
4 credit hours

COMM 4940
Communication Studies
Readings and projects adapted to the needs of individual students.
1 to 6 credit hours

COMM 4960
Topics in Communication
Experimental courses tried out in one or two terms.
4 credit hours

COMM 6260
Rhetoric, Culture, and Communication Technology
This is a graduate seminar designed to introduce Ph.D. students to the history of rhetorical theory and its intersections with culture and technology. The course will consider how theoretical reflection about language and other forms of communication is entwined with changes in technology of communication as well as cultural paradigm shifts. Rather than trace a linear evolution of rhetorical theory from Classical Antiquity to the present, the course will focus on competing conceptualizations of rhetoric and rhetorical power in different historical periods.
Offered: Spring term annually.
3 credit hours

COMM 6270
Digital Rhetoric
A study of digital rhetoric with emphasis upon the uses of verbal and visual media in digital spaces such as email, discussion lists, Webs, blogs, wikis, and community technology centers. An examination of verbal and visual communication for the purposes of persuading, negotiating, contesting, and creating individual and community identities and an exploration of issues such as the relationship between privacy and panopticism, subjectivities and intersubjectivities, local and global communities, and online and offline communities.
Offered: Fall term odd-numbered years.
3 credit hours

COMM 6280
Rhetorical Analysis
The application of rhetorical concepts in the analysis and appraisal of discourse. Students pursue projects under the direction of the instructor; weekly seminar meetings are devoted principally to discussions of ongoing projects.
Offered: Upon availability of instructor.
3 credit hours

COMM 6300
Communication Internship
This course is designed for communication majors who wish to incorporate field experience in their educational programs. Students work with local business, industrial, civic, or educational organizations in positions where they can observe communication processes and apply written, interpersonal, and public communication skills to the solution of real problems.
Prerequisite: Graduate status.
Offered: Fall and spring terms annually.
Cross listed: COMM 4300.
3 credit hours

COMM 6320
Visual Poetics and Narrative
This studio course explores new directions in art and design that include visual poetry (visual expression in which the shape and arrangement of text, images, and symbols convey the message) and interactive narrative. Visual poetics and narrative appear in advertisement, music videos, and other forms of communication. Students will experiment with these forms of communication and learn how these concepts apply in artistic and commercial contexts. The class format includes lectures, discussions, and studio work.
Offered: Annually.
3 credit hours

COMM 6380
Writing and Response
This course explores effective strategies for talking with others about oral presentations and written texts. Practice in consulting is grounded in theory and research in composition studies, reader-response, and tutoring. Students also study their own writing and reading processes through reflection and discussion. Those who complete the course with a grade of A- or A may apply to work as writing consultants in the Center for Communication Practices.
Offered: Spring term annually.
Cross listed: COMM 4380. Students cannot take both courses for credit.
3 credit hours
COMM 6400
Cross-Cultural Media: Analysis and Application
What roles does culture play in visual communication across media? This course surveys perspectives from interdisciplinary discourse on what constitutes culture and its impact on meaning. Through readings on theory and criticism and analyses of existing media and research-generated data students gain an understanding of what constitutes cultural difference and how to communicate visually across cultures.
Offered: Fall term annually.
Cross listed: COMM 4400. Students cannot obtain credit for both courses.
3 credit hours

COMM 6410
Ethnography and Cultural Analysis
This course focuses on theories, perspectives, and methods of ethnography, and on their applications to the various disciplines in which graduate students are working. Emphasis is given to foundational activities: defining a problem, research design, proposal writing, field methods, and protection of human subjects. Students will undertake original field research involving interviews, multi-sited fieldwork, participant-observation, situated ethnography, archival work, focus groups, and audio/video taping.
Offered: Fall term odd-numbered years.
3 credit hours

COMM 6420
Foundations of Human-Computer Interaction Usability
This course will consider methods for gathering users' requirements for product functions and information, ways to test products and information for usability and suitability, and procedures for incorporating the results learned through testing. Students will design and conduct usability tests on products, documents, and interfaces of interest.
Offered: Fall term annually.
Cross listed: COMM 4420. Students cannot obtain credit for both courses.

COMM 6480
Theory and Research in Technical Communication and Human-Computer Interaction
This seminar course examines theories that have shaped, and continue to drive, the fields of technical communication and human-computer interaction with an emphasis upon the ways each field makes new knowledge. Connections between theoretical findings, research results, and the evolution of both fields as they are practiced in industry, government, and academia are important themes. Course work includes lectures, discussions, student presentations, and written projects.
Prerequisite: COMM 1510 or equivalent.
Offered: Fall term annually.
3 credit hours

COMM 6510
Communication Theory
Introduces students to a range of theories from across the humanities and social sciences: theories of meaning, discourse, persuasion, interpersonal communication, and mass communication. Also introduces students to how theories are constructed and how knowledge is generated in communication studies.
Offered: Fall term annually.
3 credit hours

COMM 6530
Communication Research I
This course is designed to give training in field and experimental research methods, especially in scientific and technological communication. The student designs and conducts preliminary research projects as time permits.
Offered: A fall-spring sequence annually.
3 credit hours

COMM 6540
Communication Research II
This course is designed to give training in field and experimental research methods, especially in scientific and technological communication. The student designs and conducts preliminary research projects as time permits.
Offered: A fall-spring sequence annually.
3 credit hours

COMM 6560
Visual Design: Theory and Application
This course introduces students to the theoretical and practical use of graphics as a form of visual communication. Discussions include such topics as visual perception, design theory, formatted text, and graphics. Students have an opportunity to put theory into practice using computer graphics software.
Offered: Fall term annually.
Cross listed: COMM 4460. Students cannot obtain credit for both courses. For graduate students, one additional assignment will be required and their work will be evaluated at a higher level.
3 credit hours

COMM 6570
Typography
This course teaches the principles of typesetting text effectively for hypothetical and real-world communication. Students practice selecting typefaces, point-sizes, leading, line-length, color, justification, layouts, kerning, and tracking for printed and digitized text. An RPI-sponsored, entrepreneurial component allows student teams to conduct typographic makeovers for real-world clients and individual students to explore typographic innovation for real-world audiences.
Offered: Spring term annually.
Cross listed: COMM 4570. Students cannot obtain credit for both courses. Additional assignments at 6000-level.
COMM 6600  
Research Design and Analysis for New Media  
A practicum in research focusing on methodology for assessing Web usage and computer-mediated behavior. Topics include research design issues, data gathering, sample frames, recruitment and treatment of subjects, and quantitative analysis of online surveys, server bits, and other forms of direct and unobtrusive data.  
Prerequisite: At least one previous 4000-level research course; one course in statistics is advisable.  
Offered: Upon availability of instructor.  
3 credit hours

COMM 6620  
Information Architecture  
This course examines theoretical and empirical issues in the field of Information Architecture, aiming to identify and utilize principles of information organization, collect and interpret empirical data on human information behavior, and develop and apply methods of information design all in the service of creating usable architectures of information. Focus is on developing experience for professional information architecture projects. Requires basic knowledge of Web design.  
Offered: Spring term annually.  
3 credit hours

COMM 6660  
Visual Literacy  
This course examines the notion of visual literacy — the ability to create effective visual layouts and analyze visual language for meaning. Through readings, discussions, and praxis exercises, students learn the lexicon of visual communication, how to critically evaluate a visual argument, and how to apply visual literacy theory to practice.  
Offered: Fall term annually.  
Cross listed: COMM 4660. Students cannot obtain credit for both courses.  
3 credit hours

COMM 6700  
Rhetoric of the Photograph  
Photography is the first modern visual technology that is reproducible yet still has an aura of “objectivity” and its study addresses issues that are central to all forms of contemporary image-making. Using the rhetorical triad of producer, work, and audience, this course explores the photograph through (1) a visual semiotics that is applicable to other kinds of image/texts, (2) a psychology/psychodynamics of affect, and (3) an analysis of how the circulation and reinterpretation of photographs and other images shape our culture.  
Prerequisite: Graduate standing or permission of instructor.  
Offered: Odd-numbered years.  
3 credit hours

COMM 6730  
Computer-Mediated Communication  
This seminar examines the social uses and impacts of computer-mediated communication in contexts such as education, industry, and informal social interaction. Students may examine traditionally important variables such as self-disclosure, rules, status, power, message sequencing, etc. as well as processes such as reality construction, learning, decision making, and group development. The course introduces analytic procedures that are as useful for spoken or written discourse as for computer-mediated discourse.  
Offered: Upon availability of instructor.  
3 credit hours

COMM 6740  
Hypermedia Design and Development  
This seminar course will investigate issues in hypermedia design and development. Class discussions will include topics such as designing the structure of a hypermedia program and designing the user interface. Students will have an opportunity to put theory into practice by designing and developing an interactive program.  
Prerequisites: COMM 4460, COMM 6400, COMM 6560, or permission of the instructor.  
3 credit hours

COMM 6750  
Communication Design for the World Wide Web  
This course introduces hypermedia interface design and communication issues involved in designing interactive programs for the World Wide Web. Students will design and develop an interactive Web site or experience and explore related rhetorical, social, cultural, and legal issues.  
Prerequisites: 1) completion of Web development or hypermedia development course and 2) knowledge of basics of Web or hypermedia development, or 3) permission of the instructor.  
Offered: Fall term annually.  
3 credit hours

COMM 6770  
User-Centered Design  
Explore how users get involved in design: as specifiers of requirements, as evaluators, as sounding boards, and as collaborators. Students will gather requirements, design to meet those requirements, and evaluate their success.  
Prerequisites: COMM 4420 or permission of instructor.  
Offered: Spring term annually.  
Cross listed: COMM 4770; students taking COMM 6770 will be assigned an additional project. Students cannot obtain credit for both courses.  
3 credit hours
COMM 6780
Interactive Narrative
Lectures and class discussions will analyze narrative theory and interactive narratives in a variety of genres such as oral storytelling, literature, poetry, film, radio programs, artists' books, historical narrative, hypertext fiction, Net Art, and computer games. Students will have the opportunity to apply theory by designing and developing an interactive electronic program or completing a research paper on interactive narrative. Extra assignments are required in the graduate course.
Prerequisites: Knowledge of interactive authoring software or permission of instructor.
Offered: Fall term annually.
Cross listed: COMM 4780. Students may not receive credit for both courses.
3 credit hours

COMM 6790
Media Studies
This course is a graduate seminar examining major theories and approaches to studying the media from a cultural studies perspective, with a particular focus on the medium of television. Topics will include: the politics of representation; commercialization; celebrity; media institutions; fictional and factual programming; gender, race, and class.
Offered: Fall term even-numbered years.
3 credit hours

COMM 6800
Media and Memory
Most memories of the past are stories that circulate in the present through a variety of media. To probe the mechanism of collective memory, this course combines exploration of several visual media with case studies that interpret the rhetorical potential of specific photographs, films, museums, and monuments.
Offered: Fall term annually.
Cross listed: COMM 4800. Students cannot obtain credit for both courses. Graduate students are required to complete additional assignments.
3 credit hours

COMM 6810
Studio Design in Human-Computer Interaction
In this course, students work on collaborative projects to design human-computer interactions (HCIs) aimed at transforming people’s everyday practices. Students work with activity analysis, object-oriented modeling, and UI prototyping. The course serves as the capstone in the HCI MS Certificate.
Prerequisites: COMM 6420, COMM 6750, or COMM 6770.
Offered: Spring term annually.
Cross listed: COMM 4180; students cannot obtain credit for both courses. Additional assignments required for students at the 6000 level.
3 credit hours

COMM 6820
Usability Testing
In this course, students will examine and practice several methods of formal usability testing. Classes will consist of classroom discussion of scenario-based testing methods and statistical analysis of data collected and of laboratory sessions in which students develop, conduct, record, and analyze usability tests.
Offered: Spring term annually.
Cross listed: COMM 4820. For COMM 6820, additional statistical analysis as part of each assignment and a literature-based paper on a usability topic are required.
3 credit hours

COMM 6830
Human-Media Interaction
Advanced survey course psychological approaches to human media interaction. Key themes are 1) how minds have evolved to interact with media and computers in certain ways; 2) how media form and content influence the mind; 3) how minds socially respond to computers; 4) how media and computers create a sense of “being there” and/or “being together with someone”; and 5) how properties of human cognition are affected by the form, content, and use of media.
Offered: Spring term annually.
3 credit hours

COMM 6940
Communication Studies
Readings and projects adapted to the needs of individual students.
1 to 6 credit hours

COMM 6960
Topics in Communication
Experimental courses tried out in one or two terms.
3 credit hours

COMM 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
1 to 6 credit hours

COMM 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
Variable credit hours
CSCI Computer Science (SOS)

CSCI 1010
Introduction to Computer Programming
Computer programming is a way of thinking. A successful programmer needs to take a word problem, generate a pseudocode algorithm, and convert it to the syntax of a specific programming language. This course is an alternative to CSCI 1100 and is intended for students who want an introduction to this programming process but do not intend to do further course work in programming or computer science. Emphasis will be on the generation of the algorithms. Rather than using the complex syntax of a production language such as C or C++, this course will use Visual Basic. This allows concentration on the fundamentals and without becoming sidetracked by language complexity. It also affords students a tool for creating useful personal applications or prototypes in the future. Students cannot get credit for this course if they have already taken any other CSCI course.
Offered: Fall and spring terms annually.
4 credit hours

CSCI 1100
Computer Science I
An introduction to computer programming algorithm design and analysis. Additional topics include basic computer organization; internal representation of scalar and array data; use of top-down design and subprograms to tackle complex problems; abstract data types. Enrichment material as time allows. Interdisciplinary case studies, numerical and nonnumerical applications. Students who have passed CSCI 1200 cannot register for this course.
Offered: Fall and spring terms annually.
4 credit hours

CSCI 1190
Beginning C Programming for Engineers
This course teaches elementary programming concepts using the MATLAB environment for engineering students with little or no prior programming experience. Concepts include variables, looping, and function calls. Students cannot get credit for CSCI 1190 after earning credit for CSCI 1100 or any higher level CSCI course.
Offered: Fall and spring terms annually.
1 credit hour

CSCI 1200
Data Structures
Prerequisite: CSCI 1100 or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

CSCI 2200
Foundations of Computer Science
This course introduces important mathematical and theoretical tools for computer science, including topics from set theory, combinatorics, and probability theory, and then proceeds to automata theory, the Turing Machine model of computation, and notions of computational complexity. The course will emphasize formal reasoning and proof techniques.
Prerequisites: Intro to Calculus (MATH 1010 or MATH 1500) and CSCI 1100.
Offered: Fall and spring terms annually.
4 credit hours

CSCI 2220
Programming in Java
Introduction to programming in the Java language. Java is an object-oriented programming language widely used in developing World Wide Web applications. Topics include class declarations and definitions, graphics, threads, exceptions, and writing Web applets.
Prerequisite: CSCI 1200 or equivalent.
Offered: Spring term annually.
2 credit hours

CSCI 2300
Introduction to Algorithms
Prerequisites: CSCI 1200, MATH 1010, and either CSCI 2200 (preferred) or MATH 2800.
Offered: Fall and spring terms annually.
4 credit hours

CSCI 2500
Computer Organization
Prerequisite: CSCI 1200.
Offered: Fall and spring terms annually.
4 credit hours
CSCI 4020
Computer Algorithms
Basic algorithm design strategies such as greedy, dynamic programming, backtracking, and branch-and-bound; main approaches, including exact, probabilistic, approximate, and heuristic algorithms; sequential and parallel algorithms; algorithms for networks, string matching, matrix operations, and cryptography; learning algorithms.
Prerequisite: CSCI 2300.
Offered: Spring term annually.
4 credit hours

CSCI 4050
Computability and Complexity
This course discusses concepts of languages defined by formal grammars, Turing machines and rewriting systems, computability, Church-Turing thesis, decidable and undecidable problems, computational complexity, polynomial reducibility, NP-completeness, and Cook's theorem.
Prerequisite: CSCI 2300.
Offered: Fall term annually.
4 credit hours

CSCI 4100
Machine and Computational Learning
Introduction to the theory, algorithms, and applications of automated learning (supervised, reinforcement, and unsupervised), how much information and computation are needed to learn a task, and how to accomplish it. Emphasis will be given to unifying approaches coming from statistics, function approximation, optimization, and pattern recognition. Topics include: Decision Trees, Neural Networks, RBF's, Bayesian Learning, PAC Learning, Support Vector Machines, Gaussian processes, Hidden Markov Models.
Prerequisites: Familiarity with probability, linear algebra, and calculus.
Offered: Upon availability of instructor.
4 credit hours

CSCI 4150
Introduction to Artificial Intelligence
Topics and techniques of artificial intelligence using the language LISP. Topics include search, knowledge representation, expert systems, theorem proving, natural language interfaces, learning, game playing, and computer vision. Techniques include pattern matching, data-driven programming, substitution rules, frames, heuristic search, transition networks, neural networks, and evolutionary computation. Development of programming proficiency in LISP is emphasized.
Prerequisite: CSCI 2300.
Offered: Fall term annually.
4 credit hours

CSCI 4210
Operating Systems
Discussion of various aspects of computer operating systems design and implementation. Topics include I/O programming, concurrent processes and synchronization problems, process management and scheduling of processes, virtual memory management, device management, file systems, deadlock problems, system calls, and interprocess communication. Programming projects are required.
Prerequisites: CSCI 2300 and CSCI 2500.
Offered: Fall and spring terms annually.
4 credit hours

CSCI 4220
Network Programming
Programming with an overview of the principles of computer networks, including a detailed look at the OSI reference model and various popular network protocol suites. Concentration on Unix interprocess communication (IPC), network programming using TCP and UDP, as well as client-side and mobile programming. Programming projects are required.
Prerequisite: CSCI 4210.
Offered: Spring term annually.
4 credit hours

CSCI 4260
Graph Theory
Fundamental concepts and methods of graph theory and its applications to computing and the social and natural sciences. Topics include graphs as models, representation of graphs, trees, distances, matchings, connectivity, flows in networks, graph colorings, Hamiltonian cycles, traveling salesman problem, planarity. All concepts, methods, and applications are presented through a sequence of exercises and problems, many of which are done with the help of novel software systems for combinatorial computing.
Prerequisites: CSCI 1100 and either CSCI 2200 (preferred) or MATH 2800.
Offered: Spring term annually.
Cross listed: MATH 4150. Students cannot obtain credit for both this course and MATH 4150.
4 credit hours

CSCI 4320
Parallel Programming
Techniques and methods for parallel programming: models of parallel machines and programs, efficiency and complexity of parallel algorithms. Paradigms of parallel programming and corresponding extensions to sequential programming languages. Overview of parallel languages and coordination languages and models; programming on networks of workstations. Basic parallel algorithms: elementary computation, matrix multiplication, sorting; sample scientific application.
Prerequisites: CSCI 2300 and CSCI 2500.
Offered: Spring term annually.
4 credit hours
**CSCI 4350**  
**Data Science**  
Data science is advancing the inductive conduct of science and is driven by the greater volumes, complexity and heterogeneity of data being made available over the Internet. It combines aspects of data management, library science, computer science, and physical science. It is changing the way all of these disciplines do both their individual and collaborative work. Key methodologies in application areas based on real research experience are taught.  
**Prerequisite:** Data Structures (CSCI 1200), Database Systems (CSCI 4380) preferred.  
**Offered:** Fall term annually.  
**Cross listed:** ITWS 4350/6350, CSCI 6350 and ERTH 4350/6350. Students can obtain credits for only one of these courses.  
3 **credit hours**

**CSCI 4380**  
**Database Systems**  
Discussion of the state of practice in modern database systems, with an emphasis on relational systems. Topics include database design, database system architecture, SQL, normalization techniques, storage structures, query processing, concurrency control, recovery, security, and new directions such as object-oriented and distributed database systems. Students gain hands-on experience with commercial database systems and interface building tools. Programming projects are required.  
**Prerequisite:** CSCI 2300.  
**Offered:** Fall and spring terms annually.  
4 **credit hours**

**CSCI 4390**  
**Database Mining**  
This course will provide an introductory survey of the main topics in data mining and knowledge discovery in databases (KDD), including: classification, clustering, association rules, sequence mining, similarity search, deviation detection, and so on. Emphasis will be on the algorithmic and system issues in KDD, as well as on applications such as Web mining, multimedia mining, bioinformatics, geographical information systems, etc.  
**Prerequisites:** CSCI 2300 and either CSCI 2200 (preferred) or MATH 2800.  
**Offered:** Fall term annually.  
4 **credit hours**

**CSCI 4400**  
**Xinformatics**  
Informatics covers a broad range of disciplines addressing challenges in the explosion of data and information resources. Xinformatics provides commonality for implementations in specific disciplines, e.g. X=astro, geo. Informatics’ theoretical bases are information and computer science, cognitive science, social science, library science, aggregating these studies and adding the practice of information processing, and the engineering of information systems. This course grounds the material that students will learn in discipline areas by coursework and project assignments. Note: Students cannot obtain credit for both ITWS 4400 and ITWS 6400.  
**Prerequisite:** CSCI 1200 and Data Science (CSCI/ERTH/ITWS 496x/696x).  
**Offered:** Spring term annually.  
**Cross listed:** ITWS 6400, CSCI 6400 and ERTH 4400/6400. Students can only obtain credit for one of these courses.  
3 **credit hours**

**CSCI 4430**  
**Programming Languages**  
This course is a study of the important concepts found in current programming languages. Topics include language processing (lexical analysis, parsing, type-checking, interpretation and compilation, run-time environment), the role of abstraction (data abstraction and control abstraction), programming paradigms (procedural, functional, object-oriented, logic-oriented, generic), and formal language definition.  
**Prerequisite:** CSCI 2300.  
**Offered:** Fall and spring terms annually.  
4 **credit hours**

**CSCI 4440**  
**Software Design and Documentation**  
Software system design methodology emphasizing use of object oriented modeling of application domains and of software systems, and emphasizing the roles of written and oral communication in software engineering. Project management and software testing. Individual and team projects include specification, software architecture, user interfaces, and documentation of the phases of a project. This is a communication-intensive course.  
**Prerequisite:** CSCI 2300.  
**Offered:** Fall and spring terms annually.  
4 **credit hours**

**CSCI 4480**  
**Robotics I**  
A survey of the fundamental issues necessary for the design, analysis, control, and implementation of robotic systems. The mathematical description of robot manipulators in terms of kinematics and dynamics. Hardware components of a typical robot arm. Path following, control, and sensing. Examples of several currently available manipulators.  
**Prerequisite:** MATH 2400.  
**Offered:** Fall term annually.  
**Cross listed:** ECSE 4480. Students cannot receive credit for both this course and ECSE 4480.  
3 **credit hours**
**CSCI 4490**  
**Robotics II**  
This course introduces methods that leverage the basic analysis techniques learned in Robotics I to develop numerical and algorithmic techniques needed to endow robots with the “intelligence” to devise strategies to solve problems they will encounter. Once these abilities are sufficiently well developed, robots will become safe and autonomous, thus paving the way for pervasive personal robots. Topics include: configuration space representation, cell decomposition, roadmap methods, rapidly-exploring random trees, simultaneous localization and mapping, contact modeling, grasping, and dexterous manipulation.  
**Prerequisite/Corequisite:** CSCI 4480.  
**Offered:** Spring term annually.  
**Cross listed:** CSCI 6490, ECSE 4490, ECSE 6490.  
**3 credit hours**

**CSCI 4520**  
**Game Development**  
This class is a practical primer for anyone interested in a career in the rapidly evolving industry of video gaming. It is an intense, team-based, project-based course in which students will closely follow the actual game development cycle, with each team producing a complete PC game. Students cannot get credit for both this course and COGS 4520.  
**Prerequisites:** COGS 2520 or CSCI 2300.  
**Offered:** Fall term annually.  
**4 credit hours**

**CSCI 4530**  
**Advanced Computer Graphics**  
This course will survey classic papers and current research in computer graphics. Topics include: advanced ray tracing, global illumination, photon mapping, subsurface scattering, mesh generation and simplification, subdivision surfaces, volumetric modeling, procedural modeling and texturing, weathering, physical simulation, appearance models. Course activities include programming assignments, oral presentations, and a term project.  
**Prerequisite:** CSCI 2300; previous coursework or experience in computer graphics such as ECSE 4750 or computational geometry is recommended.  
**Offered:** Spring term annually.  
**Cross listed:** CSCI 6530.  
**4 credit hours**

**CSCI 4540**  
**Game Development II**  
This course follows Game Development I. Students work in interdisciplinary teams to create one large-scale 3D game, working from concept to public release. Projects may include games, educational games, serious games and simulations, and interactive artworks, and will focus on creative design, technical execution, and use of game design principles. The course builds on skills and knowledge in previous courses in the GSAS core, including game design, game mechanics, game programming, art, and narrative.  
**Prerequisites:** Game Development I or consent of the instructor.  
**Offered:** Spring term annually.  
**Cross listed:** ARTS 4960, COGS 4960  
**4 credit hours**

**CSCI 4650**  
**Networking Laboratory I**  
A studio course with an interactive learning style that utilizes a lab of over 139 routers, switches, and firewalls. Configuration labs include: Virtual LANs, Spanning Tree, and inter-switch communication on Gigabit switches; Class A, B, and C IP addressing using VLSM; Routing protocols including Static, Default, OSPF, EIGRP, IS-IS, and BGP routing; WAN protocols including Frame Relay and ISDN. Self-paced video demonstrations are used in conjunction with hands-on lab experiences.  
**Prerequisite:** CSCI 2300.  
**Offered:** Fall and spring terms annually.  
**Cross listed:** ARTS 4960, COGS 4960  
**4 credit hours**

**CSCI 4660**  
**Networking Laboratory II**  
A studio course with an interactive learning style that utilizes a lab of over 139 routers, switches, and firewalls. Configuration labs include: Virtual Private Network (VPN) tunnels; Network Address Translation (NAT); Class-Based Weighted Fair Queuing over Frame Relay; Inter-VLAN routing, Multi-Layer Switching, and Quality of Service for Voice-Over-IP (VOIP). Self-paced video demonstrations are used in conjunction with hands-on lab experiences.  
**Prerequisite:** CSCI 4650.  
**Offered:** Fall and spring terms annually.  
**Cross listed:** ARTS 4960, COGS 4960  
**4 credit hours**

**CSCI 4670**  
**Networking Security Laboratory**  
A studio course with an interactive learning style. Students download tools to compromise (“hack”) a network. Students will then set up defense strategies in an extensive lab of advanced routers and PIX firewalls. Configuration will include: IPSec, VPN tunnels, Authentication, Authorization, and Accounting (AAA), TACACS+ and RADIUS, Intrusion Detection, Context-Based Access Control (CBAC), Nested Object groups, Attack Guards, and Shunning. Self-paced video demonstrations are used in conjunction with hands-on lab experiences.  
**Prerequisite:** CSCI 4650.  
**Offered:** Spring term annually.  
**Cross listed:** ARTS 4960, COGS 4960  
**4 credit hours**
CSCI 4800
Numerical Computing
A survey of numerical methods for scientific and engineering problems. Topics include numerical solution of linear and nonlinear algebraic equations, interpolation and least squares approximations, numerical integration and differentiation, eigenvalue problems, and an introduction to the numerical solution of ordinary differential equations. Emphasis is placed on efficient computational procedures including the use of library and student written procedures using high-level software such as MATLAB.
Prerequisites: CSCI 1100 and MATH 2010 or ENGR 1100.
Corequisite: MATH 2400.
Offered: Fall term annually.
Cross listed: MATH 4800. Students cannot obtain credit for both this course and MATH 4800.
Credit hours: 4

CSCI 4820
Introduction to Numerical Methods for Differential Equations
Derivation, analysis, and use of computational procedures for solving differential equations. Topics covered include ordinary differential equations (both initial value and boundary value problems) and partial differential equations. Runge-Kutta and multistep methods for initial value problems. Finite difference methods for partial differential equations including techniques for heat conduction, wave propagation, and potential problems. Basic convergence and stability theory.
Prerequisite: MATH 4800 or CSCI 4800.
Offered: Spring term annually.
Cross listed: MATH 4820.
Credit hours: 4

CSCI 4940
Readings in Computer Science
Credit hours: 1 to 4

CSCI 4960
Topics in Computer Science
Credit hours: 1 to 4

CSCI 6050
Computability and Complexity
This course discusses modern concepts of computability and computational complexity theories. The Church-Turing thesis; variations of Turing Machines; Algorithms; Decidability; The Halting Problem; Reducibility; The Recursion Theorem; The Concept of Information; Time and Space Complexity; Intractability; NP-completeness and Cook’s theorem.
Prerequisite: CSCI 2300 or equivalent.
Offered: Fall term annually.
Credit hours: 3

CSCI 6100
Machine and Computational Learning
Introduction to the theory, algorithms, and applications of automated learning (supervised, reinforcement, and unsupervised), how much information and computation are needed to learn a task, and how to accomplish it. Emphasis will be given to unifying approaches coming from statistics, function approximation, optimization, and pattern recognition. Topics include: Decision Trees, Neural Networks, RBF’s, Bayesian Learning, PAC Learning, Support Vector Machines, Gaussian processes, Hidden Markov Models.
Prerequisites: Familiarity with probability, linear algebra, and calculus.
Offered: Upon availability of instructor.
Credit hours: 3

CSCI 6140
Computer Operating Systems
Topics include analysis of multiprogramming systems, virtual memory, computer system performance, and queuing theory. The course also discusses tools for synchronization of parallel programs and algorithms for mutual exclusion.
Prerequisite: CSCI 4210 or permission of instructor.
Offered: Fall term annually.
Credit hours: 3

CSCI 6210
Design and Analysis of Algorithms
Theoretical and empirical analysis of algorithms; tools for on-line monitoring of the algorithm’s performance. Advanced algorithms for polynomial problems; randomized heuristic and approximate algorithms. Problems include computation in discrete mathematics, number theory, linear algebra, graph theory, numerical and symbolic computing.
Prerequisite: CSCI 4020 or equivalent.
Offered: Spring term annually.
Credit hours: 3

CSCI 6270
Computational Vision
Introduction to the problems and techniques of vision from a computational perspective. Discussion includes computational theories of vision and particular topics such as image formation, image processing, linear systems, Fourier transforms, mathematical morphology, edge and contour detection, shape from shading, stereo, motion, surface reconstruction, robust techniques, three-dimensional representation and reasoning, object recognition, and computational geometry.
Prerequisites: CSCI 2300 or equivalent and programming experience.
Offered: Fall term annually.
Credit hours: 3
**CSCI 6350**  
**Data Science**  
Data science is advancing the inductive conduct of science and is driven by the greater volumes, complexity and heterogeneity of data being made available over the Internet. It combines aspects of data management, library science, computer science, and physical science. It is changing the way all of these disciplines do both their individual and collaborative work. Key methodologies in application areas based on real research experience are taught.  
**Prerequisite:** Data Structures (CSCI 1200), Database Systems (CSCI 4380) preferred.  
**Offered:** Fall term annually.  
**Cross listed:** ITWS 4350/6350, CSCI 4350 and ERTH 4350/6350. Students can obtain credits for only one of these courses.  
**3 credit hours**

**CSCI 6360**  
**Parallel Computing**  
A survey of fundamental issues in design of efficient programs for parallel computers. The topics discussed include models of parallel machines and programs, efficiency of parallel algorithms, programming styles for shared memory, message passing, data parallelism, and using MPI in scientific parallel programs. Parallel programming project required.  
**Prerequisite:** CSCI 4210 or equivalent.  
**Offered:** Upon availability of instructor.  
**3 credit hours**

**CSCI 6390**  
**Database Mining**  
This course will provide an introductory survey of the main topics in data mining and knowledge discovery in databases (KDD), including: classification, clustering, association rules, sequence mining, similarity search, deviation detection, and so on. Emphasis will be on the algorithmic and system issues in KDD, as well as on applications such as Web mining, multimedia mining, bioinformatics, geographical information systems, etc.  
**Prerequisites:** CSCI 2300 and either CSCI 2200 (preferred) or MATH 2800.  
**Offered:** Fall term annually.  
**3 credit hours**

**CSCI 6400**  
**Xinformatics**  
Informatics covers a broad range of disciplines addressing challenges in the explosion of data and information resources. Xinformatics provides commonality for implementations in specific disciplines, e.g. X=astro, geo. Informatics' theoretical bases are information and computer science, cognitive science, social science, library science, aggregating these studies and adding the practice of information processing, and the engineering of information systems. This course grounds the material that students will learn in discipline areas by coursework and project assignments.  
**Prerequisite:** CSCI 1200 and Data Science (CSCI/ERTH/ITWS 496x/696x).  
**Offered:** Spring term annually.  
**3 credit hours**

**CSCI 6490**  
**Robotics II**  
This course introduces methods that leverage the basic analysis techniques learned in Robotics I to develop numerical and algorithmic techniques needed to endow robots with the “intelligence” to devise strategies to solve problems they will encounter. Once these abilities are sufficiently well developed, robots will become safe and autonomous, thus paving the way for pervasive personal robots. Topics include: configuration space representation, cell decomposition, roadmap methods, rapidly-exploring random trees, simultaneous localization and mapping, contact modeling, grasping, and dexterous manipulation.  
**Prerequisite:** CSCI 4480.  
**Offered:** Spring term annually.  
**Cross listed:** ECSE 6490, CSCI 4490, ECSE 4490.  
**3 credit hours**

**CSCI 6500**  
**Distributed Computing Over The Internet**  
This course studies theoretical foundations — namely Petri nets, process calculi, actors, join calculus, and mobile ambients — and practical issues in the design of concurrent and distributed programming languages. We compare communication and synchronization aspects in actor, process, and object-oriented concurrent programming models. Current research on coordination, mobility, naming, security, fault-tolerance, and scalability within the course contest is reviewed.  
**Prerequisites:** CSCI 4430 and CSCI 4220 or equivalent or permission of instructor.  
**Offered:** Spring term annually.  
**3 credit hours**

**CSCI 6530**  
**Advanced Computer Graphics**  
In this course, there will be a survey of classic papers and current research in computer graphics. Topics include: advanced ray tracing, global illumination, photon mapping, subsurface scattering, mesh generation and simplification, subdivision surfaces, volumetric modeling, procedural modeling and texturing, weathering, physical simulation, appearance models. Course activities include programming assignments, oral presentations, and a term project.  
**Prerequisites:** CSCI 2300; previous coursework or experience in computer graphics such as ECSE 4750 or computational geometry is recommended.  
**Offered:** Spring term annually.  
**Cross listed:** CSCI 4530.  
**3 credit hours**
CSCI 6800
Computational Linear Algebra
Gaussian elimination, special linear systems (such as positive definite, banded, or sparse), introduction to parallel computing, iterative methods for linear systems (such as conjugate gradient and preconditioning), QR factorization and least squares problems, and eigenvalue problems.
Prerequisite: MATH 4800 or CSCI 4800 or permission of instructor.
Offered: Fall term even-numbered years.
Cross listed: MATH 6800. Students cannot obtain credit for both this course and MATH 6800.
4 credit hours

CSCI 6820
Numerical Solution of Ordinary Differential Equations
Numerical methods and analysis for ODEs with applications from mechanics, optics, and chaotic dynamics. Numerical methods for dynamic systems include Runge-Kutta, multistep and extrapolation techniques, methods for conservative and Hamiltonian systems, methods for stiff differential equations and for differential-algebraic systems. Methods for boundary value problems include shooting and orthogonalization, finite difference and collocation techniques, and special methods for problems with boundary or shock layers.
Prerequisite: MATH 4800 or CSCI 4800 or permission of instructor.
Offered: Spring term odd-numbered years.
Cross listed: MATH 6820. Students cannot obtain credit for both this course and MATH 6820.
4 credit hours

CSCI 6840
Numerical Solution of Partial Differential Equations
Numerical methods and analysis for linear and nonlinear PDEs with applications from heat conduction, wave propagation, solid and fluid mechanics, and other areas. Basic concepts of stability and convergence (Lax equivalence theorem, CFL condition, energy methods). Methods for parabolic problems (finite differences, method of lines, ADI, operator splitting), methods for hyperbolic problems (vector systems and characteristics, dissipation and dispersion, shocks capturing and tracking schemes), methods for elliptic problems (finite difference and finite volume methods).
Prerequisite: MATH 4800 or CSCI 4800 or permission of instructor.
Offered: Fall term odd-numbered years.
Cross listed: MATH 6840. Students cannot obtain credit for both this course and MATH 6840.
4 credit hours

CSCI 6860
Finite Element Analysis
Galerkin's method and extremal principles, finite element approximations (Lagrange, hierarchical and 3-D approximations, interpolation errors), mesh generation and assembly, adaptivity ($h$-, $p$-, $hp$-refinement). Error analysis and convergence rates. Perturbations resulting from boundary approximation, numerical integration, etc. Time dependent problems including parabolic and hyperbolic PDEs. Applications will be selected from several areas including heat conduction, wave propagation, potential theory, and solid and fluid mechanics.
Prerequisite: MATH 4800 or CSCI 4800 or permission of instructor.
Offered: Spring term even-numbered years.
Cross listed: MATH 6860. Students cannot obtain credit for both this course and MATH 6860.
4 credit hours

CSCI 6900
Computer Science Seminar
Presentation of current developments in computer science. Reports by students.
1 credit hour

CSCI 6940
Readings in Computer Science
1 to 3 credit hours

CSCI 6960
Topics in Computer Science
1 to 3 credit hours

CSCI 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

CSCI 6980
Master's Project
Active participation in a master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.
1 to 9 credit hours
CSCI 6990  
Master's Thesis  
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of S or U are assigned by the adviser each term to reflect the student's research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.  
1 to 9 credit hours

CSCI 9990  
Dissertation  
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  
Variable credit hours

ECON Economics (HSSH)

ECON 1200  
Introductory Economics  
Every society faces the question of choosing how to use its natural and human resources to produce goods and services and how to distribute these resources among its people. This course studies how these choices are made in markets. It also explains the determinants of total output, employment, and inflation. Attention may also be given to special topics such as the environment, trade, and population.  
Offered: Fall and spring terms annually.  
4 credit hours

ECON 2010  
Managerial Economics  
Applies the microeconomic theory of the firm to price, cost, and output decisions of business enterprises under different market structures. Regression analysis of demand and cost, linear programming of production and simulation analysis of risk, and capital budgeting are also presented.  
Prerequisite: ECON 1200 or permission of instructor.  
Offered: Fall and spring terms annually.  
4 credit hours

ECON 2020  
Intermediate Macroeconomics  
Attention is directed primarily to variations in the aggregate volume of output, income, and employment. Cyclical fluctuations and long-term economic trends are examined and the interrelations of business and government policies are analyzed. The applicability of economic theory to the problems of business forecasting is discussed.  
Prerequisite: ECON 1200 or permission of instructor.  
Offered: Spring term annually.  
4 credit hours

ECON 2940  
Readings in Economics  
3 or 4 credit hours

ECON 2960  
Topics in Economics  
Selected topics in economics designed to acquaint students with modern economic problems and analysis in special areas beyond the introductory level.  
Prerequisite: ECON 1200 or equivalent.  
4 credit hours

ECON 4110  
Economic Analysis of Technological Change  
An examination of the economic considerations that influence the creation and assimilation of new products and processes, and of the impact of technological change on the structures and evolution of the American economy and environment. Topics include productivity growth, the organization and management of industrial research and development, the interaction between technological change and industrial structure, diffusion of innovations, and technological unemployment. This is a communication-intensive course.  
Prerequisite: ECON 1200 or permission of instructor.  
Offered: Upon availability of instructor.  
4 credit hours

ECON 4120  
Quantitative Analysis  
Application of mathematical techniques to economic modeling and analysis. Construction of models to describe aspects of the economy and to analyze potential policies. Solution methods for issues including optimal choice with and without constraints, equilibria among multiple actors, marginal effects of policies, and dynamic economic models. Some mathematical maturity is assumed, and mathematical skills are taught throughout the course.  
Prerequisite: ECON 2010 or ECON 2020, or permission of instructor.  
Offered: Fall term annually.  
4 credit hours

ECON 4130  
Money and Banking  
Financial institutions, especially commercial banking and the Federal Reserve System, are considered from three perspectives: their monetary roles; trends in the economic, organizational, and technological aspects of their operations; and their other economic roles-a critical view. Also, the role of money in macroeconomic theory is considered along with the role of monetary policies in relation to the problems of inflation and unemployment.  
Prerequisite: ECON 1200 or permission of instructor.  
Offered: Spring term annually.  
4 credit hours
ECON 4140
Structure of Industry: Competition, Innovation, Entrepreneurship, Policy
Acquaints students with the structural characteristics and philosophical foundations of enterprise and industry. Several important industries are considered from the viewpoint of market structure, conduct, and performance. Such concepts as the corporation, entrepreneurial outcomes, technological innovation, private property, and public policy toward business are examined to orient the student to contemporary industrial activity.
Prerequisite: ECON 1200 or permission of instructor.
Offered: Fall term annually.
4 credit hours

ECON 4150
Economics of Government Regulation
Can government intervention improve the performance of private markets and if so, when and how? How is regulatory policy actually made, and what effects has it had? These questions are applied to the experience in the U.S. and elsewhere with telecommunications, electricity, transportation, financial services, job safety, and environmental regulation.
Prerequisite: ECON 2010 or permission of instructor.
Offered: Upon availability of instructor.
3 credit hours

ECON 4160
Public Finance
Emphasis is placed on the analysis of efficient resource use in the public sector at the federal level. Expenditure theory, tax incidence, and income distribution policies are discussed. The effects of personal income, corporation, sales, payroll, and property taxes on resource allocation, equity, and growth are considered.
Prerequisite: ECON 1200 or permission of instructor.
Offered: Fall term annually.
4 credit hours

ECON 4180
Development of Economic Thought
A critical examination in which comparisons are made and contrasts emphasized between different schools of economic thinking such as classicism, marginalism, socialism, institutionalism, neoclassicism, and Keynesianism. Special attention is given to historical theories and attitudes of economists toward technological change and its impact on human welfare.
Prerequisite: ECON 1200 or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

ECON 4190
International Economics and Globalization
This course investigates the significance of economic globalization, covering the following topics: international trade and financial flows, technological innovation and intellectual property, technology transfer, national government and transnational corporations, natural resources, health and the environment, impacts on selected industries and countries, and roles of the world trade organization and international monetary fund. The major controversies surrounding globalization are identified, and alternative arguments are evaluated based on available evidence.
Prerequisite: ECON 1200 or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

ECON 4210
Cost-Benefit Analysis
Addresses the identification and measurement of the economic gains and losses to different sectors of the economy resulting from public projects and policies. Among the projects studied are those in the area of transportation, energy, environment, and urban development. Also considered is the evaluation of the effects of government on business, as for example, consumer product and workplace safety regulation.
Prerequisite: ECON 2010.
Offered: Spring term annually.
4 credit hours

ECON 4230
Environmental Economics
Develops a critical understanding of environmental issues and policy from an interdisciplinary economics perspective. Covers the economics of environmental quality including the links between the economy and the environment, the causes of environmental problems, evaluation of environmental projects and policies, and policies to address environmental issues with an emphasis on efficiency, equity, and sustainability, and the international dimensions of environmental issues.
Prerequisite: ECON 1200 or permission of instructor. ECON 2010 recommended.
Offered: Fall term annually.
4 credit hours

ECON 4240
Natural Resource Economics
Addresses the allocation of natural resources through applied study of fisheries, forestry, oil, minerals, water, and biodiversity resources. Mathematical analysis will be done using Microsoft Excel with Solver. Social and policy dynamics of allocation decisions will be explored through case studies. Field trips will address ecological and physical aspects of resource management. The intent is to develop a balanced perspective and tools to address resource management decisions across their diverse economic, social, and environmental dimensions. This is a communication-intensive course.
Prerequisite: ECON 1200 or permission of instructor.
Offered: Spring term annually.
4 credit hours
ECOn 4250
Ecological Economics
Ecological economics is concerned with the relationship between economic systems, technological innovation, social institutions, and resources and pollution in the physical world. The course draws on contemporary ideas and research in several fields, with grounding in economics. It adopts a systems perspective for analyzing local and global challenges and approaches to addressing them. 
Prerequisites: ECON 1200, and either ECON 4230 or ECON 4240, or permission of instructor. 
Offered: Spring term annually. 
Cross listed: ECON 6250. Students cannot obtain credit for both courses. 
4 credit hours

ECOn 4260
Environmental and Resource Economics
Introduces students to the basic analytical approaches to environmental issues and natural resource use. Emphasis is on economic valuation and public policy. Covers traditional approaches based on assumptions of economic rationality and market efficiency as well as current approaches from the fields of environmental science behavioral economics. Emphasis is on active student participation and examination of current environmental controversies. Students cannot receive credit for both ECON 4260 and ECON 6260. 
Prerequisites: ECON 2010 or equivalent or permission of instructor. 
Offered: Upon availability of instructor. 
4 credit hours

ECOn 4570
Econometrics
This course is an introduction to econometric data analysis. The statistical methods covered enable analysis of relationships between variables in data, with special attention to identification of true casual effects. Topics covered include linear and simple nonlinear regression models, internal and external validity, methods for panel data and binary dependent variables, instrumental variable methods, use of experimental and quasi-experimental data, and basic time series methods. The course included hands-on data analysis and report writing. 
Prerequisites: MATH 2010 or equivalent, ECON 2010 or equivalent, and approved statistics course, or permission of instructor. 
Offered: Spring term annually. 
4 credit hours

ECOn 4900
Seminar in Economics
Discussion and analysis of selected topics in economic theory and of current economic issues. This is a communication-intensive course. Open to seniors with permission of instructor. 
Offered: Fall and Spring terms annually. 
2 to 4 credit hours

ECOn 4940
Readings in Economics
3 to 4 credit hours

ECOn 4960
Topics in Economics
Selected topics in economic analysis and problems to meet the special needs of upper-division students in various curricula throughout the Institute. This allows students to pursue more in-depth work in their areas of study. 
Prerequisites: ECON 1200 and permission of instructor. 
4 credit hours

ECOn 6120
Advanced Quantitative Analysis
Mathematical techniques applied to theoretical models in economics. Reviews and introduces core mathematical topics at the graduate economics level, applied to topics such as optimal behaviors of economics agents, equilibria among multiple interacting agents, economics growth processes and inter-temporal decision making, decision making in stochastic environments, and techniques to develop and work with economic models. Assumes thorough knowledge of calculus and some familiarity with linear algebra and probability theory. 
Offered: Fall term annually. 
3 credit hours

ECOn 6140
Current Problems of American Industry
An advanced analysis of current problems confronting major American industries, regulated and unregulated. Recent changes in growth patterns, market structures, and pricing policies are examined. Considerable emphasis is placed on emerging trends in technology and public policy, which are likely to affect significantly the future of these industries. 
Prerequisites: ECON 2010 or permission of instructor. 
Offered: Upon availability of instructor. 
3 credit hours

ECOn 6150
Economics of Regulation and Deregulation
Can government intervention improve the performance of private markets and if so, when and how? How is regulatory policy actually made, and what effects has it had? These questions are applied to the experience in the U.S. and elsewhere with telecommunications, electricity, transportation, financial services, job safety, health, and environmental regulation. 
Prerequisite: ECON 2010 or permission of instructor. 
Offered: Fall term annually. 
3 credit hours
ECON 6160
Advanced Public Finance
Emphasis is placed on the analysis of efficient resource use in the public sector at the federal level. Expenditure theory and tax incidence are discussed. The effects of personal income, corporation, sales, payroll, and property taxes on resource allocation, equity, growth, and technological change are considered.
Prerequisite: ECON 1200 or permission of instructor.
Offered: Fall term annually.
3 credit hours

ECON 6190
International Economics and Globalization
This course investigates the significance of economic globalization, covering the following topics: international trade and financial flows, technological innovation and intellectual property, technology transfer, national governments and transnational corporations, natural resources, health and the environment, impacts on selected industries and countries, and roles of the World Trade Organization and International Monetary Fund. The major controversies surrounding globalization are identified, and alternative arguments are evaluated based on available evidence. Students cannot receive credit for both this course and ECON 4190.
Offered: Fall and spring terms annually.
3 credit hours

ECON 6210
Advanced Cost-Benefit Analysis
The techniques necessary to appraise the economic desirability and private-sector impact of various public projects and policies are studied. Concepts such as discounting, capital rationing, project selection, shadow pricing, risk assessment, unpriced goods, and economic surplus are developed. Among the topics from which illustrative case studies are drawn are urban and transport planning, energy, water resources, government regulation, and the environment. Suitable for graduate students in professional programs.
Prerequisite: ECON 6490 or ECON 2010.
Offered: Spring term annually.
3 credit hours

ECON 6230
Advanced Environmental Economics
Develops a critical understanding of environmental issues and policy and the environmental economics literature. Covers the economics of environmental quality including the links between the economy and the environment, the causes of environmental problems, evaluation of environmental projects and policies, and policies to address environmental issues with an emphasis on efficiency, equity, sustainability, and the international dimensions of environmental issues. Students cannot receive credit for both ECON 4230 and ECON 6230.
Prerequisite: ECON 2010 or permission of instructor.
Offered: Fall term annually.
3 credit hours

ECON 6240
Advanced Natural Resource Economics
Addresses the allocation of natural resources through applied study of fisheries, forestry, oil, minerals, water, and biodiversity resources. Mathematical analysis will be done using Microsoft Excel with Solver. Social and policy dynamics of allocation decisions will be explored through case studies. Field trips will address ecological and physical aspects of resource management. The intent is to develop a balanced perspective and tools to address resource management decisions across their diverse economic, social, and environmental dimensions.
Offered: Fall term annually.
3 credit hours

ECON 6250
Advanced Ecological Economics
This interdisciplinary course explores linkages between economic, social, technological, ecological, and physical systems. Rooted in economic analysis, the course takes a fresh look at relevant economic theory and application and draws on contemporary ideas and research in economics and other fields. It adopts a systems perspective for analyzing local and global challenges and approaches to addressing them.
Prerequisite: ECON 6230 or ECON 6240.
Offered: Spring term annually.
Cross listed: ECON 4250. Students cannot obtain credit for both courses.
3 credit hours

ECON 6260
Advanced Environmental and Resource Economics
Develops a critical understanding of environmental and natural resource issues and policy and the environmental and natural resource economics literature. Covers the economics of environmental quality and natural resources including the links between the economy and the environment, the causes of environmental problems, the economics of resource exploitation, environmental and resource project evaluation, and policies to address environmental and resource issues. Emphasizes efficiency, equity, sustainability, and international dimensions of the issues. Students cannot receive credit for both ECON 4260 and ECON 6260.
Offered: Fall term annually.
3 credit hours

ECON 6490
Introduction to Economic Theory
The course examines the basic concepts and techniques of economic analysis and their applications to economics problems at the level of the firm, industry, and economy as a whole. Topics include theory of product and factor pricing, national income and employment theory, monetary and fiscal theories, economic growth and fluctuations.
Offered: Upon availability of instructor.
3 credit hours
ECON 6550  
**Advanced Microeconomic Analysis**
The central propositions of contemporary economic analysis are set forth. Topics include interaction of firms and households; determination through the market of resource allocation, outputs, prices, and incomes; capital and interest; theories of general equilibrium; static and dynamic models.
**Prerequisite:** ECON 2010 or ECON 6490 or permission of instructor.
**Offered:** Fall term annually.
3 credit hours

ECON 6560  
**Introduction to Econometrics**
This course is an introduction to econometric data analysis. The statistical methods covered enable analysis of relationships between variables in data, with special attention to identification of true causal effects. Topics covered include linear and simple nonlinear regression models, internal and external validity, methods for panel data and binary dependent variables, instrumental variables methods, use of experimental and quasi-experimental data, and basic time series methods. The course includes hands-on data analysis and report writing.
**Prerequisite:** ECON 4570.
**Offered:** Spring term annually.
Cross listed: ECON 4570. Students cannot obtain credit for both this course and ECON 4570.
3 credit hours

ECON 6570  
**Advanced Econometrics**
Application of statistical and mathematical techniques to analyze economic data. The formulation and interpretation of mathematical models that involve quantifiable economic relationships. The role of probability theory and statistical inference in the solution of model systems. Small-sample and asymptotic OLS regression, instrumental variables and GMM, multi-equation systems, panel data analysis, and maximum likelihood estimation including for binary, censored, and truncated dependent variables. Some mathematical facility is assumed.
**Offered:** Spring term annually.
3 credit hours

ECON 6580  
**Topics in Applied Econometrics**
Applications of advanced econometric techniques such as two-and three-stage least squares, maximum likelihood, seemingly unrelated regression, full information likelihood, distributed lags, and autocorrelation correction to a variety of business and economic problems, including the capital asset pricing model, learning curve, economies of scale, hedonic price indexes, investment, production, and limited dependent variable models.
**Prerequisite:** ECON 6570 or permission of instructor.
**Offered:** Upon availability of instructor.
3 credit hours

ECON 6590  
**Advanced Macroeconomic Analysis**
This course examines theory of national income determination, the role of monetary and nonmonetary factors in our economic system as described by various schools of macroeconomics. Alternative perspectives on monetary and fiscal policies are critically examined.
**Prerequisite:** ECON 2020 or ECON 6490 or permission of instructor.
**Offered:** Spring term annually.
3 credit hours

ECON 6600  
**Seminar in Ecological Economics, Values, and Policy**
This seminar in the Ecological Economics, Values, and Policy Professional Master’s Program surveys the theories, methods, and world views of the approaches of ecological economics and science and technology studies to social scientific and humanistic environmental inquiry. Topics include: valuation, social construction, market failure, cultural studies, externalities, environmental policy and politics, Pareto optimality, and environmental ethics and philosophy.
**Offered:** Fall term annually.
3 credit hours

ECON 6650  
**Ecological Economics Values and Policy Professional Projects**
This seminar focuses on the development of practical proposals for responding to environmental problems and opportunities. Research projects will include both primary data collection and the formulation of policy recommendations. Course readings will focus on case studies that involve disputes over environmental and economic issues, providing the basis for class discussion about how such disputes can be documented, analyzed, and resolved through various scientific, legal, managerial, and policy initiatives.
**Prerequisites:** EEVP Professional Master’s students or permission of instructor.
**Offered:** Fall term annually.
3 credit hours

ECON 6940  
**Readings in Economics**

3 credit hours

ECON 6960  
**Topics in Economic Theory**
Selected topics in economic analysis and problems to meet the special needs of graduate students in various curricula throughout the Institute. This allows students to pursue more in-depth work in their areas of study.
**Prerequisites:** ECON 2010 and permission of instructor.
3 credit hours
ECON 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

ECON 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
1 to 9 credit hours

ECON 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
Up to 30 credit hours

ECSE Electrical, Computer, and Systems Engineering (SOE)

ECSE 2010
Electric Circuits
Techniques for the analysis and simulation of linear electric circuits, and measurements of their properties. Topics include resistive and energy-storage elements, controlled sources and operational amplifiers, systematic analysis methods, AC steady state, power and three-phase systems, magnetic coupling and transformers, transients, s-plane representation and analysis, frequency response, and Laplace transform and computer-aided methods.
Prerequisites: MATH 2400 and PHYS 1200.
Offered: Fall, spring, and summer terms annually.
4 credit hours, 6 contact hours

ECSE 2050
Introduction to Electronics
The physics and operation of semiconductor diodes, bipolar junction transistors, and field-effect transistors in elementary analog circuits. Non-ideal operational amplifier characteristics. Amplifier biasing, small-signal analysis, and frequency response. Elementary bipolar and MOSFET digital circuits.
Prerequisite: ECSE 2010.
Offered: Fall and spring terms annually.
4 credit hours, 6 contact hours

ECSE 2100
Fields and Waves I
Development and application of Maxwell’s equations in free space and within materials. Introduction to vector calculus and computer-aided analysis and design methods in electromagnetics. Applications include calculation of lumped circuit elements from field theory, plane wave propagation in various materials, and reflection from boundaries. Transmission line concepts, Smith charts, and other design tools for distributed circuits.
Prerequisites: ECSE 2010 and MATH 2010.
Offered: Fall, spring, and summer terms annually.
4 credit hours, 6 contact hours

ECSE 2110
Electrical Energy Systems
This course introduces the major components of today’s power system such as transformers, electric machines, and transmission lines. Renewable energy sources and systems are discussed, including wind and solar energy. Integration of energy sources with the grid is addressed.
Prerequisite: ECSE 2010.
Corequisite: ECSE 2100.
Offered: Spring term annually.
4 credit hours

ECSE 2210
Microelectronics Technology
An introductory survey of microelectronics technology emphasizing physical properties of semiconductors, device and circuit fabrication, semiconductor device operation. Topics include semiconductor crystals; energy bands; electrons and holes; dopant impurities; fabrication and operation of diodes, bipolar junction transistors, and field-effect transistors.
Corequisites: ECSE 2050 and either ECSE 2100 or PHYS 4210.
Offered: Fall and spring terms annually.
3 credit hours, 4 contact hours
ECSE 2410
Signals and Systems
Prerequisite: ECSE 2010.
Offered: Fall, spring, and summer terms annually.
3 credit hours

ECSE 2500
Engineering Probability
Axioms of probability, joint and conditional probability, random variables, probability density, mass, and distribution functions, functions of one and two random variables, characteristic functions, sequences of independent random variables, central limit theorem, and laws of large numbers. Applications to electrical and computer engineering problems.
Corequisite: ECSE 2410.
Offered: Fall and spring terms annually.
3 credit hours

ECSE 2610
Computer Components and Operations
Prerequisite: CSCI 1100. Corequisite: ENGR 2350.
Offered: Fall, spring, and summer terms annually.
4 credit hours, 6 contact hours

ECSE 2660
Computer Architecture, Networks, and Operating Systems
Quantitative basis of modern computer architecture, processor design, memory hierarchy, and input/output methods. Layered operating system structures, process and storage management. Layered network organization, network protocols, switching, local and wide area networks. Examples from Unix and the Internet.
Prerequisite: ECSE 2610.
Offered: Spring term annually.
4 credit hours, 6 contact hours

ECSE 2800
Sensing and Imaging
An introduction to sensing and imaging methods using electromagnetic radiation, including hands-on experiments. Topics include physical principles of sensing/imaging, instrumentation and data acquisition strategies and computational methods for image formation and sensing. Emphasis is placed on imaging with visible light and near infrared spectrum, diffuse optical imaging and spectroscopy, x-ray imaging and computed tomography and radar. Application areas include medicine and biology, security and surveillance, environmental and chemical sensing, and buried or hidden objects.
Prerequisites: PHYS 1200 and MATH 2400.
Offered: Spring term annually.
Cross listed: BMED 2800. Students cannot receive credit for both this course and BMED 2800.
3 credit hours

ECSE 2900
ECSE Enrichment Seminar
This seminar course addresses a range of issues involving engineering and public policy, innovation systems and economic development, and the National Academy’s Engineering Grand Challenges for the 21st Century.
Offered: Fall and spring terms annually.
1 credit hour

ECSE 4030
Analog IC Design
The modeling, analysis and design of analog integrated circuits using CMOS technology. Topics include basic integrated circuit components, basic amplifier stages, operational amplifiers, frequency compensation and stability, and bandgap references. Emphasis is placed on the design of the fundamental circuits required for analog signal processing. Students undertake several design projects, including a sizeable project that comprises a significant percentage of the final grade.
Prerequisite: ECSE 2050.
Offered: Spring term annually.
3 credit hours

ECSE 4040
Digital Electronics
Analysis and design of switching-mode circuits: NMOS, CMOS, RTL, DTL, TTL, and ECL digital-logic families. Topics include: basic logic gates (voltage-transfer characteristics, noise margin, fan out, propagation delay, power dissipation), flip-flops, Schmitt triggers, oscillators, timers, memories, A/D and D/A converters, and optional advanced topics.
Prerequisites: ECSE 2050 and ECSE 2610.
Offered: Spring term annually.
3 credit hours, 5 contact hours
ECSE 4050  
**Advanced Electronic Circuits**  
Linear and non-linear applications of operational amplifiers, with an emphasis on circuit design. Non-ideal operational amplifier behavior, including both static and dynamic characteristics. Amplifier stability and frequency compensation techniques. Operational amplifier based oscillators. Circuit noise.  
**Prerequisite:** ECSE 2050.  
**Offered:** Spring term annually.  
**Cross listed:** ECSE 6050. Students cannot receive credit for both this course and ECSE 6050.  
**3 credit hours**

ECSE 4080  
**Semiconductor Power Electronics**  
The application of power semiconductor devices to the efficient conversion of electrical energy. Circuit analysis, signal analysis, and energy concepts are integrated to develop steady-state and dynamic models of generic power converters. Specific topics include AC/DC conversion, DC/DC conversion, DC/AC conversion, and AC/AC conversion. These generic converters are applied as controlled rectifiers, switching power supplies, motor drives, HVDC transmission, induction heating, and others. Ancillary circuits needed for the proper operation and control of power semiconductor devices are also discussed.  
**Prerequisite:** ECSE 2050.  
**Offered:** Fall term annually.  
**3 credit hours**

ECSE 4090  
**Mechatronics**  
The synergistic combination of mechanical engineering, electronics, control engineering, and computer science in the design process. The key areas of mechatronics studied in depth are control sensors and actuators, interfacing sensors and actuators to a microcomputer, discrete controller design, and real-time programming for control using the C programming language. The unifying theme for this heavily laboratory-based course is the integration of the key areas into a successful mechatronic design.  
**Prerequisites:** ENGR 2350, ECSE 2410, and senior standing.  
**Offered:** Fall term annually.  
**Cross listed:** MANE 4490. Students cannot receive credit for both this course and MANE 4490.  
**3 credit hours, 5 contact hours**

ECSE 4120  
**Electromechanics**  
This course studies electromechanical interactions in lumped-parameter systems. These interactions describe the operation of electric machines, electromechanical actuators and transducers. The fundamental laws of Faraday, Ampere, and Gauss are considered to develop physical models of magnetic circuits, including those which use permanent magnets. These models are then expanded to include equations of motion and the thermodynamics of electromechanical coupling. Applications include transformers, induction machines, synchronous machines, DC machines, and reluctance machines.  
**Prerequisite:** ECSE 2110.  
**Offered:** Spring term annually.  
**3 credit hours**

ECSE 4130  
**EPE Laboratory**  
A laboratory based examination of static and rotating energy conversion equipment. Topics include the experimental study of the physical phenomena and characteristics of magnetic circuits, transformers, electric machines, rectifiers, DC/DC converters and inverters. The interaction between static power converters and electric machines is emphasized.  
**Prerequisite:** ECSE 4120 or ECSE 4080 or permission of instructor.  
**Offered:** Spring term annually.  
**4 credit hours**

ECSE 4160  
**Fields and Waves II**  
A continuation of ECSE 2100. Topics include solution of boundary value problems in electromagnetics using both analytic and numerical techniques. Conducting and dielectric guiding structures for waves. Radiation from simple antennas. Low frequency applications.  
**Prerequisites:** ECSE 2100, ECSE 2050, MATH 4600.  
**Offered:** Upon sufficient demand.  
**3 credit hours**

ECSE 4180  
**Industrial Power System Design**  
Industrial power system design considerations: planning (safety, reliability, simplicity, maintenance, flexibility, cost), voltages (control, selection, effects of variation), protection (devices, limitations, requirements, coordination, testing), fault calculations, grounding (static and lightning protection, earth connections), power factor control and effects, switching and voltage transformation, instruments and meters, cable construction and installation, busways.  
**Prerequisite:** ECSE 2110.  
**Offered:** Upon availability of instructor.  
**3 credit hours**

ECSE 4220  
**VLSI Design**  
Introduction to VLSI design. The fabrication, device, circuit, and system aspects of VLSI design are covered in an integrated fashion. Emphasis is placed on NMOS and CMOS technology. Laboratory experiments focus on layout analysis, computer-aided layout, and logic and timing simulation. Project on digital design with standard cells.  
**Prerequisites:** ECSE 2050 and ECSE 2610; ECSE 2210 recommended.  
**Corequisite:** ECSE 4040 or permission of instructor.  
**Offered:** Fall and spring terms annually.  
**3 credit hours, 4 contact hours**
ECSE 4250  
Integrated Circuit Processes and Design  
Theoretical and practical aspects of techniques utilized in the fabrication of silicon-based microcircuits. Imperfections in semiconductors, crystal growth, solid solubility, alloying and diffusion, ion implantation, oxide masking, epitaxy, metallization, etching, and photolithography. Fabrication techniques for bipolar and MOS-microcircuits, and the electrical performance of devices based on these techniques. Microcircuit design and layout. Students cannot receive credit for both this course and MTLE 4160.  
Prerequisite: ECSE 2210.  
Offered: Fall term annually.  
3 credit hours

ECSE 4320  
Plasma Engineering  
Introduction to plasma physics with primary emphasis on the application of plasmas for controlled thermonuclear fusion. Plasma behavior and confinement concepts are analyzed from both single-particle and conducting-fluid models. The interaction of electromagnetic waves with plasmas, plasma transport, plasma stability, and a review of major fusion-oriented devices are also presented.  
Prerequisite: ECSE 2100.  
Offered: Upon sufficient demand.  
3 credit hours

ECSE 4440  
Control Systems Engineering  
Application of linear feedback theory to the design of large-scale, integrated control systems. Derivation of complex mathematical models of physical systems. Synthesis of appropriate control laws to provide stability. Simulation of complex control systems on digital computers.  
Prerequisite: ECSE 2410.  
Offered: Fall term annually.  
3 credit hours

ECSE 4480  
Robotics I  
A survey of the fundamental issues necessary for the design, analysis, control, and implementation of robotic systems. The mathematical description of robot manipulators in terms of kinematics and dynamics. Hardware components of a typical robot arm. Path following, control, and sensing. Examples of several currently available manipulators.  
Prerequisites: MATH 2400 and either MATH 2010 or ENGR 1100.  
Offered: Fall term annually.  
Cross listed: CSCI 4480. Students cannot receive credit for both this course and CSCI 4480.  
3 credit hours

ECSE 4490  
Robotics II  
This course introduces methods that leverage the basic analysis techniques learned in Robotics I to develop numerical and algorithmic techniques needed to endow robots with the “intelligence” to devise strategies to solve problems they will encounter. Once these abilities are sufficiently well developed, robots will become safe and autonomous, thus paving the way for pervasive personal robots. Topics include: configuration space representation, cell decomposition, roadmap methods, rapidly-exploring random trees, simultaneous localization and mapping, contact modeling, grasping, and dexterous manipulation.  
Prerequisite: ECSE 4480 or CSCI 4480.  
Offered: Spring term annually.  
Cross listed: ECSE 6490, CSCI 4490 and CSCI 6490. Students cannot receive credit for both this course and ECSE 6490, CSCI 4490, or CSCI 6490.  
3 credit hours

ECSE 4500  
Distributed Systems and Sensor Networks  
Recent developments in systems, sensors, communications and networking technologies enable the development of large-scale distributed systems incorporating many individual nodes. This course takes an algorithmic approach to distributed systems for sensor fusion, localization and tracking, distributed robotics and sensor-based control. It also presents the basic principles of sensor node architectures and wireless sensor networks. Applications include environmental monitoring, biomedical systems, and security-related tracking problems.  
Prerequisite: ECSE 2410.  
Offered: Fall term annually.  
Cross listed: ECSE 6500. Students cannot receive credit for both this course and ECSE 6500.  
3 credit hours

ECSE 4510  
Digital Control Systems  
Sampling, quantization, and reconstruction of signals. Mathematical tools used in the modeling, analysis, and synthesis of discrete-time control systems. Analysis tools include z-transforms, difference equation solutions, state variables, and transfer function techniques. Design tools digital PID controller, root locus, bilinear transformations, compensation techniques and full-state feedback. Applications to sampled-data control.  
Prerequisite: ECSE 2410.  
Offered: Spring term annually.  
3 credit hours

ECSE 4520  
Communication Systems  
Prerequisites: ECSE 2410 and ECSE 2500.  
Offered: Fall term annually.  
3 credit hours
ECSE 4530  
**Digital Signal Processing**  
This course provides a comprehensive treatment of the theory, design, and implementation of digital signal processing algorithms. The first half of the course emphasizes frequency-domain and Z-transform analysis. The second half of the course investigates advanced topics in signal processing, including FFT algorithms, multirate signal processing, filter design, adaptive filtering, and quantizer design. The course provides a strong theoretical foundation for future study in communications, control, or image processing.  
**Prerequisites:** ECSE 2410 and ECSE 2500. Also MATH 2010 or permission of instructor.  
**Offered:** Fall term annually.  
**3 credit hours**

ECSE 4540  
**Introduction to Image Processing**  
An introduction to the field of image processing, covering both analytical and implementation aspects. Topics include the human visual system, cameras and image formation, image sampling and quantization, spatial- and frequency-domain image enhancement, filter design, image restoration, image coding and compression, morphological image processing, color image processing, image segmentation, and image reconstruction. Real-world examples and assignments drawn from consumer digital imaging, security and surveillance, and medical image processing.  
**Prerequisite:** ECSE 4510 or ECSE 4530. Also MATH 2010 or permission of instructor.  
**Offered:** Spring term annually.  
**3 credit hours**

ECSE 4560  
**Digital Communications**  
An introduction to digital communications, including signal generation, signal detection, synchronization, channel modeling, and coding. Baseband pulse modulation. Signal space representation of signals and optimal receiver structures. Bandpass modulation techniques including PSK, QAM and FSK. Carrier, symbol and frame synchronization. Channel characterization and modeling, including terrestrial channels. Error control coding.  
**Prerequisites:** ECSE 4520 and ECSE 2500.  
**Offered:** Spring term annually.  
**Cross listed:** ECSE 4560. Students cannot receive credit for both this course and ECSE 4560.  
**3 credit hours**

ECSE 4630  
**Lasers and Optical Systems**  
Optical physics and applications of lasers. Design of optical systems. Topics include: wave optics and beam propagation, Gaussian beams, resonators, optical properties of atoms and laser gain media, laser amplifiers, pulsed laser systems, applications of lasers, nonlinear optics.  
**Prerequisite:** PHYS 2620 recommended.  
**Offered:** Spring term odd-numbered years.
ECSE 4750  
**Computer Graphics**  
**Prerequisite:** ECSE 2610 or CSCI 2500 or equivalent.  
**Offered:** Fall term annually.  
**3 credit hours**

ECSE 4760  
**Real-Time Applications in Control and Communications**  
Experiments and lectures demonstrate the design and use of microcomputers as both decision tools and on-line real-time system components in control and communications. Topics include the basic operations of microcomputers, data I/O, analog and digital process control, voice processing, digital filter design, digital communication, and optimal LQR control.  
**Prerequisites:** ECSE 4530 and one of ECSE 4510, ECSE 4520 or ECSE 4440.  
**Offered:** Spring term annually.  
**3 credit hours, 5 contact hours**

ECSE 4770  
**Computer Hardware Design**  
Digital design methodologies including timing chain and counter based “hardwired” microprogram design, modules, and modular design. The course bridges LSI and MSI design treating microprocessors, and I/O interfacing. Bus protocol standards, interrupts, direct memory access, priority arbitration, asynchronous timing, and overlap or double buffering. Specific examples of design include controlers for disks, cassettes, video systems, and stepping motors. Course includes a laboratory with access to FPGAs and microprocessors.  
**Prerequisite:** ECSE 2610; ENGR 2350 desirable.  
**Offered:** Fall term annually.  
**3 credit hours, 5 contact hours**

ECSE 4780  
**Advanced Computer Hardware Design**  
Design methodologies include register transfer modules and firmware microprogrammed design. “Bit-slice” philosophy of design. LSI microprocessors as design elements in larger digital systems such as high-speed channels and special purpose computers. Detailed discussion of the structure of several computers at the chip and board level. Specification of custom IC digital systems. FPGA based design implementation using VHDL. Students cannot receive credit for both this course and ECSE 6700.  
**Prerequisite:** ECSE 4770. Corequisite: ECSE 2660.  
**Offered:** Spring term annually.  
**4 credit hours**

ECSE 4790  
**Microprocessor Systems**  
Hardware and software for real-time microprocessor-based digital systems. Basic concepts and operations of on-chip components related to digital system functionality. Architectures, instructions sets, and interfacing with peripherals through serial or parallel ports. Introduction to 32-bit machines with in-depth treatment of 16- and 8-bit machines. Emphasis on C language cross-compilers. Laboratory exercises are included to demonstrate hardware and software development techniques practiced in industry.  
**Prerequisites:** ECSE 2610 and ENGR 2350.  
**Offered:** Fall term annually.  
**3 credit hours, 6 contact hours**

ECSE 4800  
**Subsurface Sensing and Imaging Systems**  
An introduction to the basics of subsurface sensing and imaging: Properties of probes such as optical beams, x-rays, ultrasonic waves, and electromagnetic waves. Physical interaction of probes with various media-transmission, reflection, attenuation, scattering, diffusion, fluorescence. Contrast agents and molecular sensing/imaging systems. Biomedical and security applications. Extracting information from subsurface signals using multi-view tomography (MVT), localized probing and mosaicing (LPM), and multi-spectral discrimination (MSD).  
**Prerequisites:** ECSE 2410 and ECSE 2100. ECSE 2800 or BMED 2800 or permission of instructor also required.  
**Offered:** Spring term annually.  
**3 credit hours**

ECSE 4900  
**ECSE Design**  
A capstone design course.† Provides all ECSE majors senior design experience by engaging them in client-sponsored projects. The students work in multidisciplinary teams, jointly responsible to the faculty, the client liaison, and to each other for project management, execution and reporting. Contemporary design tools and practices are emphasized. Senior standing required. This is a communication-intensive course.  
**Prerequisites:** Senior standing.  
**Offered:** Fall and spring terms annually.  
**3 credit hours**

ECSE 4940  
**Independent Studies in Electrical, Computer, and Systems Engineering**  
Supervised reading and research.  
**1 to 3 credit hours**

ECSE 4960  
**Topics in Electrical, Computer, and Systems Engineering**  
**3 credit hours**
ECSE 6010  
Network Theory  
The analysis of active and passive linear networks, including sensitivity, topological formulas, energy functions, positive real functions, and realizability conditions. The determination of input and transfer functions that approximate a prescribed response. Active circuit elements including negative converters, gyrators, and operational amplifiers.  
Prerequisite: ECSE 2050.  
Offered: Fall term odd-numbered years.  
3 credit hours

ECSE 6050  
Advanced Electronic Circuits  
Linear and non-linear applications of operational amplifiers, with an emphasis on circuit design. Non-ideal operational amplifier behavior, including both static and dynamic characteristics. Amplifier stability and frequency compensation techniques. Operational amplifier based oscillators. Circuit noise.  
Prerequisite: ECSE 2050.  
Offered: Spring term annually.  
Cross listed: ECSE 4050. Students cannot receive credit for both this course and ECSE 4050.

ECSE 6090  
Advanced Power Electronics  
Advanced power electronic circuits and systems, as well as their modeling and control. Topics include advanced dc-dc converters, modeling by averaging and sampled-data methods, discontinuous conduction modes, linear and nonlinear current control methods and design, spectral and dynamic characteristics of pulse-width modulation, ac-dc converters with active power factor correction, resonant and soft-switching converters, and EMI filter design, as well as autonomous and distributed power systems. Course assignments include laboratory projects involving simulation, hardware design, and measurement.  
Prerequisite: ECSE 4080 or permission of instructor.  
Offered: Upon availability of instructor.  
3 credit hours

ECSE 6110  
Power Engineering Analysis  
Characteristics and equivalent circuits for transmission lines and transformers. Per unit system. Balanced three-phase systems and power transfer limits. Symmetrical components and sequence network characteristics of transmission lines and transformers. Symmetrical component fault analysis. Clarke components.  
Prerequisite: ECSE 2110 or equivalent.  
Offered: Upon availability of instructor.  
3 credit hours

ECSE 6120  
Power Quality  
Power quality examines the causes of and solutions to electric power quality problems. Topics range from utility issues such as voltage sags, swells, and outages to consumer issues, such as harmonic distortion, and bus reliability at the equipment level. Solution methods such as implementing surge suppressors, the UPS, active filtering, and proper grounding techniques will be discussed.  
Prerequisites: ECSE 6160 or ECSE 4080 are recommended.  
Offered: Upon availability of instructor.  
3 credit hours

ECSE 6130  
Protective Relaying  
Basic relaying philosophy. Current and potential transformers. Operating principles of electromagnetic, electronic, and digital relays. Application of relays to protect generators, busses, transformers and transmission lines.  
Corequisite: ECSE 6110.  
Offered: Upon availability of instructor.  
3 credit hours

ECSE 6140  
Power Generation Operation and Control  
Corequisite: ECSE 6110.  
Offered: Upon availability of instructor.  
3 credit hours

ECSE 6150  
Electric and Magnetic Fields in Electric Power Engineering  
Review of electromagnetic theory required to undertake analysis and design of power equipment. Experimental, analog, and digital field estimation techniques. Case studies in electric and magnetic fields such as cable and bushing design, problems of gas bus systems, electrostatic precipitation, magnetic flux penetration, eddy currents, losses, shielding, generation of torque.  
Prerequisite: ECSE 4120 or equivalent.  
Offered: Upon availability of instructor.  
3 credit hours

ECSE 6160  
Surge Phenomena in Electric Power Engineering  
Analysis and computation of electrical transients in lumpy and distributed power circuits; switching surges, lightning surges, traveling waves. Impact of surges on terminal equipment. Insulation coordination; system protection; design of electric power apparatus and systems to operate reliably and economically in a transient environment.  
Prerequisite: ECSE 6110.  
Offered: Upon availability of instructor.  
3 credit hours
ECSE 6170  
**Mechanical Aspects of Electric Power Apparatus**
General theory of kinematics and dynamics of machines and structures with emphasis on power generating and distributing equipment. Special topics include basic concepts of vibration phenomena in mechanical systems, dynamic behavior of turbine-generator sets, self-excited vibrations in mechanical systems, earthquakes, circuit breaker linkages, short circuit forces on windings and bus structures.  
**Prerequisites:** ECSE 2110 and ECSE 2410 or their equivalents.  
**Offered:** Upon availability of instructor.  
3 credit hours

ECSE 6190  
**Computer Methods in Electric Power Engineering**
Applies the student’s knowledge of power engineering to the solution of large problems by computer methods. Treats matrix techniques, load-flow analysis, network building, short circuit studies, numerical integration, and finite element analysis as it applies to power systems and power apparatus.  
**Prerequisite:** ECSE 6110 or equivalent or permission of instructor.  
**Offered:** Upon availability of instructor.  
3 credit hours

ECSE 6200  
**Semiconductor Device Characterization**
This graduate-level course is designed to give students a hands-on experience in the characterization of basic semiconductor devices (diffused resistors, pn junction diodes, Schottky diodes, MOS capacitors, bipolar junction transistors, MOSFETs) in wafer and/or packaged forms. The final project involves the students in a detailed characterization of devices in a specific application (e.g. high-voltage power electronics, submicron ULSI, microwave and wireless).  
**Prerequisite:** ECSE 6230.  
**Offered:** Spring term even-numbered years.  
3 credit hours

ECSE 6210  
**Advanced Device Concepts**
An introduction to emerging electronic and optoelectronics technology. Topics cover cutting edge technologies and novel device concepts, such as quantum devices, silicon-on-insulators (SOI), compound semiconductor devices and technologies, thin film transistors (TFTs), wide band gap semiconductor devices and technologies, Si-Ge devices, solar cells, photodetectors, semiconductor lasers, opto-electronic ICs, optical interconnects and display technologies.  
**Prerequisite:** ECSE 2210 or equivalent.  
**Offered:** Fall term annually.  
3 credit hours

ECSE 6220  
**Physical Foundations of Solid-State Devices**
Physical foundations underlying the operation of modern electronic and photonic solid-state devices. Quantum mechanical foundations are emphasized, including the postulates of quantum mechanics, wave-particle duality, uncertainty relation, the Kronig-Penney model, and perturbation theory. In addition, the course covers areas such as semiconductor statistics, doping, heterostructures, transport, and tunneling.  
**Prerequisite:** ECSE 2210 or equivalent.  
**Offered:** Fall term annually.  
3 credit hours

ECSE 6230  
**Semiconductor Devices and Models I**
The physical operation of basic modern semiconductor devices and the determination of their internal parameters are discussed in detail. A review of semiconductor physics, including incomplete ionization, carrier lifetimes, and carrier transport, and solutions of continuity equation are presented. Devices include pn junction diodes, metal-oxide-semiconductor capacitors and field-effect transistors. Emphasis is placed on the fundamental mechanisms that contribute to device performance. The interrelationship between device parameters and circuit performance is also discussed.  
**Prerequisite:** ECSE 2210 or equivalent.  
**Offered:** Fall term annually.  
3 credit hours

ECSE 6240  
**VLSI Fabrication Technology**
Fabrication technology for silicon and gallium arsenide integrated circuits with emphasis on sub-micron structures. Topics include epitaxy, diffusion, binary and ternary phase diagrams, grown and deposited oxides and nitrides, polysilicon and silicide technology, single- and multi-metal systems, plasma and chemical etching, ion milling photo, e-beam and X-ray lithography.  
**Prerequisite:** ECSE 4250 or equivalent.  
**Offered:** Spring term even-numbered years.  
3 credit hours

ECSE 6250  
**Solid-State Microwave Devices**
Physical properties of operation, modeling, and application of selected semiconductor microwave devices. Devices considered include varactors, p-i-n diodes, Schottky barrier diodes, avalanche transit time devices, transferred electron devices and field effect transistors. Terminal behavior of these devices, their noise characteristics, and their use in microwave circuits.  
**Corequisite:** ECSE 6230.  
**Offered:** Upon sufficient demand.  
3 credit hours
ECSE 6260
Semiconductor Power Devices
Special problems of semiconductor devices operating at high voltage and high current levels. Devices include p-i-n and Schottky diodes, bipolar junction transistors, power MOSFETs and thyristors. Topics include space charge limited current flow, microplasmas, avalanche breakdown, junction termination, high-level injection, emitter crowding, double injection, second breakdown, triggering mechanisms, plasma propagation, switching and recovery characteristics. Introduction to the Insulated-Gate Bipolar Transistor. 
Prerequisites: ECSE 6230 and ECSE 6290 or basic knowledge (at the graduate level) of semiconductor devices or permission of the instructor.
Offered: Spring term odd-numbered years.
3 credit hours

ECSE 6270
Optoelectronics
A brief review of interaction of light with matter. Operating principles, basic designs, and applications of optoelectronic devices such as Light Emitting Diodes, Laser Diodes, Photodetectors and Solar Cells. Electro-optic, Acousto-optic and Non-linear optic based optical components such as Modulators, Switches, Couplers, Multiplexers, and Amplifiers. Optical Waveguides and Fibers. Optoelectronic Applications such as Fiber Optic and Free Space Optical Communication, Photovoltaics, Thermophotovoltaics, and Solid State Lighting.
Prerequisites: ECSE 2210 and ECSE 4720 or equivalent.
Offered: Spring term upon sufficient demand.
3 credit hours

ECSE 6290
Semiconductor Devices and Models II
A continuation of ECSE 6230. Physical operation and modeling of charge-coupled devices, junction field-effect transistors, bipolar junction transistors and heterojunction devices. Studies of heterojunction devices emphasize the exploitation of particular quantum-mechanical phenomena to achieve unique device behavior.
Prerequisite: ECSE 6230 or equivalent.
Offered: Spring term annually.
3 credit hours

ECSE 6300
Integrated Circuit Fabrication Laboratory
Theory and practice of IC fabrication in a research laboratory environment. Test chips are fabricated and the resulting devices and circuits evaluated. Processes and fabrication equipment studied and used include oxidation/diffusion, CVD reactors, photolithography, plasma etching, vacuum evaporator, ion implantation, etc. Instruments used in process monitoring and final testing include thin film profilometer, ellipsometer, resistivity probe, scanning electron microscope, capacitance-voltage system, etc. The fundamentals of hazardous material handling and clean room procedures are studied.
Prerequisite: ECSE 4250 or equivalent.
Offered: Spring term annually.

Cross listed: MTLE 6300. Students cannot receive credit for both this course and MTLE 6300.
3 credit hours

ECSE 6310
Plasma Dynamics I
Analysis of the dynamics of plasma behavior in terms of statistical models. Development of the Boltzmann equation, the moment equations of continuity, momentum, and energy, and their application to plasma transport processes.
Offered: Fall term odd-numbered years.
3 credit hours

ECSE 6320
Plasma Dynamics II
Plasma kinetic theory, suitability of magnetically confined plasmas, plasma radiation, plasma turbulence.
Prerequisite: ECSE 6310.
Offered: Spring term even-numbered years.
3 credit hours

ECSE 6400
Systems Analysis Techniques
Methods of analysis for continuous and discrete-time linear systems. Convolution, classical solution of dynamic equations, transforms and matrices are reviewed. Emphasis is on the concept of state space. Linear spaces, concept of state, modes, controllability, observability, state transition matrix. State variable feedback, compensation, decoupling.
Prerequisite: ECSE 2410 or equivalent.
Offered: Fall term annually.
Cross listed: MANE 6600. Students cannot receive credit for both this course and MANE 6600.
3 credit hours

ECSE 6420
Nonlinear Control Systems
Prerequisite: ECSE 6400 or permission of instructor.
Offered: Spring term odd-numbered years.
3 credit hours
ECSE 6430  
Optimization Methods  
Linear programming, nonlinear programming, iterative methods, and dynamic programming are presented, especially as they relate to optimal control problems. Discrete and continuous optimal regulators are derived from dynamic programming approach, which also leads to the Hamilton-Jacobi-Bellman Equation and the Minimum Principle. Linear quadratic regulators, linear tracking problems, and output regulators are treated. Linear observer and the separation theorem are developed for feedback controller implementation.  
Prerequisite: ECSE 2410. Corequisite: ECSE 6400.  
Offered: Fall term annually.  
3 credit hours  

ECSE 6440  
Optimal Control Theory  
The concepts, techniques, and tools related to optimal control for dynamical systems. Major topics include calculus of variation, minimum principle, dynamic programming, optimal estimation, and differential games. Both discrete time systems and continuous times are addressed. Particular consideration is given to linear time invariant systems in terms of linear quadratic regulator and Kalman filter.  
Prerequisite: ECSE 6400.  
Offered: Spring term even-numbered years.  
3 credit hours  

ECSE 6460  
Multivariable Control Systems  
Tools and methods for the analysis and design of linear multivariable feedback systems. Topics include the connection between frequency domain and state space models and methods, model identification, model reduction, model uncertainty and closed loop performance, convex analysis and design methods, optimal controller synthesis using H2, H-infinity, and structured singular value criteria.  
Prerequisite: ECSE 6400.  
Offered: Fall term even-numbered years.  
3 credit hours  

ECSE 6490  
Robotics II  
This course introduces methods that leverage the basic analysis techniques learned in Robotics I to develop numerical and algorithmic techniques needed to endow robots with the “intelligence” to devise strategies to solve problems they will encounter. Once these abilities are sufficiently well developed, robots will become safe and autonomous, thus paving the way for pervasive personal robots. Topics include: configuration space representation, cell decomposition, roadmap methods, rapidly-exploring random trees, simultaneous localization and mapping, contact modeling, grasping, and dexterous manipulation.  
Prerequisite: ECSE 4480 or CSCI 4480.  
Offered: Spring term annually.  
Cross listed: ECSE 4490, CSCI 4490, and CSCI 6490. Students cannot receive credit for both this course and ECSE 4490, CSCI 4490, or CSCI 6490.  
3 credit hours  

ECSE 6500  
Distributed Systems and Sensor Networks  
Recent developments in systems, sensors, communications and networking technologies enable the development of large-scale distributed systems incorporating many individual nodes. This course takes an algorithmic approach to distributed systems for sensor fusion, localization and tracking, distributed robotics and sensor-based control. It also presents the basic principles of sensor node architectures and wireless sensor networks. Applications include environmental monitoring, biomedical systems, and security-related tracking problems.  
Prerequisite: ECSE 2410 or equivalent.  
Offered: Fall term annually.  
Cross listed: ECSE 4500. Students cannot receive credit for both this course and ECSE 4500.  
3 credit hours  

ECSE 6510  
Introduction to Stochastic Signals and Systems  
Deterministic signal representations and analysis, introduction to random processes and spectral analysis, correlation function and power spectral density of stationary processes, noise mechanisms, the Gaussian and Poisson processes. Markov processes, the analysis of linear and nonlinear systems with random inputs, stochastic signal representations, orthogonal expansions, the Karhunen-Loeve series, channel characterization, introduction to signal detection, linear mean-square filtering, the orthogonality principle, optimum Wiener and Kalman filtering, modulation theory, and systems analysis.  
Prerequisites: ECSE 2410 and ECSE 2500 or equivalent.  
Offered: Fall term annually.  
3 credit hours
ECSE 6520
Detection and Estimation Theory
Prerequisites: Probability theory and ECSE 6510.
Offered: Spring term annually.
3 credit hours

ECSE 6530
Information Theory and Coding
Information measures, characterization of information sources, coding for discrete sources, the noiseless coding theorems, construction of Huffman codes. Discrete channel characterization, channel capacity, noisy-channel coding theorems, reliability exponents. Various error-control coding and decoding techniques, including block and convolutional codes. Introduction to waveform channels and rate distortion theory.
Prerequisite: Probability theory. Corequisite: ECSE 6510.
Offered: Fall term annually.
3 credit hours

ECSE 6550
Stochastic Processes in Communication and Control
Review of measure and integration theory, elements of probability, random variables, conditional probability, and expectations. Stochastic processes, stationarity, and ergodicity. Gaussian processes and Brownian motion, the Poisson process. Markov processes, wide-sense stationary processes, spectral representations, linear prediction and filtering. Stochastic integrals and differential equations, white noise and the stochastic calculus, the Fokker-Planck equation, diffusion processes, recursive filtering and estimation, evaluation of likelihood ratios. Applications in communication, information processing, and control.
Prerequisite: ECSE 6510.
Offered: Fall term upon sufficient demand.
3 credit hours

ECSE 6560
Digital Communications
An introduction to digital communications, including signal generation, signal detection, synchronization, channel modeling, and coding. Baseband pulse modulation. Signal space representation of signals and optimal receiver structures. Bandpass modulation techniques including PSK, QAM and FSK. Carrier, symbol and frame synchronization. Channel characterization and modeling, including terrestrial channels. Error control coding.
Prerequisite: ECSE 4520.
Offered: Spring term annually.

ECSE 6570
Digital Signal Compression: Data Compression in Theory and Practice
Principles of efficient digital representation of analog signals and their application to images, audio, and multimedia signals. Topics include rate-distortion theory, scalar and vector quantization, trellis-coded quantization (TCQ), entropy coding, Huffman coding, arithmetic coding, bit-plane coding, set partition coding, Ziv-Lempel coding, PCM, DPCM, transform coding, subband/wavelet coding, and tree/trellis coding. Certain standard or oft-used systems, evolving or current, such as JPEG, JPEG2000, JPEG-LS, Wavelet/TCQ, EZW, SPIHT, FBI Fingerprint, and MPEG will be treated.
Prerequisites: ECSE 6510, ECSE 6530.
Offered: Spring term odd-numbered years.
3 credit hours

ECSE 6580
Theory of Digital Communications
Review of the discrete Gaussian noise channel and development of coding theorems. Waveform channels, orthonormal expansions of signals and Gaussian noise, the vector model of waveform channels, time-bandwidth and dimensionality, optimum receiver principles, channel capacity and reliability functions, signal design and selection. Coding for the Gaussian noise channel, theoretical performance bounds, implementation of error control coding, techniques for overall system evaluation, investigation of fundamental rate versus reliability tradeoffs.
Prerequisite: ECSE 6510.
Offered: Spring term annually.
3 credit hours

ECSE 6590
Principles of Wireless Communications
A comprehensive description of the concepts used in modern wireless and cellular systems. The general topics covered will be wireless channel models, multi-access issues, such as FDMA/TDMA and CDMA with a brief view of GSM, descriptions of digital transmission methods in wireless, receiver diversity, channel estimation and multi-user detection, and wideband communications. The course will address the topics of system capacity and the effects of automatic power control, wireless networks, and DSP applications for wireless.
Prerequisites: ECSE 6510 and ECSE 6560.
Offered: Spring term annually.
3 credit hours
ECSE 6600  
**Internet Protocols**
This course will cover concepts and protocols which enable heterogeneous computer networks to work with each other, including transport (TCP, UDP), network (IP, IPng), routing (RIP, OSPF), network management (SNMP, SNMPv2, RMON), and other important protocols like ARP, ICMP, DNS, BOOTP, DHCP and HTTP. Advanced topics like Mobile IP, Real-time and reservation protocols (RTP, RSVP), IP multicast (IGMP, MBONE) and network security will also be examined. Emphasis will be on breadth of coverage, as well as hands-on programming experiences.
**Prerequisite:** ECSE 4670.
**3 credit hours**

ECSE 6610  
**Pattern Recognition**
**Prerequisite:** ECSE 2500 or equivalent.
**Offered:** Fall term annually.
**3 credit hours**

ECSE 6620  
**Digital Signal Processing**
A comprehensive treatment of the theory, design, and implementation of digital signal processing structures. The sampling, quantization, and reconstruction process. Design of digital filters in both the time and frequency domains. Analysis of finite word length effects. Theory and applications of discrete Fourier transforms and the FFT algorithm. Applications from the communication, control, and radar signal processing areas.
**Prerequisites:** ECSE 2500, ECSE 4510.
**Offered:** Fall term annually.
**3 credit hours**

ECSE 6630  
**Digital Image and Video Processing**
Theory of multidimensional signal processing and its application to digital image and video processing. The first half will cover signals and systems, Fourier transform, z-transform, discrete Fourier transform, FIR and IIR filters and their design. The emphasis will be on the unexpected and important differences from the one-dimensional case. The second half consists of applications in image and video signal processing, e.g., compression coding, noise reduction, motion estimation, deblurring, and restoration.
**Prerequisite:** ECSE 6620.
**Offered:** Spring term odd-numbered years.
**3 credit hours**

ECSE 6640  
**Digital Picture Processing**
Practice of picture processing with emphasis on the differences between techniques appropriate for symbolic and natural images. Image acquisition: digitization, coding, photometric and geometric transformations. Image processing: morphology, registration and differencing. Image interpretation: color, size, distance, directionality, layout, connectivity, and shape. File formats, document compression, image processing languages and software. Applications to documents, remote sensing, and biomedicine.
**Prerequisites:** Prior exposure to probability, stochastic processes, and assembler language programming is recommended but not required.
**Offered:** Spring term even-numbered years.
**3 credit hours**

ECSE 6650  
**Computer Vision**
Image formation and visual perception. Images, line structures, and line drawings. Preprocessing, boundary detection, texture, and region growing. Image representation in terms of boundaries, regions, and shape. Three-dimensional structures and their projections. Analysis, manipulation, and classification of image data. Knowledge-based approaches to image understanding. Applications from fields of robot vision, biomedical-image analysis, and satellite and aerial image interpretation.
**Offered:** Upon sufficient demand.
**3 credit hours**

ECSE 6660  
**Broadband & Optical Networking**
Review of fundamental concepts and protocols of broadband and optical networking. Convergence of telephony, Internet, and cable networks lead to new architectural and protocol concepts. Concepts and architectures covered in this course include: high-speed switching and router-design, traffic engineering, fiber optical communications, optical networking concepts, protection/restoration/survivability, optical link layers, quality of service, and broadband last-mile technologies.
**Prerequisite:** ECSE 4670.
**Offered:** Spring term odd-numbered years.
**3 credit hours**
ECSE 6670
Local Computer Networks and Multiaccess Communication
Review of OSI and IEEE 802 layered network architectures. Related queuing theory including basic Markov chain theory; M/M/1 and M/G/1 queues; and reservation, polling, and token passing systems. Protocols for multiple access channels such as satellite and packet radio networks including ALOHA and carrier sensing protocols. Local area network protocols: CSMA/CD, token passing rings and buses, implicit token protocols, and protocols for fiber optic LANs. Emphasis throughout on access protocols and their analysis.
Prerequisites: ECSE 2500, ECSE 4670.
Offered: Spring term even-numbered years.
3 credit hours

ECSE 6680
Advanced VLSI Design
Introduction to VLSI architecture design approaches and methodologies for digital signal processing systems, digital memory circuits and architectures, and computer VLSI arithmetic. Topics include: pipelining, parallel processing, timing and clocking, systolic architectures, digital filter architectures, Viterbi decoder architectures, SRAM, DRAM, flash memory, high-speed adder and multiplier architectures. Laboratory experiments involve the use of commercial EDA tools with hardware description language (HDL).
Prerequisite: ECSE 4220.
Offered: Upon availability of instructor.
3 credit hours

ECSE 6690
VLSI Design Automation
Software design aids for specifying IC design. Covers a spectrum of logic entry, simulation, placement, routing, network extraction, verification, PG tape generation, and testing. Use of a tool set for 2 micron CMOS gate array design using an industrial foundry. Designs are actually fabricated.
Prerequisites: ECSE 4770, ECSE 6700.
Offered: Upon sufficient demand.
3 credit hours

ECSE 6700
Computer Architecture Prototyping with FPGA’s
An advanced design and laboratory course. Design methodologies include register transfer level and firmware microprogrammed design. Advanced microprocessor topics. “Bit-slice” philosophy of design. LSI microprocessors as design elements in larger digital systems such as high-speed channels and special purpose computers. Detailed discussion of the structure of several computers at the chip and board level. Emphasis on high-speed ECL and Schottky circuits. Specification of custom IC digital systems. FPGA based design implementation using VHDL. Students cannot receive credit for both this course and ECSE 4780.
Prerequisite: ECSE 4770.
Offered: Spring term annually.
3 credit hours

ECSE 6710
Fuzzy Sets and Expert Systems
Introduction to fuzzy set theory and fuzzy logics: basic concepts, fuzzy logics operations. Semantic manipulation applied to case studies in approximate reasoning, linguistic modeling, decision theory, and cluster analysis. Expert systems architecture and applications. Symbolic manipulation knowledge representation, control structure, and explanation capabilities. Analysis of expert systems such as MYCIN, PROSPECTOR, OPS5, DELTA.
Prerequisites: Expertise in a high-level programming language, some knowledge of probability.
Offered: Fall term annually.
3 credit hours

ECSE 6720
Neural Network Computing
The theoretical background for learning using neural networks and important issues in the applications of neural networks. Topics include perception, associative memory, multilayer networks, recurrent networks, learning and generalization capabilities, training algorithms, learning with prior knowledge, and examples in applications.
Prerequisite: Familiarity with probability theory, linear algebra, and FORTRAN or C programming.
Offered: Upon sufficient demand.
3 credit hours

ECSE 6730
Fault-Tolerant Digital Systems
Theory and techniques for the diagnosis of hardware faults in digital systems and the design of fault-tolerant systems. Fault detection and diagnosis in logic networks. Static and dynamic redundancy to achieve error detection and error correction.
Prerequisite: ECSE 2610.
Offered: Upon sufficient demand.
3 credit hours

ECSE 6750
Finite-State Machine Theory
Topics vary from year to year and may include methods of representation for finite-state machines, state assignments, machine decomposition theory, Experiments on finite-state machines, finite-memory machines, information-lossless machines. Linear machines, probabilistic machines, cellular arrays.
Prerequisite: ECSE 2610 or consent of instructor.
Offered: Upon sufficient demand.
3 credit hours
ECSE 6770
Software Engineering I
Engineering approach to the development of small and large programming projects. The life cycle steps of project planning, requirements analysis and specification, design, production, testing and maintenance of programming systems. Examples from current literature. Use of Unix workstations and a team project with object-oriented analysis are required.
Prerequisites: ECSE 2660 and CSCI 2300 or equivalent.
Offered: Fall term annually.
3 credit hours

ECSE 6780
Software Engineering II
Continuation of ECSE 6770. Current techniques in software engineering with topics selected from economics, reusability, reliable software, program analysis, reverse engineering, CASE tools, automatic code generation, and project management techniques.
Prerequisite: ECSE 6770.
Offered: Spring term annually.
3 credit hours

ECSE 6790
Computational Geometry
Literature survey of current research in computational geometry and theoretical computer graphics showing recent efficient algorithms useful in graphics and CAD. Algorithms such as Voronoi networks, geometric searching, convex hulls, divide and conquer in multidimensional space, repeated rotation, preprocessing scenes to draw back to front from any viewpoint, new hidden surface algorithms, haloes line elimination, polyhedron intersection, and algorithms for scenes with thousands of faces are discussed. Major research paper required.
Prerequisites: ECSE 4750 and CSCI 2300 or equivalent.
Offered: Upon sufficient demand.
3 credit hours

ECSE 6800
Advanced 3-D Computer Graphics and Visualization
This course will cover 3-D graphical application programmer interfaces (APIs) and advanced rendering techniques, visualization pipelines, creating simulations, and visualization packages. Also covered will be algorithms for extracting visual information from data sets, such as determining iso-surfaces, contours, and cut planes. A programming emphasis will be on object-oriented design and systems. Term project required.
Prerequisites: ECSE 4750, CSCI 2300 or equivalent, some familiarity with Java/C++.
Offered: Spring term annually.
3 credit hours

ECSE 6820
Queuing Systems and Applications
A course on fundamentals of stochastic processes and queuing theory emphasizing applications. Poisson processes, renewal processes, Markov chains, general methods in the study of Markovian and non-Markovian systems, tandem queues, networks of queues, priority and bulk queues, computational methods, and simulation. Focus of the course is the application of these tools in the performance evaluation and design of computer systems, communication networks, manufacturing systems, and service systems.
Prerequisite: ECSE 2500 or MATP 4600.
Offered: Spring term even-numbered years.
Cross listed: ISYE 6820. Students cannot receive credit for both this course and ISYE 6820.
3 credit hours

ECSE 6830
Large-Scale Systems: Case Studies and Analyses
A case-study approach introducing the systems method to analyze large-scale systems. Qualitative and quantitative study of the problems, from problem examination, to problem definition, to problem solution, and to implementation. Case studies in manufacturing, transportation, community development, water resources, and criminal justice. Emphasis is on analysis of real-world problems, using techniques of systems engineering and operations research, and considering diverse factors such as economic, technical, sociological, and environmental issues.
Prerequisite: ECSE 2500. Corequisite: MATP 4700 or equivalent or permission of instructor.
Offered: Fall term odd-numbered years.
3 credit hours

ECSE 6840
Modeling Large-Scale Systems
Applications of operations research and systems analysis techniques to mathematical modeling of complex systems, especially large-scale public systems. Discussion of model-building approaches, emphasizing the role of creativity, rationality, and mathematics. Introduction of important quantitative techniques (e.g., geometrical probability, optimization theory, and stochastic processes) and their application to modeling emergency service systems, spatial distribution of public service facilities, congestion, land-use patterns, transportation systems, demographics, and energy.
Prerequisites: MATP 4700 and ECSE 2500 (or equivalent); ECSE 6830 desirable.
Offered: Fall term annually.
Cross listed: ISYE 6840. Students cannot receive credit for both this course and ISYE 6840.
3 credit hours
ECSE 6860
Evaluation Methods for Decision Making
Evaluation provides structured information for policy-relevant decision making based on a purposeful analysis of the identified measures. Topics include test hypotheses, randomization/control schemes, measures framework, measurement methods, and pertinent analytic techniques. Emphasis is on the application of evaluation methods (including systems engineering and operations research techniques) to issues arising in criminal justice, education, health, housing, transportation, welfare, automated information systems, and military programs.
Prerequisite: ECSE 2500 or MATP 4600 or equivalent.
Offered: Fall term odd-numbered years.
3 credit hours

ECSE 6900
Seminar in Electrical, Computer, and Systems Engineering
Credit hours to be arranged

ECSE 6910
Seminar in Electric Power Engineering
0 credit hours

ECSE 6940
Readings in Electrical, Computer, and Systems Engineering
Supervised reading and problems, by individual arrangement.
1 to 3 credit hours

ECSE 6960
Topics in Electrical, Computer, and Systems Engineering
New or special courses are presented under this listing from time to time.
3 credit hours

ECSE 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.
3 to 9 credit hours

ECSE 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
6 to 9 credit hours

ECSE 7010
Optical Fiber Communications
Review of the state of the art in optical fibers, light sources, and photodetectors. Topics include: propagation, coupling, dispersion, loss and cut-off characteristics of guided wave models in optical fibers, structural and operating parameters of various types of heterostructure lasers and light-emitting diodes and quantum efficiency, response time and noise characteristics of silicon PAD and PIN diodes. Also includes applications of optical fibers in optical communications, in data processing, and in control systems.
Offered: Upon availability of instructor.
3 credit hours

ECSE 7020
Digital Control and Estimation
Prerequisite: ECSE 6400.
Offered: Upon availability of instructor.
3 credit hours

ECSE 7100
Real-Time Programming and Applications
Hardware and software characteristics of real-time systems for analysis and control. Real-time programming techniques, standard interfaces and busses, sensors, data smoothing, digital filtering, and digital control.
Prerequisites: CISH 4030 and CSCI 4210.
Offered: Upon sufficient demand.
3 credit hours

ECSE 9990
Dissertation
ENGR Core Engineering (SOE)

ENGR 1010 Professional Development I
An introduction to the issues related to working in team settings. Topics explored include: communications in teams, public speaking and self awareness, stages of group development, building a team, group decision making, and conflict resolution. The course format will include small and large group discussions, case studies, experiential exercises, and regular participation from industry guests. Offered in conjunction with ENGR 2050.
Offered: Fall and spring terms annually.
1 credit hour

ENGR 1100 Introduction to Engineering Analysis
An integrated development of linear algebra and statics emphasizing engineering applications and also incorporating computer exercises involving matrix techniques and calculations using available software packages.
Offered: Fall, spring, and summer terms annually.
4 credit hours

ENGR 1200 Engineering Graphics and CAD
An introduction to the techniques for creating solid models of engineering designs. Topics include three-dimensional modeling of parts and assemblies, visualization, orthographic and isometric free-hand sketching, and computer-generated design documentation.
Offered: Fall, spring, and summer terms annually.
1 credit hour, 3 contact hours

ENGR 1300 Engineering Processes
The use of basic machine tools such as lathes, milling machines, drill presses, band saws, and grinders, including micrometers, vernier calipers, and other devices of use in a machine shop or laboratory. Welding techniques and tool making are also considered.
Offered: Fall, spring, and summer terms annually.
1 credit hour

ENGR 1400 Engineering Communications
This is an undergraduate introductory course covering basic concepts and skills in engineering communication. Topics include technical writing, project planning and proposal writing, data visualization, system modeling and simulation, engineering graphics and CAD, and effective uses of software tools. Note: This course is recommended as an alternative to ENGR 1200 for the following disciplines only: Biomedical, Chemical, Industrial & Systems, Materials, Electrical and Computer Systems and Nuclear Engineering. Prerequisites: A mobile computing platform w/Internet capability and working knowledge of the operating system is required. Microsoft Windows operating system strongly recommended.
Offered: Fall and spring terms annually.
1 credit hour

ENGR 1600 Materials Science for Engineers
Introduction to “real” (defect-containing) solids, and equilibria and kinetic processes in solids. Macroscopic properties, such as mechanical strength and electrical conductivity, are dominated by structure and bonding, and the course continuously emphasizes this connection. Each of the materials classes (metals, ceramics, semiconductors, and polymers) is discussed in detail in this context.
Prerequisites: CHEM 1100.
Offered: Fall and spring terms annually.
4 credit hours, 5 contact hours

ENGR 2020 Product Design and Innovation Design Studio II
This design studio focuses on the product development process with an emphasis on problem definition and the impact that the designer has on the final outcome. Students are exposed to basic social science methods of observation and the role they can play in discovering and defining problems. Students are expected to develop a design from initial definition through actual use. Development of individual design skills in design development, presentation, and portfolio building are also emphasized.
Prerequisite: ARCH 2200, Design Studio, or permission of the instructor.
Offered: Spring term annually.
4 credit hours

ENGR 2050 Introduction to Engineering Design
A first course in engineering design which emphasizes creativity, teamwork, communication, and work across engineering disciplines. Students are introduced to the design process through a semester-long project which provides a design-build-test experience. Oral and written communication are important elements of the course. The course meets with ENGR 1010.
Prerequisites: ENGR 1100 and ENGR 1200 or ENGR 1400.
Corequisite: PHYS 1200.
Offered: Fall, spring, and summer terms annually.
4 credit hours, 6 contact hours

ENGR 2090 Engineering Dynamics
An integrated development of modeling-and problem-solving techniques for particles and rigid bodies emphasizing the use of free-body diagrams, vector algebra, and computer simulation. Topics covered include the kinematics and kinetics of translational, rotational, and general plane motion, energy and momentum methods.
Prerequisites: ENGR 1100 and PHYS 1100.
Corequisite: MATH 2400.
Offered: Fall and spring term annually.
4 credit hours
ENGR 2250
Thermal and Fluids Engineering I
Application of control volume balances of mass, momentum, energy, and entropy in systems of practical importance to all engineers. Identification of control volumes, properties of pure materials, mass and energy conservation for closed and open systems, second law of thermodynamics, Bernoulli equation, fluid statics, forces and heat transfer in external and internal flows, conduction and radiative heat transfer.
Prerequisites: ENGR 1100 and PHYS 1100.
Corequisite: MATH 2400.
Offered: Fall, spring, and summer terms annually.
4 credit hours

ENGR 2350
Embedded Control
Engineering laboratory introduction to the microprocessor as an embedded element of engineering systems. Students simultaneously develop the hardware and software of one or more target systems during the semester. Topics include concepts and practices of microcontroller hardware and software for command, sensing, control, and display. Specifically this includes control of dynamic systems and sensor interfaces; analog-digital conversion; parallel input/output; driver circuits, modular programming, and subsystem integration.
Prerequisite: One of CSCI 1010, CSCI 1100, CSCI 1190 or permission of instructor.
Offered: Fall, spring, and summer terms annually.
4 credit hours

ENGR 2530
Strength of Materials
Concept of stress and strain, generalized Hooke’s law, axial load, torsion, pure bending, transverse loading, transformation of stress and strain components in 2-D, design of beams and shafts for strength, deflection of beams, work and energy, columns.
Prerequisite: ENGR 1100.
Offered: Fall, spring and summer terms annually.
4 credit hours

ENGR 2600
Modeling and Analysis of Uncertainty
Appreciation and understanding of uncertainties and the conditions under which they occur, within the context of the engineering problem-solving pedagogy of measurements, models, validation, and analysis. Problems and concerns in obtaining measurements; tabular and graphical organization of data to minimize misinformation and maximize information; and development and evaluation of models. Concepts will be supported with computer demonstration. Applications to problems in engineering are emphasized.
Prerequisite: MATH 1010.
Offered: Fall and spring terms annually.
3 credit hours

ENGR 2710
General Manufacturing Processes
A classroom study of the basic theory and methods of traditional and nontraditional machining, metal joining, material working, and foundry processes, and the variety of functions performed by the primary machine tools employed by the modern manufacturing community. A basic first course or terminal course for all students who are interested in manufacturing processes.
Offered: Fall and spring terms annually.
3 credit hours

ENGR 2720
Computer Aided Machining
This course will introduce students to the basic concepts associated with computer numerical controlled (CNC) machining. Specifically, the student will be introduced to the processes and operations associated with CNC milling, drilling, and turning. All of these processes will be controlled by code written by the students. Students are expected to apply their knowledge of computer-aided engineering as well as manufacturing processes to class exercises, homework assignments, tests, and a final project.
Offered: Fall and spring terms annually.
3 credit hours

ENGR 2940
Engineering Project
1 to 3 credit hours

ENGR 2960
Topics in Engineering
1 to 3 credit hours

ENGR 4010
Professional Development III
Students will study issues associated with working in teams in a modern work environment. Various styles of leadership, the definitions of power and empowerment and their applications in industry and team settings will be studied. Additionally, other topics to be explored include vision, values and attitudes, and organizational culture. The course format will include small and large group discussions, case studies, experiential exercises, and regular participation from industry guests.
Offered: In conjunction with senior courses.
1 credit hour
ENGR 4100  
**Business Issues for Engineers and Scientists**  
Investigates business-related considerations in successfully commercializing new technology in a new venture or within an existing enterprise: market and customer analysis, beating the competition, planning and managing for profitability, high-tech marketing and sales, and business partnerships and acquisitions. Not a general management course; focuses explicitly on what is relevant for engineers and scientists working in a commercial environment. For junior/senior undergraduate or graduate students.  
**Offered:** Fall term annually.  
4 credits undergraduate; 3 credits graduate credit hours

ENGR 2300  
**Electronic Instrumentation**  
**Prerequisite:** PHYS 1200; corequisite: MATH 2400.  
**Offered:** Fall and spring terms annually.  
4 credit hours

ENGR 4700  
**Introduction to Manufacturing Planning**  
A survey of the basic concepts and analytical methodologies used to plan and control a manufacturing system. Topics include forecasting, production scheduling, facility layout, inventory control, and project planning. Admission by application. Restricted to juniors in engineering. Students cannot obtain credit for both this course and ISYE 2210.  
**Offered:** Spring term annually.  
3 credit hours

ENGR 4710  
**Manufacturing Processes and Systems Laboratory I**  
Manufacturing theory, laboratory experimentation, and manufacturing systems design and development comprised of selected modern manufacturing technologies. Technologies include robotics and automation, injection molding, computer numerically controlled (CNC) machining, metal forming, inspection, and rapid prototyping. Student teams apply lessons to develop a proposal for a manufacturing system to produce a product requiring multiple coordinated manufacturing processes. Students will prepare appropriate technical documentation for communicating keys aspects of the developed manufacturing system to a separate fabrication group.  
**Prerequisites:** Both ENGR 1300 and ENGR 2710 are suggested.  
**Offered:** Fall term annually.  
3 credit hours, 6 contact hours

ENGR 4720  
**Manufacturing Processes and Systems Laboratory II**  
Student teams finalize manufacturing system plans from select ENGR 4710 projects, build a manufacturing system to complete several hundred units of a product, optimize the system, manage a project budget, and conform to a project schedule as proposed in the associated project Technical Data Packages produced by ENGR 4710 teams.  
**Prerequisite:** ENGR 4710.  
**Offered:** Spring term annually.  
3 credit hours

ENGR 4750  
**Engineering Economics and Project Management**  
This course deals with cost analysis in engineering decision making and the management and control of complex projects. Engineering economics topics include interest formulas and equivalence calculations, inflation, measures of investment worth, after tax analysis, depreciation accounting and replacement analyses, life-cycle costing and design economics, risk analysis and cost-benefit analysis. Engineering project management topics include methods for planning, evaluation, organization, budgeting, cost estimating, scheduling, expediting, reporting, monitoring, and implementation of projects. Students cannot obtain credit for both this course and either ENGR 4760 or ISYE 4240.  
**Offered:** Spring term annually.  
4 credit hours

ENGR 4760  
**Engineering Economics**  
The objective is to help engineering students recognize and understand the importance of cost factors that are inherent in all engineering decisions. Development of ability to handle engineering problems that involve economic factors. The course includes economic environment, selections in present economy, value analysis, critical path economy, interest and money-time relationships, depreciation and valuation, capital financing and budgeting, basic methods for undertaking economic studies, risk, uncertainty and sensitivity, selections between alternatives, fixed, increment, and sunk costs, the effects of income taxes in economic studies, replacement studies, minimum cost formulas, economic studies of public projects, economic studies in public utilities. Effects of inflation are considered at each step. Students cannot obtain credit for both this course and ENGR 4750.  
**Offered:** Spring term annually.  
3 credit hours

ENGR 6100  
**Business Issues for Engineers and Scientists**  
Investigates business-related considerations in successfully commercializing new technology in a new venture or within an existing enterprise: market and customer analysis, beating the competition, planning and managing for profitability, high-tech marketing and sales, and business partnerships and acquisitions. Not a general management course; focuses explicitly on what is relevant for engineers and scientists working in a commercial environment. For junior/senior undergraduate or graduate students.
ENGR 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

ENVE Environmental Engineering (SOE)

ENVE 2110
Introduction to Environmental Engineering
The application of basic principles and equations dealing with water, air, and solid and hazardous wastes; material and energy balances; and chemical and biochemical cycles. Topics include water resources, water quality and pollution, air quality and pollution, solid and hazardous wastes, and environmental legislation.
Prerequisite: CHEM 1100.
Corequisites: MATH 2400, ENGR 2250.
Offered: Fall term annually.
4 credit hours

ENVE 2940
Readings in Environmental Engineering
1 to 3 credit hours

ENVE 4110
Aqueous Geochemistry
Fundamentals of aqueous chemistry as applied to the evolution of natural waters. The course covers principles of chemical equilibrium, activity models for solutes, pH as a master variable, concentration and Eh-pH diagrams, mineral solubility, aqueous complexes, ion exchange, and stable isotopes. The carbonate system, weathering reactions, and acid rain are examined in detail. Emphasis is on the chemical reactions that control surface and groundwater evolution in natural and engineered (treatment process) settings. Students learn theory, computation methods, and the use of computer programs for calculation of speciation and mass balance.
Prerequisite: Permission of the instructor.
Offered: Fall term annually.
Cross listed: CHEM 4690 and ERTH 4690. Students cannot obtain credit for both this course and either CHEM 4690 or ERTH 4690.
4 credit hours

ENVE 4180
Environmental Process Design
The design of equipment, processes, and systems of interest in environmental engineering through application of scientific, technological and economic principles. Emphasis is placed on problem formulation and conceptual, analytical, and decision aspects of open-ended design situations. Students will integrate knowledge and skills gained in previous and concurrent courses, and learn research techniques to find and use resources from the technical literature. Health and safety issues are presented. Professional development topics are presented including professional ethics and registration. Students will develop communication skills through proposal preparation, report writing, oral presentation. This is a communication-intensive course.
Prerequisite: ENVE 2110 and senior standing.
Offered: Spring term annually.
3 credit hours

ENVE 4200
Solid and Hazardous Waste Engineering
Classification and characteristics of solid and hazardous wastes; appropriate waste management systems; design of collection and transfer systems; methods of destruction and disposal, including landfills; recycle methods; and salvage and conversion operations for resource recovery.
Offered: Spring term annually.
3 credit hours

ENVE 4210
Industrial Waste Treatment and Disposal
Physical, chemical, and biological characteristics of industrial wastes. Application of unit operations and processes to the treatment of waste streams. Consideration of recovery and/or recycling of useful products.
Offered: Upon availability of instructor.
3 credit hours

ENVE 4240
Bench Scale Design
The design and operation of different laboratory experiments to provide experience for the environmental engineer in the practical application of chemical and biological theory. Design parameters are developed via bench scale testing. Topics can include biological treatment, phytoremediation, composting of solid waste and soil columns, and microbial respirometry.
Offered: Spring term annually.
3 credit hours
ENVE 4310
Applied Hydrology and Hydraulics
Physical processes governing occurrence and distribution of precipitation, infiltration, evaporation, and surface water runoff. Statistical hydrology, unit hydrograph theory, and watershed modeling. Floodplain hydrology and open channel hydraulics. Urban hydrology, hydraulics and design of storm sewers, and design of detention structures for flood control. Design project using the Army Corps of Engineers Hydraulic Engineering Center HEC-1 flood hydrograph package.
Prerequisite: ENGR 2250 or CHME 4010.
Offered: Spring term annually.
4 credit hours

ENVE 4320
Environmental Chemodynamics
The movement of chemicals in air, water, and soil is presented to demonstrate the relation of physiochemical principles in the behavior of chemicals in the environment. Topics include chemical and thermal equilibrium at environmental interfaces, transport fundamentals, and the fate and transport of chemicals in various environmental compartments. Includes experimental analysis of natural and engineered chemical and thermodynamic processes, emphasizing experimental design, data evaluation, and report writing.
Prerequisites: ENVE 2110, CHEM 2250.
Offered: Spring term annually.
4 credit hours

ENVE 4330
Introduction to Air Quality
Quantitative introduction to the engineering methods for the study of air quality. Topics include but are not limited to: estimation procedures for air pollution emissions; indoor air quality problems, impacts and control strategies; sources, impacts and control strategies for greenhouse gases; dispersion modeling for point sources; pollutant acidification of lakes; chemistry of stoichiometric and non-stoichiometric combustion; assessment methods for human exposure to air pollutants. Includes experimental analysis of air quality and air quality control processes, emphasizing experimental design, data evaluation, and report writing.
Prerequisite: ENVE 211.
Offered: Fall term annually.
4 credit hours

ENVE 4340
Physicochemical Processes in Environmental Engineering
Physical and chemical processes governing water quality in natural and engineered systems with applications to potable water treatment. Topics include reactor dynamics, coagulation and flocculation, sedimentation, filtration, gas transfer, adsorption and ion exchange, and membrane processes. A design project for which students develop a computer model of an environmental process is required. Includes laboratory experiments to measure physicochemical process parameters, emphasizing experimental design, data evaluation, and report writing.
Corequisite: ENVE 4320.
Offered: Spring term annually.
4 credit hours

ENVE 4350
Biological Processes in Environmental Engineering
The study of biochemical and biological processes common to environmental engineering. Introductory physiology, biochemistry and ecology of bacteria, yeasts, fungi. Laboratory work in microbial techniques. Development of reaction rate and mass balances on biological processes for pollution control. Includes experimental analysis of natural and engineered biological processes, emphasizing experimental design, data evaluation, and report writing.
Prerequisite: ENVE 4320.
Offered: Fall term annually.
4 credit hours

ENVE 4940
Studies in Environmental Engineering
1 to 4 credit hours

ENVE 4960
Topics in Environmental Engineering
1 to 4 credit hours

ENVE 4980
Senior Project
1 to 4 credit hours

ENVE 6110
Advanced Groundwater Hydrology
An intensive study of hydrologic, geologic, and other factors controlling groundwater flow, occurrence, development, chemistry, and contamination. Groundwater flow theory and aquifer test methods are introduced. Interaction between surface and subsurface hydrologic systems are covered. Some field trips are possible.
Prerequisite: MATH 1020 or equivalent, or permission of instructor.
Offered: Fall term annually.
Cross listed: ERTH 6710. Students cannot obtain credit for both this course and ERTH 6710 or ERTH 4710.
3 credit hours

ENVE 6130
Land Applications of Wastewater
Treatment efficiency and design parameters for different methods of treatment of wastewaters by land application. Methods considered include irrigation, rapid infiltration, overland flow, septic-tank leach field systems, and deep well injection. Soil geology and groundwater flow maintenance, monitoring of systems, and public health considerations. Evaluation of sludge disposal.
Offered: Upon availability of instructor.
3 credit hours
ENVE 6140
Stream Pollution Control
Principles of limnology applied to the ecological conditions of streams and bodies of fresh water relative to capacity to stabilize organic materials. The economic aspects of water pollution; health aspects of bacterial pollution.
Offered: Upon availability of instructor.
3 credit hours

ENVE 6160
Environmental Impact Analysis
Studies related to the evaluation of the impacts of major actions by state and federal agencies on the quality of human environment. Consideration is given to the preparation of impact statements. The impacts of various types of action are discussed; the adverse effects produced and alternatives to proposed action considered, and the tradeoffs between short-term uses and long-term productivity are evaluated. Case studies are presented and analyzed.
Offered: Upon availability of instructor.
3 credit hours

ENVE 6190
Public Health
Occurrence and control of communicable diseases; principles of epidemiology and biostatistics and their application, emphasizing the relationship with environmental factors; food infections and food poisoning; use and impact of pesticides and other methods of pest control; air pollution sources and health effects. Organization of government health agencies.
Offered: Upon availability of instructor.
3 credit hours

ENVE 6200
Hazardous Waste Management I
This course concentrates on management issues and study of the fate and transport of hazardous materials in the environment. Management topics are broken down into three broad categories: regulatory issues, those necessary for daily operation of an industrial facility (industrial hygiene, storage, and transportation issues), and preliminary environmental site assessments. Fate and transport issues will be dealt with quantitatively.
Prerequisite: Permission of instructor.
Offered: Fall term annually.
3 credit hours

ENVE 6210
Hazardous Waste Management II
A continuation of ENVE 6200. The principal topic discussed is the selection of remediation alternatives and waste minimization.
Prerequisite: ENVE 6200.
Offered: Spring term annually.
3 credit hours

ENVE 6230
Mathematical Modeling of Environmental Engineering Systems
Basic modeling approaches and techniques for the simulation of environmental engineering systems. Model development, system conceptualization and analysis, mathematical representation, solution and simulation, as well as model calibration and verification, are discussed. Problems such as simulation of biochemical reactors and behavior of toxic chemicals in groundwater are drawn from the literature. Ongoing research projects are discussed.
Offered: Upon availability of instructor.
3 credit hours

ENVE 6240
Air Pollution Control
The major approaches to air pollution control are discussed from three viewpoints: equipment for particle and gaseous emissions control, control of specific processes and pollutants, control strategies. Emphasis is on control devices for particles, sulfur oxides, and nitrogen oxides; absorption with chemical reaction; wet scrubber technology. Combination with other approaches to develop control strategies.
Prerequisite: ENVE 4330.
Offered: Upon the availability of instructor.
3 credit hours

ENVE 6250
Bench Scale Design
The design and operation of different laboratory experiments to provide experience for the environmental engineer in the practical application of chemical and biological theory. Design parameters are developed via bench scale testing. Topics include biological treatment, ion exchange, test for total carbon in a solid waste and PARR bomb calorimeter, soil columns, and microbial respirometry.
Offered: Upon availability of instructor.
3 credit hours

ENVE 6300
Bioremediation of Hazardous and Toxic Compounds
Lecture course stresses multidisciplinary approaches to the use of microbial system for biotransformation and biodegradation of toxic and hazardous material. Topics include biodegradability, enzymatic transformations, microbial ecology, and properties of organic and inorganic compounds, in situ and ex situ engineering techniques. Real world design examples and projects are introduced. Permission of instructor is required.
Prerequisite: ENVE 4350 or equivalent.
Offered: Spring term annually.
3 credit hours
ENVE 6910
Colloquium Series
Seminars by distinguished guest speakers and graduate students on current problems in environmental and energy engineering. A broad range of subjects is covered. All undergraduates and graduates are strongly encouraged to attend as many lectures as possible.
Offered: Fall and spring terms annually.

ENVE 6940
Studies in Environmental Engineering
1 to 4 credit hours

ENVE 6960
Topics in Environmental Engineering
1 to 4 credit hours

ENVE 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

ENVE 6980
Master’s Project
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.
1 to 9 credit hours

ENVE 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
1 to 9 credit hours

ENVE 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
1 to 12 credit hours

ERTH Earth and Environmental Sciences (SOS)

ERTH 1010
Planet Earth I: The Solid Earth
Age and origin of the Earth, internal constituents, and energy sources; how plates move, oceans develop, resources accumulate, and mountains rise. Gives nonspecialists a picture of the Earth's major processes and the ways in which they interact to provide the world's citizens with adequate material resources. Lectures and recitation. (Students cannot obtain credit for both ERTH 1010 and ERTH 1100.)
Offered: Fall term annually.
4 credit hours

ERTH 1020
Planet Earth II: Oceans and Atmosphere
An overview of the Earth's surface processes and environment. Nature and interactions between the major oceanic, atmospheric, and terrestrial systems. Interrelations between geology, the environment, and human activities. Geologic and environmental implications, constraints, and opportunities for past, present, and future human populations and cultures. Short- and long-term benefits and consequences of actions or inaction. Lectures and recitation. (Students cannot obtain credit for both ERTH 1020 and ERTH 1200.)
Offered: Spring term annually.
4 credit hours

ERTH 1030
Natural Sciences I
The sciences of the natural world, focusing primarily upon physics and chemistry but including some discussion of relevant topics in astronomy and planetary science. Both classical and modern concepts are treated, at scales ranging from the atom to the universe, and an effort is made to instill an appreciation for the nature of science and the scientific method. Examples are used as appropriate to illustrate the value of science in our everyday lives. The course is designed for nonscience majors and cannot be used by science majors to fulfill a distribution requirement. (Note: Natural Sciences II does qualify as a science distribution requirement for some science majors.)
Offered: Fall term annually.
4 credit hours
ERTH 1040
Natural Sciences II
The sciences of the natural world, focusing primarily on the earth and life sciences. The course addresses the origin, evolution, and current state of our planet, and examines the earth as a life-supporting system. Specific examples of developments in scientific thinking are used to illustrate connections among the various disciplines comprising the natural sciences. The course is designed for nonscience majors, and cannot be used by students majoring in one of the bio- or geosciences to fulfill a distribution requirement. This restriction does not apply to students majoring in computer science, mathematics, chemistry, or physics.
Prerequisites: ERTH 1030 or recent course work in basic physics and chemistry.
Offered: Spring term annually.
4 credit hours

ERTH 1100
Geology I: Earth’s Interior
Age and origin of the Earth, internal constituents and energy sources; how plates move, oceans develop, and mountains rise. The course aims to give a quantitative picture of the Earth’s major processes and the ways in which they interact. Lectures and lab. (Students cannot obtain credit for both ERTH 1010 and ERTH 1100.)
Offered: Fall term annually.
4 credit hours

ERTH 1200
Geology II: Earth’s Surface
The geological environment of humankind: the atmosphere, oceans, groundwater, rivers, glaciers, deserts, and soils. The course explores the processes by which these and other features develop and change, both naturally and as a result of human activity. Lectures and lab. (Students cannot obtain credit for both ERTH 1020 and ERTH 1200.)
Offered: Spring term annually.
4 credit hours

ERTH 2100
Introduction to Geophysics
An introduction to various aspects of the study of the physics of the Earth. Stress and strain, deformation, isostasy, seismic waves, earthquakes, Earth structure, resource exploration, Earth dynamics, plate tectonics, mountain building, gravity and geodesy, magnetic field, and heat flow. Included are weekly labs and occasional field exercises.
Prerequisite: ERTH 1100.
Offered: Spring term odd-numbered years.
4 credit hours

ERTH 2120
Structural Geology
Introduction to stress and strain; observation, measurement, recording, and interpretation of rock structures including joints, faults, folds, and fabrics. Interpretation of structures from geologic maps. Structures and regional tectonics. Laboratory and field trips required.
Prerequisite: ERTH 2210 or permission of instructor.
Offered: Fall term annually.
4 credit hours

ERTH 2140
Introduction to Geochemistry
An introduction to the application of chemistry to problems in the Earth and Environmental Sciences. Topics include thermodynamics and phase equilibria as applied to mineral stability, rock evolution, and water chemistry; stable isotope systematics; radiogenic isotope systematics; trace element geochemistry, organic geochemistry, and geochemical cycles.
Offered: Spring term annually.
Cross listed: CHEM 2540. Students cannot obtain credit for both this course and CHEM 2540.
4 credit hours

ERTH 2210
Field Methods
Principles and methods of geologic mapping. Use of instruments. Selected field problems. Several field trips (usually on weekends) required. This is a communication-intensive course.
Prerequisites: ERTH 1100 or ERTH 1200 or permission of instructor.
Offered: Fall term annually.
3 credit hours

ERTH 2330
Earth Materials
Overview of the chemical and physical properties of the material constituents of the Earth and terrestrial planets, including minerals, rocks, lavas, and supercritical water. Topics include mineral structure and composition, bonding, optical properties, phase transformations, and surface properties. The role of minerals in the man-made environment is also discussed.
Offered: Fall term annually.
4 credit hours

ERTH 2610
Oceanography
Ocean basins and margins; origin, distribution, chemistry, and history of sediments; physical and chemical properties of seawater; global atmospheric and oceanic circulations and climatic interactions.
Prerequisites: CHEM 1100 and PHYS 1100 or permission of instructor.
Offered: Fall term even-numbered years.
4 credit hours
ERTH 2620
Current Topics in Earth Science
This course provides the student with a formal participation in the weekly colloquium series of the Department of Earth and Environmental Sciences. These colloquia involve lectures on a wide variety of topics in the geologic and environmental sciences primarily by outside investigators who are currently active in those fields. (Students may take this course a maximum of two times for credit.)
Prerequisite: Geology or environmental science majors only or permission of instructor.
Offered: Fall and spring terms annually.
1 credit hour

ERTH 4070
Sedimentology/Stratigraphy
Formation and interpretation of sediments and sedimentary rocks, including the processes and depositional environments that form them. Analysis of sedimentary sequences, recent sedimentary environments, and their ancient analogs. Principles of correlation. Includes labs and field trips (several one-day field trips on weekends will be required).
Prerequisites/Corequisites: ERTH 1100 and/or ERTH 1200 recommended, but not required; CHM 1100/1110 and PHYS 1100, or permission of instructor.
Offered: Fall term odd-numbered years.
4 credit hours

ERTH 4180
Environmental Geology
A consideration of technical and scientific aspects of key geosocietal issues. Case studies and analysis of current and historic data bases will be used to illustrate topics including, but not limited to, climate modification, energy resources, future energy, water resources, water pollution, and health risks posed by lead, mercury, and emerging pollutants.
Offered: Spring term annually.
4 credit hours

ERTH 4190
Environmental Measurements
Modern methods used in analysis of environmental samples for monitoring and research purposes. Standard and advanced techniques of air, water, sediment, and soil analysis are covered including spectrometric and chromatographic methods.
Prerequisite: Permission of the instructor required.
Offered: Fall term odd-numbered years.
4 credit hours

ERTH 4200
Applied Micropaleontology
This course will encompass marine, freshwater, and terrestrial microfossils (with emphasis on foraminifera), including taxonomy, evolutionary history, ecology and paleoenvironments, and a broad spectrum of micropaleontological applications, such as sea-level and climate reconstructions, geochemical analyses, oil industry research and production, and forensic geology. This course will also cover concepts of biostratigraphy and micropaleontological applications to stratigraphic correlation and time scale construction. Extensive hands-on microscope and lab work will be required.
Prerequisites/Corequisites: ERTH 1200, ERTH 2610 are strongly recommended. Permission of the instructor is required.
Offered: Fall term even-numbered years.
4 credit hours

ERTH 4340
Igneous and Metamorphic Petrology
Introduction to the observation and interpretation of igneous and metamorphic rocks in outcrop, hand sample, and thin sections. Processes of melting, solidification and migration of magmas; solid state recrystallization and pressure-temperature histories. Heat flow and regional crustal dynamics. Laboratory and field trips required.
Prerequisites: ERTH 2330 and ERTH 2140.
Offered: Spring term even-numbered years.
4 credit hours

ERTH 4350
Data Science
Data science is advancing the inductive conduct of science and is driven by the greater volumes, complexity and heterogeneity of data being made available over the Internet. It combines aspects of data management, library science, computer science, and physical science. It is changing the way all of these disciplines do both their individual and collaborative work. Key methodologies in application areas based on real research experience are taught. This course meets with ERTH/CSCI/ITWS 4350 and ERTH/CSCI/ITWS 6350. A student can get credit for only one of these courses.
Prerequisite: CSCI 1200 and CSCI 4380.
Offered: Fall term annually.
Cross listed: CSCI 4350 and ITWS 4350.
3 credit hours

ERTH 4400
Xinformatics
Informatics covers a broad range of disciplines addressing challenges in the explosion of data and information resources. Xinformatics provides commonality for implementations in specific disciplines (e.g. X=astronomy, geology). Informatics’ theoretical bases are information and computer science, cognitive science, social science, library science, aggregating these studies and adding the practice of information processing, and the engineering of information systems. This course grounds the material that students will learn in discipline areas by coursework and project assignments. Students cannot obtain credit for more than one of ITWS or ERTH or CSCI 4400.
Prerequisite: CSCI 1200, ITWS or ERTH or CSCI 4960.
Offered: Spring term annually.
Cross listed: ITWS/CSCI 4400 and ITWS/CSCI/ERTH 6400.
3 credit hours
ERTH 4500
Earth’s Climate: Past, Present and Future
Overview of physical components of Earth’s climate system; builds on this foundation by examining the roles of both natural Earth system processes and anthropogenic influences in determining Earth’s climate and climate changes in the past, present, and future. Initial focus is on recent and future climate change. Remainder of course will emphasize the study and reconstruction of climates and climate change through geologic history.
Prerequisite: CHEM 1100/1110 and PHYS 1100, or permission of instructor.
Offered: Spring term annually.
4 credit hours

ERTH 4540
Organic Geochemistry
A broad survey of organic geochemistry suitable for students with a strong chemistry background who are majoring in science or engineering. Topics include the transport and fate of organic pollutants and the geochemistry of natural organic compounds in oceans, lakes, sediments, and soils.
Prerequisites: CHEM 2250 and ERTH 1200 or permission of instructor.
Offered: Spring term even-numbered years.
4 credit hours

ERTH 4570
Solid Earth Geophysics
The course covers the physics of the Earth’s interior, including a survey of its evolution, rotation, gravity and tides, seismicity, internal heat, magnetism, and tectonics.
Prerequisite: ERTH 1100 or permission of instructor.
Offered: Upon sufficient demand.
4 credit hours

ERTH 4650
Seismology
Introduction to the causes, consequences, and uses of vibrations in the Earth. Topics include elastic wave propagation, earthquake source mechanisms, seismic risk analysis, exploration seismology, and tomographic imaging.
Prerequisite: MATH 1020.
Offered: Spring term on demand.
4 credit hours

ERTH 4690
Aqueous Geochemistry
Fundamentals of aqueous chemistry as applied to the evolution of natural waters. Principles of chemical equilibrium, activity models for solutes, pH as a master variable, concentration and Eh-pH diagrams, mineral solubility, aqueous complexes, ion exchange, and stable isotopes. The carbonate system, weathering reactions, and acid rain are examined in detail. Emphasis is on the chemical reactions that control surface and groundwater evolution in natural and engineered (treatment process) settings. Students learn theory, computation methods, and the use of computer programs for calculation of speciation and mass balance.
Prerequisite: Permission of instructor.
Offered: Spring term odd-numbered years.
Cross listed: CHEM 4690 and ENVE 4110. Students cannot obtain credit for both this course and either CHEM 4690 or ENVE 4110.
4 credit hours

ERTH 4710
Groundwater Hydrology
Study of hydrologic, geologic, and other factors controlling groundwater flow, occurrence, development, chemistry, and contamination. Groundwater flow theory and aquifer test methods are introduced. Interactions between surface and subsurface hydrologic systems are covered. Some field trips are possible. (Students cannot receive credit for both this course and ERTH 6710.)
Prerequisite: MATH 1020 or equivalent or permission of the instructor.
Offered: Fall term annually.
Cross listed: ENVE 4170.
4 credit hours

ERTH 4750
Geographic Information Systems in the Sciences
Introduction to analysis and interpretation of spatial data and their presentation on maps (using MapInfo software). Concepts of map projections, reference frames, multivariate analysis, correlation analysis, regression, interpolation, extrapolation, and kriging will be covered.
Prerequisite: Knowledge of Windows OS.
Offered: Spring term annually.
4 credit hours

ERTH 4810
Chemistry of the Environment
Chemical processes important in the environment from naturally occurring and man-induced systems. Thermodynamic and chemical considerations of fuels; the thermodynamics of the atmosphere; atmospheric photochemistry; chemistry of natural water systems; chemistry of pesticides, fertilizers, and other important environmental contaminants; aspects of the carbon, nitrogen, and sulfur cycles.
Prerequisites: CHEM1200 and one prior or concurrent course in organic chemistry or permission of instructor.
Offered: Spring term annually.
Cross listed: CHEM 4810. Students cannot obtain credit for both this course and CHEM 4810.
4 credit hours

ERTH 4940
Readings in Geology
1 to 4 credit hours

ERTH 4960
Topics in Geology
1 to 4 credit hours
ERTH 4970
Out-of-Classroom Experience in Earth Sciences
Credits are earned while the student gains practical experience in applying skills to working in a private company or government agency in an area relevant to the student's educational goals. Requires a written proposal and final report.
2 to 4 credit hours

ERTH 4980
Undergraduate Research Thesis
Independent field experience for undergraduates. Requires a written proposal and final report.
2 to 4 credit hours

ERTH 6200
Applied Micropaleontology
This course will encompass marine, freshwater, and terrestrial microfossils (with emphasis on foraminifera), including taxonomy, evolutionary history, ecology and paleoenvironments, and a broad spectrum of micropaleontological applications, such as sea-level and climate reconstructions, geochemical analyses, oil industry research and production, and forensic geology. This course will also cover concepts of biostratigraphy and micropaleontological applications to stratigraphic correlation and time scale construction. Extensive hands-on microscope and labwork will be required.
Prerequisites/Corequisites: ERTH 1200, ERTH 2610 strongly recommended. Permission of the instructor is required.
Offered: Fall term even-numbered years.
4 credit hours

ERTH 6300
Advanced Metamorphic Petrology
In-depth analysis of metamorphic phase equilibria in pelites, amphibolites, carbonates, and ultramafic rocks. Schreinemakers’ analysis, petrogenetic grids, P-T-X relations, reaction space, geothermometry, geobarometry, and analysis of zoned prophyroblasts. Heat flow, metamorphic, and tectonic evolution. Laboratory involves analysis of textural relations in thin section and computer exercises.
Offered: Fall term odd-numbered years.
4 credit hours

ERTH 6350
Data Science
Data science is advancing the inductive conduct of science and is driven by the greater volumes, complexity and heterogeneity of data being made available over the Internet. It combines aspects of data management, library science, computer science, and physical science. It is changing the way all of these disciplines do both their individual and collaborative work. Key methodologies in application areas based on real research experience are taught. This course meets with ERTH/CSCI/ITWS 4350 and ERTH/CSCI/ITWS 6350. A student can get credit for only one of these courses.
Prerequisite: CSCI 1200 and CSCI 4380.
Offered: Fall term annually.
Cross listed: CSCI 6350 and ITWS 6350.
3 credit hours

ERTH 6400
Xinformatics
Informatics covers a broad range of disciplines addressing challenges in the explosion of data and information resources. Xinformatics provides commonality for implementations in specific disciplines (e.g. X=astronomy, geology). Informatics’ theoretical bases are information and computer science, cognitive science, social science, library science, aggregating these studies and adding the practice of information processing, and the engineering of information systems. This course grounds the material that students will learn in discipline areas by coursework and project assignments. Students cannot obtain credit for more than one of ITWS or ERTH or CSCI 6400.
Prerequisites: CSCI 1200, ITWS or ERTH or CSCI 6960.
Offered: Spring term annually.
Cross listed: ITWS/CSCI 4400, ERTH 4400, and ITWS/CSCI 6400.
3 credit hours

ERTH 6540
Advanced Igneous Petrology
Topical treatment of current problems and frontiers in igneous petrology, with emphasis on physical and chemical processes. Principles of fluid dynamics and chemical kinetics are applied to the formation and evolution of crust-and mantle-derived magmas.
Prerequisite: ERTH 4340.
Offered: Spring term odd-numbered years.
3 credit hours

ERTH 6580
Seminar in Geophysics: Selected Topics
General topics in advanced geophysics vary each time the seminar is offered. Previous subjects covered include crustal deformation, inverse theory, global positioning system, and seismic wave propagation.
Prerequisite: Permission of instructor.
Offered: Spring term even-numbered years.
3 credit hours

ERTH 6710
Advanced Groundwater Hydrology
An intensive study of hydrologic, geologic, and other factors controlling groundwater flow, occurrence, development, chemistry, and contamination. Groundwater flow theory and aquifer test methods are introduced. Interaction between surface and subsurface hydrologic systems are covered. Some field trips are possible. (Students cannot receive credit for both this course and ERTH 4710.)
Prerequisite: MATH 1020 or equivalent, or permission of instructor.
Offered: Fall term annually.
3 credit hours

ERTH 6940
Readings in Geology
1 to 4 credit hours
**ERTH 6960**  
**Special Topics in Geology**  
Topics offered previously: geomagnetism, seismology, mineral equilibria; mineral structures; igneous minerals and rocks; sedimentary processes; marine geology, convergent plate margins, geoeexploration, remote sensing applications, seismic stratigraphy; physical oceanography.  
1 to 4 credit hours

**ERTH 6970**  
**Professional Project**  
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

**ERTH 6980**  
**Master’s Project**  
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the library. Grades will then be listed as S.  
1 to 9 credit hours

**ERTH 6990**  
**Master’s Thesis**  
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presentend, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library. Grades will then be listed as S.  
Variable credit hours

**ESCI Engineering Science (SOE)**

**ESCI 6980**  
**Master’s Project**  
Active participation in a Master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the library. Grades will then be listed as S.  
1 to 9 credit hours

**ESCI 6990**  
**Master’s Thesis**  
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  
Variable credit hours

**ESCI 9990**  
**Dissertation**  
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  
Variable credit hours

**IENV Interdisciplinary Environmental Courses**

**IENV 1910**  
**Environmental Seminar**  
Topical issues in environmental sciences covered in a seminar and discussion format. Seminar includes guest speakers from academics, industry, non-profits, and government who are experts in an array of environment-related fields. Each class includes weekly reading and short writing assignments. A short final research paper is required (~10 pgs.).  
Offered: Spring term annually.  
2 credit hours
IENV 2100
Introduction to Environmental Studies
An introduction to a variety of ways to study the environment, especially science and technology studies, environmental science, and environmental engineering. Case studies and projects emphasize the cooperation of disciplines in addressing local and global environmental issues such as PCBs in the Hudson River, acid rain in the Adirondacks, and population growth.
Offered: Spring term annually.
Cross listed: IENV 2100. Students cannot obtain credit for both this course and IENV 2100.
4 credit hours

IENV 4700
One Mile of the Hudson River
A course that focuses on the Hudson River Basin as an environmental microcosm and a vehicle through which to illustrate the natural science of river systems with particular attention to human influences. This interdisciplinary environmental science course is for environmentally oriented junior, senior, and graduate students.
Prerequisites: junior, senior, or graduate student status; introductory courses in biology, chemistry, and geology; environmentally oriented humanities/social sciences courses, or permission of instructor.
Offered: Fall term even-numbered years.
4 credit hours

IHSS Interdisciplinary Humanities and Social Science Studies (HSSH)

IHSS 1210
Information in History and Society
What is the relationship between information, information technology, and culture? How are understandings of the world acquired, organized, and shared? How has this been done differently in different time periods and in different cultural contexts? Through an analysis of a broad spectrum of information technologies, from the printing press and early maps, to telephone, television, computers, and the Internet, the goal of this course is to come to a deeper, more critical understanding of these questions and their answers. This is a communication-intensive course.
Offered: Fall term annually.
4 credit hours

IHSS 1220
IT and Society
Will IT increase prosperity? For whom? What role should governments play in IT development? Do corporations have new responsibilities in the Information Era? What about IT professionals? This course explores the issues, the arguments, and working solutions. The first section examines macro indicators and trends.
The second section examines the microeconomics and politics of specific arenas — the software industry, the automated work place, telemedicine, television. The last section explores opportunities for improving society, using IT. This is a communication-intensive course.
Offered: Fall term annually.
Cross listed: ITWS 1220. Students cannot obtain credit for both this course and ITWS 1220.
4 credit hours

IHSS 1610
Product Design and Innovation Design Studio I
The first design studio in the Product Design and Innovation Program introduces students to general design through a series of short projects. The projects stress creative thinking and invention, observation and perception, communication and visualization, sketching, photography, model-making, and especially open-ended exploration.
Offered: Fall term annually.
4 credit hours

IHSS 1960
Topics in Interdisciplinary Humanities and Social Science Studies
4 credit hours

IHSS 2100
Introduction to Environmental Studies
An introduction to a variety of ways to study the environment, especially science and technology studies, environmental science, and environmental engineering. Case studies and projects emphasize the cooperation of disciplines in addressing local and global environmental issues such as PCBs in the Hudson River, acid rain in the Adirondacks, and population growth.
Offered: Spring term annually.
Cross listed: IENV 2100. Students cannot obtain credit for both this course and IENV 2100.
4 credit hours

IHSS 2500
Product Design and Innovation Studio III
This studio design course focuses on an enriched sense of problem definition through an emphasis on the reach and interconnectedness of technology and the conditionality of design selection criteria. Its design exercises, readings, and discussions press beyond marginal substitutions toward a broadened sense of possibility from, for example “hypercars” and human-powered homes to small-scale local agriculture and extreme ecological living systems.
Prerequisite: PDI I or PDI II or permission of instructor.
Offered: Fall term annually.
4 credit hours
IHSS 2610
Product Design and Innovation Studio III
This studio design course focuses on an enriched sense of problem definition through an emphasis on the reach and interconnectedness of technology, and the conditionality of design selection criteria. Its design exercises, readings, and discussion press beyond marginal substitutions toward a broadened sense of possibility from, for example, “hypercars” and human-powered homes to small-scale local agriculture and extreme ecological living systems. This is a communication-intensive course.
Prerequisite: PDI I or PDI II or permission of instructor.
Offered: Fall term annually.
4 credit hours

IHSS 2960
Topics in Interdisciplinary Humanities and Social Science Studies
4 credit hours

IHSS 4800
Experiential Learning Project
This is an individually tailored reading course in which the student does readings and also completes an internship-type field project for the minor in cross-cultural studies of science and technology. The goal is to provide students with immersion in a multicultural milieu involving science and technology issues. Projects include student exchange programs, co-op placement, public service internships, community service, and other individually tailored projects subject to adviser approval. Students are expected to write up a description of their field project that integrates their field experience with the readings.
Prerequisite: Completion of other course requirements for the minor.
Offered: Upon sufficient demand.
3 credit hours

IHSS 4850
The Phelan Seminar on Technology and Society
An undergraduate honors-style seminar examining interactions between technology and modern society. Particular attention will be given to the historical origins and contemporary contexts of technological change in America, especially the Hudson/Mohawk region of New York. The specific topic of the seminar will change each year, coordinated with visiting lecturers and other scholarly events, publicized during the fall term. This course cannot be used towards the HASS depth requirement.
Prerequisite: Any 2000-level STS course and permission of instructor.
Offered: Spring term annually.
4 credit hours

IHSS 4960
Topics in Interdisciplinary Humanities and Social Science Studies
3 credit hours

IHSS 6960
Topics in Interdisciplinary Humanities and Social Science Studies
3 credit hours

ISCI General Interdisciplinary Courses (SOS)

ISCI 4510
Origins of Life Seminar
Discussion of current issues relevant to origins of life, in astrophysics, biology, chemistry, and earth sciences.
Prerequisite: Junior standing or higher or permission of instructor.
Offered: Fall and spring terms annually.
1 credit hour

ISCI 4950
Research Rotation
Students will contact several faculty members prior to the start of the semester. They and the participating faculty will mutually agree about the general area of the research and the time commitment for the rotation. Expectations for the research experience will be specified, and mutually agreed to, by the start of the semester. Restricted to School of Science majors accepted into the Accelerated B.S./Ph.D. Program.
Offered: Fall and spring terms annually.
Variable credit hours

ISCI 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A professional project often serves as a culminating experience for a professional master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one professional project. Professional projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.
3 to 4 credit hours
ISCI 6980
Master's Project
Active participation in a master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.
1 to 9 credit hours

ISCI 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presentend, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
1 to 9 credit hours

ISCI 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
Variable credit hours

ISYE Industrial and Systems Engineering (SOE)

ISYE 1100
Intro to Industrial & Systems Engineering
An introduction to industrial and systems engineering (ISE). Major elements of the ISE disciplines are overviewed in the context of operations engineering problems. Topics include deterministic and stochastic applications of operations research methods, soft computing, applications of probability and statistics, engineering economics, discrete event simulation, and decision analysis.
Offered: Fall term annually
1 credit hour

ISYE 2210
Production and Operations Management and Cost Accounting
The design and analysis of production and service systems. Topics include forecasting, scheduling, inventory systems, total quality management, line balancing, and capacity planning. Introduction to cost accounting. Use of analytic techniques in accounting-based decision making. Formulation and solution of POM models practiced on computers. Students cannot obtain credit for both this course and ENGR 4700.
Prerequisites: MATH 1020 or equivalent.
Offered: Spring term annually.
4 credit hours

ISYE 2940
Readings in ISYE
1 to 4 credit hours

ISYE 2960
Topics in ISYE
4 credit hours

ISYE 4140
Statistical Analysis
Review of simple and multiple regression, selection procedures, regression diagnostics, residual analysis, stepwise regression, analysis of variance, design of experiments including factorial experiments, analysis of ordinal data and nonparametric inference, basic time series models. Extensive use of statistical software. Emphasis on statistical applications to industrial engineering.
Prerequisites: ENGR 2600 and knowledge of calculus.
Offered: Fall term annually.
4 credit hours

ISYE 4200
Design and Analysis of Work Systems
Analysis and design of work and workplace. Topics covered include human-machine systems, ergonomics, work measurement systems, methods and standards, process design, direct time study, standard time data, predetermined time systems, work sampling, work load balancing, and workplace layout. Computer-based analysis of problems in work systems.
Prerequisites: ISYE 2210 or ENGR 4700, and ENGR 2600 or equivalent.
Offered: Upon availability of instructor.
3 credit hours

ISYE 4210
Design and Analysis of Supply Chains
An overview of the principles involved in the design and operation of supply chains with applications to manufacturing and service industries. Topics include dynamics of manufacturing systems and supply chains, lean manufacturing, lead time reduction in manufacturing and office operations, advanced pull systems, concurrent design of products and supply chains, rapid new product introduction, remanufacturing and reverse supply chains, and integration of information technology in supply chain operations. The goal of the course is to enable students to synthesize models and tools and to understand how these could be applied to address emerging challenges in manufacturing and service systems and their supply chains.
Prerequisites: ISYE 2210 or ENGR 4700, and ENGR 2600 or equivalent.
Offered: Spring term annually.
3 credit hours
ISYE 4220
Optimization Algorithms and Applications
Design, analysis, and implementation of algorithms for combinatorial optimization problems. Introduction to theoretical analysis of algorithms and applications that can be formulated as combinatorial optimization problems. Specific topics include complexity analysis, network flow problems, traveling salesman problems, matching problems, knapsack problems, and greedy algorithms. Implementation of combinatorial algorithms in a commercial software language. An introduction to this software language will be given at the beginning of the course.
Prerequisites: ISYE 4600 or equivalent.
Offered: Fall term annually.
3 credit hours

ISYE 4230
Quality Control
The statistical approach to manufacturing quality control is emphasized. Consideration is given to the managerial implications and responsibilities in implementing the statistical approach. Topical coverage includes construction and interpretation of various control charts; special control charts (e.g., CUSUM, EWMA); graphical methods; specifications, tolerance limits, process capability indices; acceptance sampling; discussion of experimental design; and Taguchi methods of quality improvement.
Prerequisites: ISYE 4140 or ISYE 4760 (MATP).
Offered: Spring term annually.
3 credit hours

ISYE 4240
Engineering Project Management
Planning, controlling, and evaluating engineering projects. Use of network analysis techniques, PERT/CPM, budget control, time/cost tradeoff, time estimation, resource allocation, and resource leveling. Extensions include probabilistic models, multiple resource models, project organization, risk analysis, technical forecasting, and network theory. Students cannot obtain credit for both this course and ENGR 4750.
Offered: Upon availability of instructor.
3 credit hours

ISYE 4250
Facilities Design and Industrial Logistics
An in-depth study of the major design issues in location and physical configuration of production and service facilities. The course emphasizes the use of mathematical models, computer modeling, and quantitative analysis as aids to the design process. Topics include plant layout and location, material handling, material flow analysis, and distribution systems. Major course concepts are developed through case studies and projects.
Prerequisites: ISYE 2210 or equivalent, ISYE 4140 or equivalent, and an introductory operations research course.
Offered: Spring term annually.
3 credit hours

ISYE 4260
Human Performance Modeling and Support
This course introduces methods, tools, and technologies for describing human performance via various types of models, and supporting this performance via tools and advanced technologies. The course is hands-on, involving student projects that investigate human performance in challenging domains as well as direct engagement with technologies for decision support.
Prerequisite: ENGR 2600.
Offered: Fall term annually.
3 credit hours

ISYE 4270
Industrial and Management Engineering Design
This course provides a capstone and professional experience. Student teams work on independent projects in any field of industrial and management engineering approved by a faculty adviser. Typically, projects involve a manufacturing and service sector client who provides the student with an opportunity to gain an actual industrial experience. Memos, progress reports, and a final written and oral report are submitted to the project adviser and client. This course is a communication-intensive course.
Prerequisite: Senior standing.
Offered: Fall and spring terms annually.
3 credit hours

ISYE 4280
Decision Focused Systems Engineering
The objective of this course is to introduce students to systems engineering, especially from a decision-focused perspective. System concepts, methodologies, models and analysis are covered in relation to a system's design, development, test, evaluation, and operation. Decisions concerning a system's reliability, maintainability, usability, disposability, and affordability are systematically considered. A range of systems, including service systems, is also considered.
Prerequisite/Corequisite: ENGR 2600.
Offered: Fall term annually.
3 credit hours

ISYE 4290
Discrete Event Simulation Modeling and Analysis
Introduction to discrete-event simulation modeling and analysis techniques including; graphical simulation modeling approaches, animation techniques, modeling large-scale and complex systems, pseudo-random number and random variate generation, stochastic processes, input modeling (data collection, analysis, and fitting distribution), output analysis (initial bias and termination bias, variance reduction techniques), sensitivity analysis, design of experiments, interactive simulation-based decision-support systems.
Prerequisites: ISYE 4140 or equivalent and CSCI 1100 or CSCI 1010 or permission of instructor.
Offered: Spring term annually.
4 credit hours
ISYE 4300
Complex Systems Models for Industrial and Systems Engineering
This course introduces simulation-based modeling methods for complex systems frequently encountered and used by industrial and systems engineers. Examples include production systems, queuing networks, communication systems, healthcare systems, supply chains, social networks, transportation systems, and financial markets. This course introduces techniques including discrete-event simulation and agent-based simulation for modeling and analyzing interdependent, interacting, and coupling variables, agents, components, and related subsystems.
Prerequisite: ISYE 4290.
Offered: Spring term odd-numbered years.
3 credit hours

ISYE 4310
Ethics of Modeling for Industrial and System Engineering
This course introduces students to past, current, and future issues in the ethics of information technology, and encourages students to develop their own standpoint from which to address the diverse range of ethical challenges facing us in the information age. During the course, students will learn about a wide range of ethical theories, and then will apply these theories to address ethical dilemmas in creating models for decision support using an educational computer simulation.
Prerequisites: ENGR 2600 and CSCI 1010 or CSCI 1100 or permission of instructor.
Offered: Fall term annually
3 credit hours

ISYE 4530
Information Systems
This course surveys information-systems technology for the management of enterprise information as a resource. Topics include elements of system design life cycle, database concepts, and decision support. Managerial and technical dimensions of information systems are blended in a framework for IS systems. Additional topics include telecommunications, artificial intelligence (including expert systems), and structured design. The implementation, operation, and maintenance of information systems are also discussed. Projects are required.
Prerequisite: CSCI 1190 or equivalent.
Offered: Fall term annually.
4 credit hours

ISYE 4600
Operations Research Methods
An introduction to commonly used methods of deterministic and stochastic operations research. Topics include linear programming, simplex algorithms, duality, linear networks, integer programming, dynamic programming, goal programming, location models, exact and heuristic solution procedures for integer and sequencing problems, queuing theory, Markov chains, multi-criteria decision mak-
**ISYE 6010**  
**Applied Regression Analysis**  
Emphasis is on empirical model building and evaluation for both multiple linear and nonlinear regression models. Topics specifically addressed are simultaneous estimation, diagnostics and remedial measures, selection procedures, locally weighted least squares classification variables, binary response variables, time series data, nonlinear estimation, software packages.  
**Prerequisites:** ISYE 4140 or MATP 4600 and ISYE 4760 (MATP 4620) or permission of the instructor.  
**Offered:** Upon sufficient demand.  
3 credit hours

**ISYE 6020**  
**Design of Experiments**  
Methods of designing experiments so that statistical analysis of the resulting data will yield the maximum useful information. Testing of hypotheses; analysis of variance and covariance. Various designs, including the factorial and its modifications, incomplete blocks, Latin squares, and response surface designs are covered. Also discussed are optimality properties of design.  
**Prerequisites:** ISYE 4140 or MATP 4600 and ISYE 4760 (MATP 4620) or permission of the instructor.  
**Offered:** Upon sufficient demand.  
3 credit hours

**ISYE 6100**  
**Time Series Analysis**  
Study of time series data for both description and prediction. Main emphasis on the classical Box-Jenkins approach to model identification, estimation, and diagnosis. Includes an introduction to spectral analysis. Applications to real data series, including forecasting problems and empirical comparison of alternative approaches. Use of computer packages for time series analysis.  
**Prerequisite:** ISYE 4760 (MATP 4620) or equivalent.  
**Offered:** Upon sufficient demand.  
3 credit hours

**ISYE 6140**  
**Exploratory Data Analysis**  
Exposition of the philosophy and tools of exploratory data analysis. Tools include graphical techniques, data transformation, robust and resistant summaries, residual analysis, and resampling methods. Applications to the analysis of real data sets, stressing alternative analysis using statistical software.  
**Prerequisites:** MATP 4600 and ISYE 4760 (MATP 4620) or equivalent; ISYE 6100 recommended.  
**Offered:** Upon sufficient demand.  
3 credit hours

**ISYE 6180**  
**Knowledge Discovery with Data Mining**  
Data mining is the computationally intelligent extraction of information from large databases. It is the process of automated presentation of patterns, rules, and functions from large data bases to make crucial business decisions. This course takes a multi-disciplinary approach to data mining and knowledge discovery involving statistics, rule and tree induction, neural networks, genetic algorithms, visualization and fuzzy logic. The course is project driven and puts a special emphasis on the use of computational intelligence for scientific data mining related to drug design and bioinformatics.  
**Prerequisite:** ENGR 2600 or equivalent introductory course in statistics.  
**Offered:** Upon sufficient demand.  
3 credit hours

**ISYE 6210**  
**Theory of Production Scheduling**  
Problems of scheduling several tasks over time. Topics include measures of performance, single machine sequencing, flowshop scheduling, the job shop problem, and priority dispatching. Integer programming, dynamic programming, and heuristic approaches to various problems are also presented.  
**Prerequisite:** Introductory course in operations research.  
**Offered:** Upon sufficient demand.  
3 credit hours

**ISYE 6500**  
**Information and Decision Technologies for Industrial and Service Systems**  
This course emphasizes topics related to information systems and decision making including information and decision systems in organizations, database systems, knowledge systems, system analysis and design, networks and telecommunications in information systems, information systems for service delivery.  
**Offered:** Upon sufficient demand.  
3 credit hours

**ISYE 6520**  
**Enterprise Database Systems**  
Focus on developing competence for database systems analysis, design, and processing. Additional topics such as data and rules modeling, integrity, data languages, DBMS, and distributed databases are also covered. The course presents a high-level look at design and operation issues from the perspective of information systems. Projects are required.  
**Prerequisite:** ISYE 6500 or permission of instructor.  
**Offered:** Upon sufficient demand.  
3 credit hours

**ISYE 6530**  
**Decision Support and Expert Systems**  
Concepts and types of managerial decision support systems. Topics include models for decision making, applied database, and applications of artificial intelligence. Knowledge representation, knowledge acquisition, and the development of expert systems are taught through cases and a project. Use of commercially available software packages.  
**Prerequisite:** ISYE 4530 or ISYE 6500 or permission of instructor.  
**Offered:** Upon sufficient demand.  
3 credit hours
ISYE 6600
Design of Manufacturing System Supply Chains
Dynamics of manufacturing systems and supply chains, lean manufacturing, lead time reduction in manufacturing and service operations, advanced pull systems, concurrent design of products and supply chains, rapid new product introduction, remanufacturing and reverse supply chains, and integration of information technology in supply chain operations. Analysis of models and their application to design and planning problems in manufacturing as well as service systems is emphasized.
Prerequisites: ISYE 4140 (or equivalent) or permission of instructor.
Offered: Spring term annually.
3 credit hours

ISYE 6610
Systems Modeling in Decision Sciences
Survey of decision science methodologies in the context of technical and economic decision problems. The course seeks to develop a conceptual understanding of these methods and basic implementation skills. Students will learn how to apply decision science methods from problem recognition and data development through problem formulation and computer solution. Students cannot get credit for both ISYE 4600 and ISYE 6610.
Prerequisite: ISYE 4140 or permission of instructor.
Offered: Fall term annually.
3 credit hours

ISYE 6620
Discrete-Event Simulation
A thorough development of a simulation language is stressed in order to progress through a series of increasingly sophisticated applications of computer simulation. Projects cover a wide range of topics: production systems, inventory, finance, transportation, and public systems. The course includes model development, statistical analysis of simulation input/output data, validation planning, and managing simulation projects.
Prerequisite: ISYE 4140 or equivalent.
Offered: Fall term annually.
3 credit hours

ISYE 6760
Combinatorial Optimization and Integer Programming
Review of exact and heuristic methods for solving discrete problems, including the traveling salesman problem, the knapsack problem, packing and covering problems. Algorithm complexity and NP-completeness, cutting plane methods and polyhedral theory, branch and bound, simulated annealing, tabu search, Lagrangian duality.
Prerequisite: Introductory course in operations research.
Offered: Spring term odd-numbered years.
Cross listed: MATP 6620. Students cannot obtain credit for both this course and MATP 6620.
4 credit hours

ISYE 6770
Linear Programming
A unified development of linear systems and linear programming, polyhedral theory, the simplex method, interior point methods, decomposition methods for large scale linear programming problems, the ellipsoid method, column generation algorithms for stochastic programming and other problems.
Prerequisite: Introductory course in operations research.
Offered: Spring term even-numbered years.
Cross listed: MATP 6640. Students cannot obtain credit for both this course and MATP 6640.
4 credit hours

ISYE 6780
Nonlinear Programming
Convex sets and functions, optimality conditions in nonlinear programming, Lagrangian duality, quadratic programming algorithms for nonlinear programming including Newton's method, quasi-Newton methods, conjugate gradient methods, together with proofs of convergence.
Prerequisite: MATH 4200 or equivalent, or permission of instructor.
Offered: Fall term annually.
Cross listed: MATP 6600. Students cannot obtain credit for both this course and MATP 6600.
4 credit hours

ISYE 6820
Queuing Systems and Applications
A course on fundamentals of stochastic processes and queuing theory emphasizing applications. Poisson processes, renewal processes, Markov chains, general methods in the study of Markovian and non-Markovian systems, tandem queues, networks of queues, priority and bulk queues, computational methods and simulation. Focus of the course is the application of these tools in the performance evaluation and design of computer systems, communication networks, manufacturing systems, and service systems.
Prerequisite: ECSE 2500 or MATP 4600 or equivalent.
Offered: Spring term annually.
Cross listed: ECSE 6820. Students cannot obtain credit for both this course and ECSE 6820.
3 credit hours
**ISYE 6840**  
Modeling Large-Scale Systems  
Applications of operations research and systems analysis techniques to mathematical modeling of complex systems, especially large-scale public systems. Discussion of model-building approaches, emphasizing the role of creativity, rationality, and mathematics. Introduction of important quantitative techniques (e.g., geometrical probability, optimization theory, and stochastic processes) and their application to modeling emergency service systems, spatial distribution of public service facilities, congestion, land-use patterns, transportation systems, demographics, and energy. **Prerequisites:** Introductory course in operations research and ECSE 2500 or equivalent; ECSE 6830 desirable. **Offered:** Fall term even-numbered years. **Cross listed:** ECSE 6840. Students cannot obtain credit for both this course and ECSE 6840. **3 credit hours**

**ISYE 6870**  
Introduction to Neural Networks  
Neural networks are program and memory at once, useful where traditional techniques fail, i.e., for artificial speech and image recognition. Emphasis on existing and emerging engineering applications. Parallel distributed processing, Hebb's rule, Hopfield net, back-propagation algorithm, perceptrons, unsupervised learning, Kohonen self-organizing map, genetic algorithms, neocognitron, adaline. Illustrated with computer programs and lectures. **Offered:** Upon sufficient demand. **3 credit hours**

**ISYE 6900**  
Seminar in ISYE Research  
A review of active ISYE doctoral research projects and activities. Students develop a research paper or proposal under the guidance of a selected faculty adviser and present research findings in class. It is anticipated that the research paper will lead to identification of the broad area of dissertation research. The proposal should be of a quality that can be submitted to an external funding agency. **Prerequisite:** ISYE doctoral student or permission of instructor. **Offered:** Fall term annually. **3 credit hours**

**ISYE 6940**  
Readings in ISYE  
**3 to 6 credit hours**

**ISYE 6960**  
Topics in ISYE  
**3 credit hours**

**ISYE 6970**  
Professional Project  
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work. **1 to 4 credit hours**

**ISYE 6980**  
Master’s Project  
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. **1 to 9 credit hours**

**ISYE 6990**  
Master’s Thesis  
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library. **1 to 9 credit hours**

**ISYE 9990**  
Dissertation  
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. **Variable credit hours**
ITWS 1100
Introduction to Information Technology and Web Science
This course introduces students to the field of information technology and Web science, the types of problems encountered in the field, and the solution approaches used to solve them. Through a series of activities and projects, students are introduced to topics such as Web systems design, emerging Web standards, database systems, security, and computer networking. Guest speakers highlight information technology practices in industry. Students work in groups on a team project and presentation at the end of the course. 
Offered: Fall term annually.
4 credit hours

ITWS 1220
IT and Society
Will IT increase prosperity? For whom? What role should governments play in IT development? Do corporations have new responsibilities in the Information Era? What about IT professionals? This course explores the issues, the arguments and working solutions. The first section examines macro indicators and trends. The second section examines the microeconomics and politics of specific arenas — the software industry, the automated work place, teledicine, television. The last section explores opportunities for improving society, using IT. This is a communication-intensive course.
Offered: Spring term annually.
Cross listed: IHSS 1220. Students cannot obtain credit for both this course and IHSS 1220.
4 credit hours

ITWS 2110
Web Systems Development
This course involves a study of the methods used to extract and deliver dynamic information on the World Wide Web. The course uses a hands-on approach in which students actively develop Web-based software systems. Additional topics include installation, configuration, and management of Web servers. Students are required to have access to a PC on which they can install software such as a Web server and various programming environments.
Prerequisite: CSCI 1200 or equivalent.
Offered: Fall term annually.
4 credit hours

ITWS 2210
Introduction to Human Computer Interaction
An introduction to the current theories, methods, and issues in human-computer interaction. Theory and research along with practical application are discussed within the context of organizational impact. The course provides the knowledge of HCI systems and research used for the implementation of safe, quick, and useable interactive technologies.

ITWS 4100
Information Technology and Web Science Capstone
Students work on collaborative projects to design innovative ITWS solutions which address a specific problem or area of need in the student’s field. Students work to identify a problem and research viable solutions. They go on to propose, design, and prototype their ITWS solution learning best practices for ITWS project management, communication, and user-center design. This course serves as the culminating experience for the undergraduate ITWS program. Restricted to ITWS majors. This is a communication-intensive course.
Prerequisite: ITWS 2210 and ITWS 4310.
Offered: Fall and spring terms annually.
Cross listed: ITWS 6800. Students cannot receive credit for both ITWS 4100 and ITWS 6800 during the same semester.
4 credit hours

ITWS 4200
Web Science
Since its inception the World Wide Web has changed the ways people work, play, communicate, collaborate and educate. There is, however, a growing realization among researchers across a number of disciplines that without fundamental understanding of the current, evolving, and potential Web, we may be missing or delaying opportunities for new and revolutionary capabilities. This course attempts to provide the foundations of that understanding, exploring the fundamentals of the World Wide Web’s function including the HTTP protocol, key algorithms that make the Web function, future trends, and social issues with respect to Web use and effect.
Prerequisite: ITWS 2110.
Offered: Spring term annually.
4 credit hours

ITWS 4300
Business Issues for Engineers and Scientists
Investigates business-related considerations in successfully commercializing new technology in a new venture or within an existing enterprise: market and customer analysis, beating the competition, planning and managing for profitability, high-tech marketing and sales, and business partnerships and acquisitions. Not a general management course; focuses explicitly on what is relevant for engineers and scientists working in a commercial environment. For junior/senior undergraduate or graduate students.
Offered: Fall and spring terms annually.
Cross listed: ENGR 4100/ENGR 6100 and ITWS 6300. Students can only obtain credit for one of these courses.
4 credit hours undergraduate; 3 credit hours graduate
ITWS 4310
Managing IT Resources
This course provides an introduction to fundamental concepts of management and applies them to IT. It examines the use of IT in business processes and the management issues of integrating IT into organizational processes to gain competitive advantage. Topics include: management, organizations, and information systems; development life cycle; project management and systems engineering; process reengineering; and organizational learning. This course includes the planning, development, and implementation of an IT project for a real client.
Prerequisite: ITWS 2110 or permission of instructor.
Offered: Fall term annually.
4 credit hours

ITWS 4350
Data Science
Data science is advancing the inductive conduct of science and is driven by the greater volumes, complexity and heterogeneity of data being made available over the Internet. It combines aspects of data management, library science, computer science, and physical science. It is changing the way all of these disciplines do both their individual and collaborative work. Key methodologies in application areas based on real research experience are taught.
Prerequisite: Data Structures (CSCI 1200), Database Systems (CSCI 4380) preferred.
Offered: Fall term annually.
Cross listed: ITWS 6350, CSCI 4350/6350 and ERTH 4350/6350.
Students can obtain credits for only one of these courses.
3 credit hours

ITWS 4370
Information System Security
This course covers foundational models for information security, policies, authentication, access control, database security, assurance, auditing, and intrusion detection. It also devotes substantial time to secure coding practices. Students will be expected to complete projects that explore an aspect of information security in detail. Cryptography is not covered since it is a focus of other courses.
Prerequisite: CSCI 2500 or ECSE 2660, and CSCI 1200. Experience with database systems recommended.
Offered: Spring term annually.
4 credit hours

ITWS 4400
X-Informatics
Informatics covers a broad range of disciplines addressing challenges in the explosion of data and information resources. Xinformatics provides commonality for implementations in specific disciplines, e.g. X=astro, geo. Informatics’ theoretical bases are information and computer science, cognitive science, social science, library science, aggregating these studies and adding the practice of information processing, and the engineering of information systems. This course grounds the material that students will learn in discipline areas by coursework and project assignments. Note: Students cannot obtain credit for both ITWS 4400 and ITWS 6400.
Prerequisites: CSCI 1200 and Data Science (CSCI/ERTH/ITWS 496x/696x).
Offered: Spring term annually.
Cross listed: ITWS 6400, CSCI 4400/6400 and ERTH 4400/6400. Students can only obtain credit for one of these courses.
3 credit hours

ITWS 4980
Special Projects
Active participation in a senior-level project supervised by a faculty member and requiring a presentation and project report. Grades of “in-progress” are assigned until the special project has been approved by the faculty member.
Prerequisite: Permission of instructor.
Offered: Fall and spring terms annually.
1 to 4 credit hours

ITWS 4990
Senior Thesis
A two-semester spring-fall or fall-spring course dealing with an advanced level independent research project supervised by a faculty member and requiring the presentation of a thesis. First term registration is limited to second semester juniors and first semester seniors. The grade for the first semester will be listed as “in progress.”
Prerequisite: Permission of instructor.
Offered: Fall and spring terms annually.
3 credit hours

ITWS 6300
Business Issues for Engineers and Scientists
Investigates business-related considerations in successfully commercializing new technology in a new venture or within an existing enterprise: market and customer analysis, beating the competition, planning and managing for profitability, high-tech marketing and sales, and business partnerships and acquisitions. Not a general management course; focuses explicitly on what is relevant for engineers and scientists working in a commercial environment. For junior/senior undergraduate or graduate students.
Offered: Fall and spring terms annually.
Cross listed: ENGR 4100/ENGR 6100 and ITWS 4300. Students can only obtain credit for one of these courses.
4 credit hours undergraduate; 3 credit hours graduate
**ITWS 6350**  
**Data Science**
Data science is advancing the inductive conduct of science and is driven by the greater volumes, complexity and heterogeneity of data being made available over the Internet. It combines aspects of data management, library science, computer science, and physical science. It is changing the way all of these disciplines do both their individual and collaborative work. Key methodologies in application areas based on real research experience are taught.  
**Prerequisite:** Data Structures (CSCI 1200), Database Systems (CSCI 4380) preferred.  
**Offered:** Fall semester annually.  
**Cross listed:** ITWS 4350, CSCI 4350/6350 and ERTH 4350/6350. Students can obtain credits for only one of these courses.  
3 credit hours

**ITWS 6400**  
**X-Informatics**
Informatics covers a broad range of disciplines addressing challenges in the explosion of data and information resources. Xinformatics provides commonality for implementations in specific disciplines, e.g. X=astro, geo. Informatics' theoretical bases are information and computer science, cognitive science, social science, library science, aggregating these studies and adding the practice of information processing, and the engineering of information systems. This course grounds the material that students will learn in discipline areas by coursework and project assignments. Note: Students cannot obtain credit for both ITWS 4400 and ITWS 6400.  
**Prerequisites:** CSCI 1200 and Data Science (CSCI/ERTH/ITWS 496x/696x).  
**Offered:** Spring term annually.  
**Cross listed:** ITWS 4400, CSCI 4400/6400 and ERTH 4400/6400. Students can only obtain credit for one of these courses.  
3 to 6 credit hours

**ITWS 6800**  
**Information Technology Master’s Capstone**
Integration of the knowledge and professional practice of the Master's in IT core and concentration courses. Topics in database systems, networking, software design, human computer interaction, management of technology, and ethics are applied within a framework of global e-business strategy. The course utilizes a Team Project with a real organization to practice major IT concepts. Team members select, develop, and present a significant technology implementation project, incorporating strategy, systems development, and business planning.  
**Offered:** Fall and spring terms annually.  
**Cross listed:** ITWS 4100. Students cannot receive credit for both ITWS 4100 and ITWS 6800 during the same semester.  
3 credit hours

**ITWS 6980**  
**Master’s Project**
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser and the Office of Graduate Education to then be archived in a standard format in the library. Grades will then be listed as S.  
**Offered:** Fall and spring terms annually.  
3 to 4 credit hours

**ITWS 6990**  
**Master’s Thesis**
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.  
**Offered:** Fall and spring terms annually.  
3 to 6 credit hours

**LANG Foreign Languages**
(Note: It is not necessary to take a second semester of a foreign language to receive credit for the first.)

**LANG 1110**  
**French I**
This introductory course deals with the basic elements of the French language and, in so doing, places equal stress on speaking, listening, and writing abilities, using daily-life vocabulary. Intensive oral drills designed to teach good speaking habits make class attendance compulsory. The reading of short anecdotes on French life provides exposure to written French. This course is enhanced by the use of audio-visual materials designed to expose the student to contemporary broadly based French culture which constitutes the foundation for an end of the semester paper (in English).  
**Offered:** Upon availability of instructor.  
4 credit hours

**LANG 1120**  
**French II**
This course, a continuation of French I, is a practical approach to everyday situations through the development of listening, speaking, and writing abilities. Intensive oral drills of a more complex nature designed to achieve fluency, make class attendance compulsory. The reading of short anecdotes on French life provides exposure to written French. This course is enhanced by the use of audio-visual materials designed to expose the student to contemporary French culture which constitutes the basis for an end of the semester paper (in English).  
**Prerequisite:** LANG 1110 or permission of the instructor.  
**Offered:** Upon availability of instructor.  
4 credit hours
LANG 1210
Japanese I
Introduction to basic aspects of Japanese grammar, conversation, reading, and writing. Practice with everyday situations with focus on various features of Japanese life and culture.
Offered: Upon availability of instructor.
4 credit hours

LANG 1220
Japanese II
Continuation of Japanese I. Grammar, conversation, reading, and writing will be emphasized. The course will focus on various features of Japanese life and culture. The class will consist of short lectures with various communication drills, written and spoken. Approximately 30 Kanji characters will be introduced.
Prerequisite: LANG 1210 or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

LANG 1310
German I
Introductory course in the basic elements of German language and aspects of contemporary culture. Equal stress on speaking, reading, writing, and listening. Cultural materials used as a basis for reading comprehension and elementary conversation.
Offered: Upon availability of instructor.
4 credit hours

LANG 1320
German II
Continuation of German I, supplemented by authentic readings in literature and culture. Presupposes a basic knowledge of German grammar and vocabulary such as acquired in German I.
Offered: Upon availability of instructor.
4 credit hours

LANG 1410
Chinese I
This course assumes no previous knowledge of the subject. The course is designed to provide students with fundamental skills in listening, speaking, reading, and writing Mandarin Chinese. Oral and aural skills will be emphasized. Background on Chinese culture will be introduced as an element of the course.
Offered: Upon availability of instructor.
4 credit hours

LANG 1420
Chinese II
This is a continuation of Chinese I, a course for the standard modern Chinese language (Mandarin). Students learn more Chinese characters and words, reach a total of near 500 characters and 650 words, and use more complicated grammatical structures, including some compliment phrases and topic-comment sentences. In sum, students will learn more in all four aspects – listening, speaking, reading, and writing – presented in Chinese I.
Prerequisite: LANG 1410.

LANG 1510
Spanish I
This course is specially designed to provide beginners with fundamental skills in listening, speaking, reading, and writing Spanish. The primary stress will be on Spanish phonetics and basic grammar drills. After taking this course, students will be able to function in everyday situations in an environment in which Spanish is spoken.
Offered: Upon availability of instructor.
4 credit hours

LANG 1520
Spanish II
This course provides a review and further development of the basic language skills introduced in the Level I course and continues to explore the history, arts, and cultures of Spain, Latin America, and the Hispanic population of the United States. Students hear and present brief informal oral presentations in Spanish, read passages dealing with contemporary cultural and political issues, short stories, myths and poems, and are encouraged to discuss and write about those things which interest them.
Prerequisite: Spanish I or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

LANG 1610
Italian I
In this course, students will develop basic conversational and comprehension skills in Italian and gain familiarity with essential aspects of Italian culture. The course will include basic readings and an array of cultural materials to acquaint students with life in an Italian-speaking environment.
Offered: Spring term annually.
4 credit hours

LANG 2110
French III
This course takes a two-pronged approach to conversational fluency, writing competency, and reading skills by offering a review and an expansion of grammar through grammatical exercises and by providing audio-visual materials and texts that focus on various aspects of French culture while raising cross-cultural awareness. The learning and practice of an extensive vocabulary give the student the wherewithal to write an end of the semester essay in French on an aspect of French culture.
Prerequisite: LANG 1120 or permission of the instructor.
Offered: Upon availability of instructor.
4 credit hours
LANG 2120
French IV
This course is a continuation of French III. While similar in form and content, the audio-visual materials and texts offered stress the accomplishments of the Francophonie in the arts and sciences.
Prerequisite: LANG 2110 or permission of the instructor.
Offered: Upon availability of instructor.
4 credit hours

LANG 2210
Japanese III
Continuation of Japanese II. The course reinforces fundamental skills introduced in Japanese I and II and further develops functional ability to communicate in Japanese beyond the elementary level. The class consists of short lectures with various communication activities, written and spoken. Aspects of contemporary Japanese culture will also be discussed. Approximately 45 new Kanji characters will be introduced.
Prerequisites: LANG 1210 and LANG 1220 or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

LANG 2220
Japanese IV
Continuation of Japanese III. This course will extend the knowledge and the skills acquired in Japanese I through III to the intermediate level. The course will further develop fluency in conversational skill while reading and writing skills of more complex texts are emphasized. Approximately 120 new Kanji characters will be introduced.
Prerequisites: LANG 1210, LANG 1220, and LANG 2210 or consent of instructor.
Offered: Upon availability of instructor.
4 credit hours

LANG 2310
German III
Discussion of readings in contemporary German culture and literature. Further development of the skills acquired in German I and II. The entire course is conducted in German.
Prerequisite: LANG 1320 or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

LANG 2420
Chinese III
This is a continuation of Chinese II, a course for the standard modern Chinese language (Mandarin). Students learn more Chinese characters and words, reach a total of about 800 characters, 1350 words, and complicated grammatical structures, e.g., expression of approximation, comparison of structural and aspect particles, etc. In sum, students learn more in all four aspects — listening, speaking, reading, and writing — presented in Chinese III.
Prerequisite: LANG 2420 or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

LANG 2940
Language Studies
Readings and projects adapted to the needs of individual students.

LANG 2960
Topics in Language
Experimental courses tried out in one or two terms.

LANG 4210
French Readings in the Arts and Sciences
This course introduces the student to the written French in the Arts and Sciences. The student is taught the grammar and the translation techniques needed to translate texts from French into English. The texts chosen cover a wide range of literature, from the literary to the more popular genres of mass communications. The course is intended for those who will take the foreign language proficiency examination and is useful for those who plan to work for a multinational company. A grade of A or B satisfies the language requirement.
Prerequisite: Prior knowledge of French required. Open only to graduate and senior students. No core program credit.
Offered: Upon availability of instructor.
4 credit hours

LANG 4400
Business French I
This course surveys the technical and cultural aspects of the French business world within its geographical, social, and political context. It provides the student with insights into the social and political make-up of French society as they affect the economy of France and her trading partners. It introduces the vocabulary and the essential tools needed by business professionals and requires an extensive practice in business writing and communication. Audio-visual materials supplement the text by helping the student to discover the French business world and its language and by bridging the gap between French and American business cultures.
Prerequisite: LANG 2120 or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours
**LANG 4410**  
*Business French II*  
This course is a continuation of Business French I using the same format. It constitutes the second part of a two-course series.  
**Prerequisite:** LANG 4400.  
**Offered:** Upon availability of instructor.  
*4 credit hours*  

**LANG 4500**  
*Japanese V*  
This course is a continuation of Japanese IV, an intermediate course for standard modern Japanese language. The course aims to further develop communicational skills with a socio-cultural appropriateness, while reading and writing skills are emphasized. This course covers Chapters 6 through 9 of Nakama 2, and 120 new Kanji characters will be introduced. The course will cover a range of topics including: honorific and humble expressions; asking and giving directions; gifts giving; employment; expressing complaints. This course may be applied towards the fulfillment of the minor in Japanese.  
**Prerequisites:** LANG 1210, LANG 1220, LANG 2210, and LANG 2220 or permission of instructor.  
**Offered:** Upon availability of instructor.  
*4 credit hours*  

**LANG 4940**  
*Language Studies*  
Readings and projects adapted to the needs of individual students.  

**LANG 4960**  
*Topics in Language*  
Experimental courses tried out in one or two terms.  

**LANG 6940**  
*Language Studies*  
Readings and projects adapted to the needs of individual students.  

**LGHT 4770**  
*Lighting Technologies and Applications*  
This course provides students with an in-depth understanding of the components of advanced lighting systems and enables them to critically explore applications of those components. Through lectures, readings, assignments, and application projects, students acquire working knowledge of the relevant products and techniques for lighting application and develop solutions to lighting problems. Students will undertake practical applications of advanced lighting technologies and develop skills in the application of photometric data, use of manual and computer-based lighting calculations, and the development of lighting specifications.  
**Offered:** Spring term annually.  
*4 credit hours*  

**LGHT 4840**  
*Human Factors in Lighting*  
An introduction to lighting and human factors, including classical literature and contemporary studies and development of skills needed to conduct and evaluate human factors research.  
**Offered:** Fall term annually.  
*3 credit hours*  

**LGHT 4940**  
*Advanced Individual Projects in Lighting*  
Individual projects and readings adapted to the needs of individual students at the advanced level.  
*1 to 6 credit hours*  

**LGHT 6750**  
*Lighting Research Design*  
An introduction to the philosophy of research and different approaches to it. Emphasis is placed on planning, executing, analyzing, and describing experiments. Each student is required to keep a laboratory notebook and to perform statistical tests in concert with assigned research projects.  
**Offered:** Fall term annually.  
*4 credit hours*  

**LGHT 6760**  
*Lighting Workshop*  
The Lighting Workshop is a research and design studio integrating scholarship, technology, design, policy, and communication in an intensive, project specific context. The course includes a number of topics, selected each year by faculty. These topics are selected to emphasize scholarship; require a variety of written and verbal presentation techniques; increase synthesizing skills in design, applications, and visualization software; and require teamwork and individual efforts. The Lighting Workshop emphasizes studio and seminar work supplemented with lecture, class discussions, and individual and group research, design, writing, and reading assignments.  
**Prerequisite:** LGHT 4230.  
**Offered:** Spring term annually.  
*4 credit hours*  

**LGHT Lighting (SOA)**  

**LGHT 4230**  
*Lighting Design*  
A design studio that explores the roles of light in architecture and its application by design. Students conceive, evaluate, and synthesize solutions that contribute to successful lighting and architectural design.  
**Offered:** Fall term annually.  
*4 credit hours*  

**LGHT 4770**  
*Lighting Technologies and Applications*  
This course provides students with an in-depth understanding of the components of advanced lighting systems and enables them to critically explore applications of those components. Through lectures, readings, assignments, and application projects, students acquire working knowledge of the relevant products and techniques for lighting application and develop solutions to lighting problems. Students will undertake practical applications of advanced lighting technologies and develop skills in the application of photometric data, use of manual and computer-based lighting calculations, and the development of lighting specifications.  
**Offered:** Spring term annually.  
*4 credit hours*  

**LGHT 4840**  
*Human Factors in Lighting*  
An introduction to lighting and human factors, including classical literature and contemporary studies and development of skills needed to conduct and evaluate human factors research.  
**Offered:** Fall term annually.  
*3 credit hours*  

**LGHT 4940**  
*Advanced Individual Projects in Lighting*  
Individual projects and readings adapted to the needs of individual students at the advanced level.  
*1 to 6 credit hours*  

**LGHT 6750**  
*Lighting Research Design*  
An introduction to the philosophy of research and different approaches to it. Emphasis is placed on planning, executing, analyzing, and describing experiments. Each student is required to keep a laboratory notebook and to perform statistical tests in concert with assigned research projects.  
**Offered:** Fall term annually.  
*4 credit hours*  

**LGHT 6760**  
*Lighting Workshop*  
The Lighting Workshop is a research and design studio integrating scholarship, technology, design, policy, and communication in an intensive, project specific context. The course includes a number of topics, selected each year by faculty. These topics are selected to emphasize scholarship; require a variety of written and verbal presentation techniques; increase synthesizing skills in design, applications, and visualization software; and require teamwork and individual efforts. The Lighting Workshop emphasizes studio and seminar work supplemented with lecture, class discussions, and individual and group research, design, writing, and reading assignments.  
**Prerequisite:** LGHT 4230.  
**Offered:** Spring term annually.  
*4 credit hours*
LGHT 6770  
Light and Health  
This course will explore the effects of light and lighting on people’s physical and psychological health and well-being. Lectures will focus on the physiology of the visual and circadian systems, the relationship between lighting and visual performance and circadian photobiology, including the relationship between lighting and Alzheimer’s disease, sleep disorder, alertness, seasonal affective disorder (SAD), and breast cancer. The course will conclude with a research project studying the interaction of light and human health in the built environment. Students will learn to apply their newly acquired knowledge of the health effects of light to lighting design and application.  
Prerequisite: LGHT 4840.  
Offered: Spring term annually.  
4 credit hours

LGHT 6780  
Lighting Leadership Seminar  
A series of topics and case studies to prepare students for leadership roles in the lighting industry. Topics relate to product innovation and factors influencing changes of policy and processes in the lighting industry and involve lecture and discussion sessions and reading assignments. Case studies examine selected topics in greater depth, using actual situations to illustrate interactions of technology and business forces.  
Offered: Spring term annually.  
4 credit hours

LGHT 6830  
The Physics of Light  
A comprehensive overview of the physics of light and its applications for lighting. The course uses a variety of instructional methodologies, including lectures, laboratory sessions, hands-on experimentation, and individual student projects and presentations to cover various areas of lighting study. Topics include geometric optics, physical optics, lighting calculations and measures, spectro-radiometry, measurement techniques for advanced light sources, radiometry, and photometry.  
Offered: Fall term annually.  
4 credit hours

LGHT 6940  
Advanced Individual Projects in Lighting  
Individual projects and readings adapted to the needs of individual students at the advanced level.  
1 to 6 credit hours

LGHT 6980  
Master’s Project  
Active participation in a master’s-level project, under the supervision of a faculty adviser, leading to a master’s project report. The course is the culminating experience in the Master’s of Science in Architectural Sciences with a Concentration in Lighting. It is taught by faculty at the Lighting Research Center (LRC). The course allows students to work independently with a member of faculty to synthesize the information provided in formal course work by undertaking a master’s-level project in lighting. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. Grades will then be listed as S. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the library.  
3 credit hours

LGHT 6990  
Master’s Thesis  
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.  
1 to 9 credit hours

LITR Literature (HSSH)

LITR 2110  
Introduction to Literature  
A study of major literary works that introduces students to basic ideas and terminology in literary criticism. Students learn to read and interpret a selection of novels, plays, poetry, or other forms of writing to be determined each semester by the instructor.  
Offered: Spring term annually.  
4 credit hours

LITR 2150  
Contemporary Literature  
Students explore the philosophical, political, and artistic grounds from which contemporary literature arises and develop their own creative capacities in a project related to the course readings.  
Offered: Fall term annually.  
4 credit hours

LITR 2350  
Shakespeare  
A study of the major plays of William Shakespeare, including his comedies, histories, and tragedies. As well as textual discussion, students will have an opportunity to view film versions of the dramatic works and to perform or read extracts in class.  
Offered: Spring term annually.  
4 credit hours
LITR 2360
The Novel
Study of about seven representative novels. Each book is reviewed as a unique work of art, as an outgrowth of certain traditions, as a mirror of its time, and as an expression of one author’s personal vision of human nature and the human condition.
Offered: Upon availability of instructor.
4 credit hours

LITR 2420
Art of the Film
A survey of selected films whose directors have contributed to the resources of the medium, as well as a study of technical and aesthetic considerations that distinguish film from other arts. Reading assignments in film history, techniques, scripts, and special research projects.
Offered: Spring term annually.
4 credit hours

LITR 2450
Utopian Literature
An exploration of the use of fiction to propagate ideas about ideal or nightmarish societies. This course examines the artistic techniques employed in this distinct tradition and the unusual interplay between fiction and reality that this popular genre represents. Students work toward the design of their own utopian scheme in short story or other form. This is a communication-intensive course.
Offered: Fall term odd-numbered years.
4 credit hours

LITR 2500
The Short Story
A study of outstanding short stories from 19th- and 20th-century Europe and America, usually including works by such writers as Boccaccio, Flaubert, Chekhov, Borges, Ellison, Faulkner, Hemingway, Chopin, Joyce, Kafka, O’Connor, and Welty.
Offered: Upon availability of instructor.
4 credit hours

LITR 2770
Women Writers
Women Writers examines creative works of literature produced by women of different times, such as novels, poetry, performance art, and graphic novels. These diverse works explore issues of personal identity and social responsibility that are complicated by different historical attitudes towards matters of gender, race, and class. Discussion and viewing of film and visual art will complement the course’s focus on literature.
Offered: Spring term annually.
4 credit hours

LITR 2940
Literature Studies
Readings and projects adapted to the needs of individual students.
4 credit hours

LITR 2960
Topics in Literature
Experimental courses tried out in one or two terms.
4 credit hours

LITR 4150
Science and Fiction
An exploration of the ongoing dialogue between science/technology and literature through the reading of landmark works about science and fictional works that describe scientific ideas and methods. Topics include artificial intelligence, genetic engineering, and cyborgs.
Offered: Spring term annually.
4 credit hours

LITR 4160
The Human Mind in Fiction
Works of literature reflect theories about the human mind. Just as people have vigorously debated theories about the movement of planets in the material world, they have proposed radically different theories of the human mind. Such theories offer explanations of emotion, reason, dreams, the body, and memory. Drawing on material from Homeric Greece to 20th-century neuroscience, this course pairs a theory of mind with a corresponding literary work. Theories of the mind will be drawn from writings in philosophy, psychology, sociology, and neuroscience. This is a communication-intensive course.
Prerequisite: A 2000- or 4000-level course in cognitive science, psychology, literature, STS, or by permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

LITR 4210
Humor, Comedy, and Satire
Readings of literature from various periods in these three modes, including works by classical, renaissance, and contemporary writers. May include film, videos, and audio recordings.
Prerequisite: One literature course.
Offered: Upon availability of instructor.
4 credit hours

LITR 4410
Film Theory
The purpose of this course is to study significant theories of representation that analyze the visual codifications generically called “film.” The course will examine theories of visual rhetoric and of narrativity; look at the way economic and technological factors have affected the construction of cinematic codes, styles, and trends; examine influential psychoanalytic theories and feminist theories; and consider the ways in which popular films participate in the cultural narratives specific to their moment of production.
Prerequisite: Any film course or permission of instructor.
Offered: Spring term annually.
4 credit hours
LITR 4960  
Topics in Literature  
Experimental courses tried out in one or two terms.  
4 credit hours

LITR 6940  
Literature Studies  
Readings and projects adapted to the needs of individual students.  
3 credit hours

LITR 6960  
Topics in Literature  
Experimental courses tried out in one or two terms.  
3 credit hours

MANE Mechanical, Aerospace, and Nuclear Engineering (SOE)

MANE 2060  
Fundamentals of Flight  
An introduction to aerospace engineering technologies of aircraft, rotorcraft, rockets and spacecraft, including basic concepts of fluid mechanics, thermodynamics, aerodynamics, propulsion, aerostructures, dynamics, and flight mechanics.  
Offered: Spring term annually.  
3 credit hours

MANE 2400  
Fundamentals of Nuclear Engineering  
Nuclear reactor systems and types; basic reactor physics, criticality calculations; fuel cycles; reactivity changes; reactor kinetics. Instrumentation and control; radiation protection. Reactor materials; shielding; energy removal. Reactor safety; economics. Waste management. Reactor design.  
Prerequisite: MANE 2830 or equivalent.  
Offered: Fall term annually.  
4 credit hours

MANE 2830  
Nuclear Phenomena for Engineering Applications  
A survey of atomic and nuclear phenomena and their application in various engineering disciplines. Systematics of atoms and nuclei; nuclear reactions and their characterization; radioactive decay; fission and fusion energy release; radiation effects on materials and biological systems; radiation production, detection and protection. Applications in energy production, manufacturing, medicine, etc.  
Prerequisite: PHYS 1100 and CHEM 1100.  
Offered: Spring term annually.  
4 credit hours

MANE 2940  
Readings in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics  
1 to 3 credit hours

MANE 2960  
Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics  
3 credit hours

MANE 2980  
Senior Project  
Offered: Fall and spring terms annually.  
3 credit hours

MANE 4010  
Thermal and Fluids Engineering II  
Application of thermodynamics, heat transfer, and fluid flow principles to practical engineering systems, including power generation, HVAC, automotive design, materials processing, etc. Extends and complements concepts introduced in ENGR 2250. Utility of the 2nd Law will be demonstrated and emphasized.  
Prerequisite: ENGR 2250.  
Offered: Fall and spring terms annually.  
4 credit hours

MANE 4020  
Thermal and Fluids Engineering Laboratory  
Laboratory experience to complement MANE 4010. Demonstration of principles of thermodynamics, heat transfer, and fluid mechanics for mechanical engineering applications through a number of structured experiments.  
Prerequisite: MANE 4010 must be taken either before or concurrently with MANE 4020.  
Offered: Fall and spring terms annually.  
2 credit hours

MANE 4030  
Elements of Mechanical Design  
Introduction to the design of mechanical components and integrated assemblies. Loads, stresses, and strains. Failure phenomena and material selection. Mechanical components including shafts, couplings, bearings, gears, springs, clutches, brakes, screws and fasteners, and bonded joints.  
Prerequisites: MATH 2400, ENGR 2530.  
Offered: Fall and spring terms annually.  
4 credit hours
MAE 4040
Mechanical Systems Laboratory
Laboratory experience to complement MAE 4030. Tolerancing; gear kinematics and torque transfer; stress-strain behavior; beam bending; contact, friction, and wear; snap fasteners; fatigue; mechanical component design and analysis.
Prerequisite: MAE 4030 must be taken either before or concurrently with MAE 4040.
Offered: Fall and spring terms annually.
2 credit hours

MAE 4050
Modeling and Control of Dynamic Systems
Corequisites: MATH 2400, PHYS 1200.
Offered: Fall and spring terms annually.
4 credit hours

MAE 4060
Aerospace Structures and Materials
Beam structures under combined shear, bending, and torsional loads. Semi-monocoque structures: idealizations involving wings, ribs, and fuselage bulkheads. Effects of taper and cutouts in stiffened shell structures, shear deformations and warping, location of elastic axis in open and closed sections, torsion of multicell sections. Stability of beam and membrane elements. Introduction to materials used in aerospace vehicles including metals, ceramics, and composites with special emphasis on fiber-reinforced composite materials. Methods for material analysis and selection for various aerospace components.
Prerequisite: ENGR 2530.
Offered: Fall term annually.
4 credit hours

MAE 4070
Aerodynamics I
The fundamental principles of fluid dynamics, theory of inviscid incompressible flow, thin airfoils, high aspect ratio wings, delta wings, vortex panel and vortex lattice methods, subsonic compressible small-disturbance theory, transonic flow.
Prerequisites: ENGR 2250 and MAE 2060.
Offered: Fall term annually.
3 credit hours

MAE 4080
Propulsion Systems
Analysis of thrust generation: propeller theory, combustion, reciprocating engines, gas turbines. One-dimensional compressible flow, Prandtl-Meyer expansions and oblique shock waves, application to diffusers and rocket nozzles. Linearized supersonic flow.
Prerequisite: MAE 4070 or permission of instructor.
Offered: Fall term annually.
4 credit hours

MAE 4090
Flight Mechanics
Prerequisite: MAE 4070 or permission of instructor. Corequisite: MAE 4050.
Offered: Fall term annually.
4 credit hours

MAE 4100
Spaceflight Mechanics
Review of basic dynamics. Analysis of spacecraft trajectories, target rendezvous, and interception. Hohmann transfer, escape trajectories, interplanetary missions, the restricted three-body problem. Rigid body dynamics with application to gyrodynamics, stabilized platforms, gravity-gradient and spin stabilization of satellites, gyrostats. Selected topics such as drag-free satellites, vehicle launch and reentry, deployment dynamics (time permitting). MATLAB/Simulink is used as a simulation-visualization aid.
Prerequisites: ENGR 2090, MAE 2060, and MATH 2400, or equivalent.
Offered: Spring term annually.
4 credit hours

MAE 4170
Machine Dynamics
The principles of dynamics as applied to the analysis of the accelerations and dynamic forces in machines and machine components such as linkages, cams, and gears. The effect these dynamic forces have on the dynamic balance and operation of the machines and the attending stresses in the individual components of the machines.
Prerequisites: ENGR 2090 and MATH 2400.
Offered: Spring term annually.
3 credit hours

MAE 4180
Mechanisms
The displacement, velocity, and acceleration analysis of planar mechanisms, four bar linkages, slider, cranks, cams, and gear systems. Some synthesis techniques. Explore the use of existing large and small computer graphics programs.
Prerequisite: ENGR 2090.
Offered: Spring term annually.
3 credit hours
MANE 4200
Rotorcraft Performance, Stability, and Control
Topics in flight dynamics generic to rotorcraft (e.g., helicopters and tilt-rotor VTOLs). Lift and propulsion systems, hovering, and forward flight characteristics. Dynamics of flapping rotors. Longitudinal and lateral trim. Dynamic flight stability, controllability, and basics of automatic control requirements.
Prerequisite: MANE 4070 or equivalent.
Offered: Fall term annually.
3 credit hours

MANE 4220
Inventor’s Studio
Students work in teams to continue design and development work on approved projects that started in other courses such as Introduction to Engineering Design. New projects can also be proposed by students. Emphasis will be on completing the design, building an improved prototype, applying for patent protection, and licensing the design. Open to undergraduate and graduate students. Oral and written presentations are required. This is a communication-intensive course.
Prerequisite: ENGR 2050 or permission of instructor.
Offered: Fall and spring terms annually.
3 credit hours

MANE 4230
Air Vehicle Design
Conceptual and preliminary design of manned and unmanned air vehicles to satisfy given mission requirements and aircraft specifications. Includes elements of initial sizing and weights, geometry selection, aerodynamic design, propulsion integration, stability and control, loads, structural design, materials, manufacturability, and cost analysis. This is a communication-intensive course.
Prerequisites: MANE 4060 and MANE 4090 and MANE senior standing.
Offered: Spring term annually.
3 credit hours

MANE 4240
Introduction to Finite Elements
An introductory course in use of the Finite Element Method (FEM) to solve one-and two-dimensional problems in fluid mechanics, heat transfer, and elasticity. The methods are developed using weighted residuals. Algorithms for the construction and solution of the governing equations are also covered. Students will be exposed to the use of commercial finite element software.
Prerequisites: ENGR 2250 or ENGR 2530 or ECSE 4160 and senior standing.
Offered: Fall and spring terms annually.
Cross listed: CIVL 4240. Students cannot obtain credit for both this course and CIVL 4240.
3 credit hours

MANE 4250
Mechatronic System Design
Mechatronic system design principles, modeling/analysis/control (continuous and digital) of dynamic systems, control sensors/actuators and microcomputer/microcontroller interfacing, control electronics, and real-time programming for control. Lectures and weekly homework exercises; student teams complete two projects, each with required oral and written presentations; reverse engineering of a successful mechatronic system and a design-build-test exercise based on one of the laboratory systems of Mechatronics.
Prerequisite: MANE 4490.
Offered: Spring term annually.
3 credit hours

MANE 4260
Design of Mechanical Systems
This course acquaints students with all the phases of the design process from recognizing the need through a detailed conceptual design. Students work in teams on a semester-long project with the assistance of faculty consultants. The design projects require students to draw upon their engineering background, experience, and other pertinent resources. Oral and written presentations are required. This is a communication-intensive course.
Prerequisite: Senior standing.
Offered: Fall and spring terms annually.
3 credit hours

MANE 4280
Design Optimization: Theory and Practice
This course introduces the student to the theory and practical use of numerical design optimization methods, with a major focus on the practical problem formulations and results evaluation — relevant to engineering design. Optimal design topics include methods for unconstrained nonlinear problems, constrained linear and nonlinear problems, sensitivity analysis, multiobjective optimization, physical programming, and Pareto optimality. Some prior knowledge of MATLAB is helpful, but not required. MATLAB is used extensively. Most assignments require the use of a computer to generate numerical results using MATLAB. Use of a laptop in class is also required.
Prerequisite: MANE 4030 or equivalent.
Offered: Fall term annually.
3 credit hours

MANE 4340
Physics of Radiology
An introductory course on physical principles behind the creation of diagnostic medical images. Medical imaging is one of the most exciting and technologically demanding fields of medicine. Topics include radiation interaction, radiation dosimetry, formation and quality of X-ray images, computed tomography (CT), nuclear medicine, magnetic resonance imaging (MRI), ultrasound imaging, and radiation detection and safety. Current research on image quality optimization, image-guided radio-surgery, 3-D/4-D ultrasound imaging, and Monte Carlo simulations are reviewed.
Prerequisite: MANE 2830 or equivalent.
Offered: Fall term annually.
3 credit hours
MANE 4350
Nuclear Instrumentation and Measurement
Nuclear instrumentation and radiation detector systems for the
collection, processing and displaying of signals related to photons,
electrons, alpha particles, and neutrons. Topics include: radiation
interactions, counting statistics, ionization chambers, proportional
counters, Geiger counters, scintillators, gamma-ray spectroscopy,
semiconductor detectors, slow and fast neutron detection, liquid
scintillation and TLD, and background and shielding. Students
will tour a 100-MeV electron accelerator facility and learn to use
MCNP code to simulate an HPGe gamma spectrometer.
Prerequisite: MANE 2830 or equivalent.
Offered: Fall term annually.
3 credit hours

MANE 4360
Introduction to Fusion Devices and Systems
Examination of the requirements and approaches for the com-
mercial application of nuclear fusion. Discussion of fusion basics
including fusion reactions, competing processes, energy balances,
the need for plasmas, plasma confinement, and heating concepts.
Analyses of fusion reactor embodiments based on magnetic and
inertial confinement concepts. Identification of key physics, engi-
neering, and technology issues associated with fusion development.
Consideration of economics, environmental, and resource implica-
tions of fusion energy systems.
Prerequisite: Permission of instructor.
Offered: All term annually.
3 credit hours

MANE 4370
Nuclear Engineering Laboratory
A laboratory course covering topics in instrumentation, radiation
detection and dosimetry associated with X-ray, gamma-ray, electron
and neutron sources, applied physics, fluid dynamics, spectroscopy,
neutron time of flight, and a project on shielding design using the
MCNP code. Statistics of random events, error propagation, end
error analyses are emphasized. Lab attendance is required along
with formal written lab reports, which include data error analysis.
Prerequisites: ENGR 2600 and MANE 2830.
Offered: Fall term annually.
4 credit hours

MANE 4380
NEEP Senior Design Project I
This is the first of a two-semester sequence for seniors intended to
be a “capstone” design project where students have the opportunity
to utilize the broad range of their undergraduate experience in an
interdisciplinary design project. Projects are selected to provide
interaction between nuclear engineering and engineering physics
majors to provide exposure to cross-fertilization of ideas and team
interaction, which simulates anticipated future professional experi-
ence. The product of each design project is a comprehensive report
or design proposal having both global and detail completeness. Un-
der some circumstances, the project may involve development of
cost information necessary to effect construction and may actually
involve construction and commissioning of the designed apparatus.
This is a communication-intensive course.
Prerequisite: Permission of instructor.
Offered: Fall term annually.
1 credit hour

MANE 4390
NEEP Senior Design Project II
This is a required continuation of MANE 4380. This is a communi-
cation-intensive course.
Offered: Spring term annually.
2 credit hours

MANE 4400
Nuclear Power Systems Engineering
Application of thermodynamics, heat transfer, and fluid flow prin-
ciples to nuclear energy generation systems, including nuclear reac-
tors, nuclear fusion devices and systems, and radiation technology.
Engineering aspects of 1st and 2nd Laws of Thermodynamics will
be emphasized. Characteristics and safety aspects of nuclear power
equipment will be discussed.
Prerequisite: ENGR 2250.
Offered: Spring term annually.
4 credit hours

MANE 4410
Applied Atomic and Nuclear Physics
Review of atomic and nuclear physics and quantum mechanics;
application to atomic, molecular and nuclear systems; particle and
photon emissions; photon/particle interactions; quantum statistics;
field theory of electricity and magnetism; Maxwell equations in
free space and within materials; applications to semiconductors,
superconductors, accelerators, fusion systems, nuclear reactors; key
measurements and databases.
Prerequisites: MANE 2830 or equivalent.
Offered: Fall term annually.
4 credit hours

MANE 4420
Radiation Technology
An introductory course on the generation, distribution, and in-
teraction of ionizing radiation. Radiation sources such as radioiso-
topes, accelerators, focused ion beams, and cosmic rays are studied.
Applications to semiconductor electronic devices, chemical
polymerization, food preservation, sterilization, material modifica-
tion, industrial and medical radiography, and radiation damage are
presented.
Prerequisite: MANE 2830.
Offered: Fall term annually.
3 credit hours
MANE 4430  
Fundamentals of Gas-Liquid, Two-Phase Flow  
Theory of systems involving two-phase flow of liquids and gases or vapors: flow regimes including bubbly, slug, annular, and droplet, and combinations, homogeneous, separated, or dispersed flows are introduced. Single-phase flows modeling concepts and modeling methods based on the drift-flux model, and the two-fluid model are utilized in the analysis of gas-liquid flow behavior.  
Prerequisites: ENGR 2250 and either MATH 4600 or permission of instructor.  
Offered: Fall term annually.  
3 credit hours

MANE 4440  
Critical Reactor Laboratory  
Theory and operation of a low-power critical reactor facility: reactor layout, instrumentation, shielding, controls, hazards, problems of start-up and shutdown, and operating parameters. Approach to criticality, operating procedures, kinetics. Measurements are made of neutron flux, fuel rod worth, radiation, and various reactivity effects.  
Prerequisite: MANE 4480.  
Offered: Spring term annually.  
3 credit hours

MANE 4450  
Nuclear Fuel Management  
Prerequisite: MANE 2400.  
Offered: Spring term annually.  
3 credit hours

MANE 4470  
Radiological Engineering  
An introductory course on the principles of radiation and radiation protection (health physics). Provides a fundamental understanding of radiation interactions in matter, the biological effects of radiation, internal and external dosimetry, occupational and environmental radiation protection, health physics instrumentation, regulations, waste management, risk assessment, and radiation shielding.  
Prerequisite: MANE 2830 or equivalent.  
Offered: Spring term annually.  
3 credit hours

MANE 4480  
Physics of Nuclear Reactors  
Basic nuclear reactor theory; fuel cycles. Neutron diffusion and slowing down; criticality analyses for homogeneous and heterogeneous systems; reactor kinetics and control; reactivity coefficients; fuel management. Reactor systems and types; reactor design. Power plant safety.  
Prerequisite: MANE 2400 or equivalent.  
Offered: Spring term annually.  
4 credit hours

MANE 4490  
Mechatronics  
The synergistic combination of mechanical engineering, electronics, control engineering, and computer science in the design process. The key areas of mechatronics studied in depth are control sensors and actuators, interfacing sensors and actuators to a microcomputer, discrete controller design, and real-time programming for control using the C programming language. The unifying theme for this heavily laboratory-based course is the integration of the key areas into a successful mechatronic design.  
Prerequisites: ENGR 2350, MANE 4050, and senior standing.  
Offered: Fall term annually.  
3 credit hours, 5 contact hours

MANE 4550  
Analysis of Manufacturing Processes  
Review of basic aspects of manufacturing engineering including driving forces, quality attributes, tolerances, etc. Examination of basic principles of mechanics, engineering materials, analysis of both bulk-forming (forging, extrusion, rolling, etc.) and sheet-forming processes, metal cutting, and other related manufacturing processes. Discussion and role of computer-aided manufacturing in these areas.  
Prerequisites: ENGR 2530 and MANE 4030.  
Offered: Spring term annually.  
3 credit hours

MANE 4610  
Vibrations  
Prerequisite: ENGR 2090 or equivalent; Math 2400.  
Offered: Fall term annually.  
3 credit hours
MANE 4670
Mechanical Behavior of Materials
Prerequisite: ENGR 2530.
Offered: Fall term annually.
3 credit hours

MANE 4700
Solar Devices and Renewable Energy
Solar irradiation, its nature, and its measurement. Insolation on tilted surfaces. Application of the principles of heat transfer and thermodynamics to the theoretical and experimental analysis of solar energy components used in the heating and cooling of buildings as well as hot water heating devices. Theoretical consideration of thermal storage devices, solar collectors, and solar-augmented heat pumps. Approximate techniques; other ongoing research topics.
Prerequisite: Open to juniors and above.
Offered: Spring term annually.
3 credit hours

MANE 4710
Heat Transfer
Comprehensive treatment of conduction, convection (including boiling and condensation), and radiation heat transfer. Thermal system design and performance (including heat exchangers). Emphasis is on physical and mathematical modeling of engineering systems for application of modern analytical and computational solution methods.
Prerequisite: MANE 4010 or equivalent.
Offered: Fall term annually.
3 credit hours

MANE 4720
Design and Analysis of Energy Systems
The course focuses on design and analysis of energy systems from accessibility (cost), availability (security/reliability) and acceptability (Environmental, health impacts etc). The course discusses various forms of energy sources, various forms of energy consumption. The life cycle analyses build on first principles and thermo-economic considerations. Methods of life cycle analyses from net energy, economics and impact will be studied.
Prerequisite: MANE 4010.
Offered: Spring term annually.
3 credit hours

MANE 4750
Combustion Systems
Introduction to elementary theory of combustion and applications to energy sources, fires, and explosions. Discussion of internal and external combustion piston and turbine engines, solid-and liquid-propellant rockets, fire and explosion hazards of gaseous fuels, propellant and explosive performance.

Prerequisite: MANE 4010 or equivalent.
Offered: Fall term annually.
3 credit hours

MANE 4760
Heating, Ventilation, and Air Conditioning
Principles for the control of air properties to meet comfort and industrial requirements, load determination, psychrometry, cycles, transmission, distribution, and automatic control.
Prerequisite or corequisite: MANE 4010.
Offered: Fall term annually.
3 credit hours

MANE 4800
Boundary Layers and Heat Transfer
The Navier-Stokes equations and the boundary layer approximation. Exact solutions and integral methods of incompressible boundary layers. Transition; turbulence. Convective heat transfer in laminar and turbulent flow.
Prerequisite: MANE 4070 or MANE 4010.
Offered: Fall term annually.
3 credit hours

MANE 4830
Acoustics Engineering
Solutions of acoustic wave and diffusion equations; stationary and moving monopole, dipole, quadrupole sources; geometrical acoustics; acoustical impedance, energy density, source strength, intensity flux; near and far field approximations; stationary and moving boundary interaction (viscous, dilational boundary layers, streaming, scattering). Applications include propeller, turbulent noise; total- and semi-anechoic chambers; loudspeakers; microphones, straight, tapered fluidic transmission lines; water hammer; musical instruments; room acoustics; sound absorbing, transmitting, and reflecting solid, liquid, gaseous media property determination.
Prerequisites: ENGR 2090 and MATH 2400.
Offered: Spring term even-numbered years.
3 credit hours

MANE 4850
Space Vehicle Design
Space vehicle design introduces all elements of the spacecraft design process from proposal preparation through detailed specification and prototyping. Students are organized into design teams associated with different subsystems and tasks, to develop a solution to a space vehicle system's problem of practical interest, by drawing on their background in aerospace engineering science, machine design, and manufacturing methods. Topics include problem definition and requirement analysis, design specifications, concept development, reliability, consideration of alternative solutions, materials considerations, engineering prototyping, mission analysis, and presentation skills. This is a communication-intensive and writing-intensive course. Seniors only.
Offered: Fall term annually.
3 credit hours
MANE 4860  
Introduction to Helicopter Design  
Aerodynamics and dynamics of lifting rotors. Design concepts by which rotor weight and stress are minimized and vehicle control is provided. Weight and engine power trends for configuration definition. Center of gravity and aerodynamic lift and moment for equilibrium and desired aircraft attitude. Methods for determining size, weight, and cost for a given payload, useful volume, and specified performance. This is a communication-intensive course.  
Prerequisites: MANE 4200 Rotorcraft Performance, Stability, and Control and MANE senior standing.  
Offered: Spring term annually.  
3 credit hours

MANE 4900  
Aeroelasticity and Structural Vibrations  
Basic concepts in static and dynamic aeroelasticity. Structural vibrations, free and forced motion of discrete and continuous structures, introduction to modal analysis, and use of materials for dynamics tailoring. Aeroelastic behavior of complex structures, dynamic aeroelasticity. The phenomena of divergence, control surface effectiveness, and flutter and the use of composite materials for aeroelastic tailoring. The role of numerical methods will be emphasized.  
Prerequisites: MATH 2400, MANE 2060 and MANE 4060 or equivalent.  
Offered: Spring term annually.  
3 credit hours

MANE 4910  
Fluid Dynamics Laboratory  
Wind tunnel experiments in fluid mechanics and the aerodynamics of airplane models with emphasis on lift, drag, separation and stall, transition and turbulence, longitudinal and lateral stability, and data acquisition and analysis. This includes pressure and velocity measurement techniques, hot wire anemometry, demonstrations of Particle Imaging Velocimetry, flow visualizations, tunnel characterization, laboratory instrumentation, errors and noise in measurements, digital sampling, and comparison of measured data with theoretical and computational predictions.  
Prerequisite: MANE 4070.  
Offered: Fall and spring term annually.  
2 credit hours

MANE 4920  
Aerospace Structures and Control Laboratory  
Laboratory experiments with primary emphasis on lightweight structures, structural dynamics, and control as it applies to aircraft and spacecraft. Experiments include elastic instability, linear and nonlinear structural vibrations, gyrodynamics, spacecraft stability, the role of materials (including composites), etc.  
Prerequisite: MANE 4060.  
Offered: Spring term annually.  
2 credit hours

MANE 4940  
Individual Projects in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics  
Prerequisite: Permission of instructor.  
Offered: Fall and spring terms annually.  
3 to 6 credit hours

MANE 4960  
Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics  
Offered: Fall and spring terms annually.  
3 credit hours

MANE 5000  
Advanced Engineering Mathematics I  
A presentation of mathematical methods useful in engineering practice. The course covers analytical and numerical techniques used in linear algebra, the numerical solution of nonlinear equations, the foundations of vector and tensor algebra and an introduction to vector operators. Also covered are methods of polynomial and trigonometric interpolation and approximation, numerical solution methods for initial and boundary value problems for ordinary differential equations and an overview of the fundamentals of probability and statistics including random variables, density and distribution functions and hypothesis testing. Symbolic manipulation and scientific computation software used extensively. Emphasis on reliable computing is made throughout.  
3 credit hours

MANE 5060  
Introduction to Compressible Flow  
3 credit hours

MANE 5080  
Turbomachinery  
Representation of performance of turbomachines; mechanism of energy transfer; factors limiting design and performance including surge, choking, and cavitation; two- and three-dimensional flow phenomena; performance analysis including multistage effects and off-design performance.  
3 credit hours
MANE 5100
Mechanical Engineering Foundations I
A presentation of the principles of macroscopic transport useful in the analysis of mechanical engineering systems. The course covers the formulation energy mass and momentum balances in continua; the development of mathematical models of heat conduction and mass diffusion in solids and of flow in ideal and Newtonian fluids. Models are illustrated using examples from mechanical engineering. Particular attention throughout is devoted to the development of the ability to create realistic and reliable models.
3 credit hours

MANE 6060
Rotorcraft Performance, Stability, and Control
Topics in flight dynamics, generic to rotorcraft. Lift and propulsion system, hovering, forward flight. Longitudinal and lateral trim. Dynamic stability.
Corequisite: MANE 4050.
Offered: Fall term annually.
3 credit hours

MANE 6110
Kinematic Synthesis
Analytical and geometrical theories of function, path, and motion generation of four bar linkages. Consists of 3, 4, and 5 accuracy points. Review of recent developments and use of computer graphic methods.
Offered: Spring term annually.
3 credit hours

MANE 6120
Robotics
Elements of robot manipulators, mobility criteria, 3-D coordinate systems, matrix representation. Joint solutions and motion characteristics. Simulation on computer graphics. Hands-on experience of several robots and applications in industry.
Offered: Upon sufficient demand.
3 credit hours

MANE 6130
Dynamics of Rotating Machinery
Analytical basis of design for rotating machinery mounted on various types of bearing supports, as exemplified by turboshaft engines, centrifugal or axial flow compressors, vehicle drivetrains, etc. Description of analytical and numerical tools for evaluation of dynamic stability, critical speeds, and unbalance response of rotor-bearing systems. Special problems encountered in modern applications operating through and above the critical speeds, and means of their solution, including rigid and flexible rotor balancing and support damper design. Several informal laboratory sessions are included to enhance visualization of rotordynamic phenomena. Seniors and graduate students only.
Prerequisite: MANE 4170.
Offered: Upon availability of instructor.
3 credit hours

MANE 6150
Advanced Structural Analysis
Development and application of the variational formulation to structural dynamics problems involving effects such as rotary inertia, shear deformation, extensionality, and nonlinearities. Several papers published in the technical journals are also discussed during the semester.
Offered: Upon availability of instructor.
3 credit hours

MANE 6170
Mechanics of Solids
This course provides an introduction to the mechanics of solids from a continuum perspective. Topics covered in this course include: vector and tensor analysis, coordinate systems and calculus in curvilinear coordinate systems, kinematics (motion, deformation and strain), stress and momentum balance, energy principles and balance laws, linear isotropic and anisotropic elasticity, thermoelasticity, method of solutions for 2-D and 3-D linear elastic boundary value problems, applications to simple structures.
Offered: Fall term annually.
Cross listed: CIVL 6170. Students cannot obtain credit for both this course and CIVL 6170.
3 credit hours

MANE 6180
Mechanics of Composite Materials
Prerequisite: One graduate course in mechanics of solids.
Offered: Fall term annually.
Cross listed: CIVL 6180. Students cannot obtain credit for both this course and CIVL 6180.
3 credit hours

MANE 6200
Plates and Shells
Offered: Upon availability of instructor.
Cross listed: CIVL 6200. Students cannot obtain credit for both this course and CIVL 6200.
3 credit hours
MANE 6210  
**Structural Stability**  
Indicial and invariant notation, elements of variational calculus and nonlinear elasticity. Variational derivation of the linear stability equations for plates, rods, open thin-walled sections and cylindrical shells. Solutions of stability problems in each of these systems and development of approximation procedures.  
**Offered:** Upon availability of instructor.  
**Cross listed:** CIVL 6210. Students cannot obtain credit for both this course and CIVL 6210.  
**3 credit hours**

MANE 6240  
**Introduction to Neural Networks**  
Neural networks are program and memory at once, useful where traditional techniques fail, i.e., for artificial speech and image recognition. Emphasis on existing and emerging engineering applications. Parallel distributed processing, Hebb’s rule, Hopfield net, back-propagation algorithm, perceptrons, unsupervised learning, Kohonen self-organizing map, genetic algorithms, neocognitron, adaline. Illustrated with computer programs and lectures.  
**Offered:** Upon sufficient demand.  
**Cross listed:** ISYE 6870. Students cannot obtain credit for both this course and ISYE 6870.  
**3 credit hours**

MANE 6250  
**Continuum Mechanics**  
**Prerequisites:** MANE 4330 or permission of instructor.  
**Offered:** Fall term annually.  
**3 credit hours**

MANE 6270  
**Environmental Radiation Safety Controls**  
Consideration and control of the health hazards peculiar to the atomic industry. Radiological units; exposure control; shielding; fallout; toxic materials; shipping and storage; waste disposal; legal aspects. Introduction to criticality hazards. Nonionizing radiation.  
**Prerequisites:** MANE 2400 or equivalent.  
**Offered:** Upon availability of instructor.  
**4 credit hours**

MANE 6280  
**Nuclear Reactor Analysis II**  
**Prerequisite:** MANE 4480.  
**Offered:** Fall term annually.  
**3 credit hours**

MANE 6290  
**Radiation Transport Methods**  
**Prerequisite:** MANE 4480.  
**Offered:** Spring term odd-numbered years.  
**3 credit hours**

MANE 6300  
**Numerical Methods in Reactor Analysis**  
Difference equations; matrix operation, linear systems, matrix eigenvalue problems, multi-group diffusion, and transport theory methods. Sn calculations, Monte Carlo methods. Application to nuclear engineering calculations, such as flux and power distributions, heat conduction, programming reactor problems for digital computers, codes, etc.  
**Prerequisites:** MANE 4480, MATH 4600 or equivalent.  
**Offered:** Fall term odd-numbered years.  
**3 credit hours**

MANE 6310  
**Reactor Design**  
The reactor design problem is studied using current methods. Emphasis is placed on thermal and hydraulic analyses of power reactors, neutronics, fuel cycles, economics, nuclear analysis, control, siting, and safety. Complete reactor systems are analyzed. Standard reactor design codes are utilized.  
**Prerequisite:** MANE 2400 (may be concurrent).  
**Offered:** Spring term even-numbered years.  
**3 credit hours**
MAME 6320  
Radiation Waste Management  
Prerequisite: MANE 2400.  
Offered: Spring term odd-numbered years.  
3 credit hours

MAME 6350  
Radiation Shielding  
Prerequisite: MANE 4480.  
Offered: Upon availability of instructor.  
3 credit hours

MAME 6360  
Reactor Reliability and Safety  
Prerequisites: MANE 4050 and MATH 4600.  
Offered: Upon availability of instructor.  
3 credit hours

MAME 6370  
Thermal-Hydraulic Design of Nuclear Reactors  
An introduction to the principles underlying the thermal-hydraulic design of nuclear power reactors. Topics include plant thermal limits, sub-channel analysis, thermal-hydraulic stability analysis, and reactor system response during both normal and postulated accidental conditions.  
Prerequisite: MANE 6840 or equivalent.  
Offered: Upon availability of instructor.  
3 credit hours

MAME 6380  
Nuclear Reactor Materials  
The physical metallurgy and associated physical chemistry of problems encountered in the application of materials in nuclear reactors is discussed. Specifically, the metallurgy and physical chemistry of ceramic fuels (e.g., oxygen potentials), the primary fuel densification and pellet-clad interaction mechanisms, irradiation-induced creep, hardening, and embrittlement mechanisms, and the properties of zircalloy are covered.  
Prerequisite: MANE 4480.  
Offered: Upon availability of instructor.  
3 credit hours

MAME 6390  
Atomic and Nuclear Physics Applications  
Principles and design of spectrometers and accelerators; NMR, ESR, Mossbauer methods, lasers, microwave devices, and combinations of these; sources, beam transport and focusing; targets and effects.  
Prerequisite: MANE 4410.  
Offered: Spring term odd-numbered years.  
3 credit hours

MAME 6400  
Analytical Dynamics  
A fundamental course in dynamics of rigid and flexible bodies. Review of kinematics and Newtonian dynamics; virtual variations and fundamentals of calculus of variations; generalized coordinates, velocities and momenta; constraints; generalized Hamilton's principle and Lagrangean dynamics; rotational dynamics, orientation angles and Euler parameters; brief introduction to the analysis of nonlinear systems and stability of motion. Applications to the motion of rigid and flexible bodies. The role of symbolic manipulation in dynamics is introduced.  
Offered: Fall term annually.  
3 credit hours

MAME 6420  
Multibody Dynamics  
Analytical and numerical analysis of dynamic behavior of multibody mechanical systems. Emphasis on understanding all aspects of modeling and analysis process associated with real (spacecraft, automotive, biomechanical, etc.) systems. Review of traditional dynamic analysis methods (Newtonian-Euler, Lagrangean, etc.), presentation of more efficient, powerful, recently developed methods (including Kane's method). Comparison of the different formulations and their applicability to computer simulation. Treatment of constraints, extraction of data from equations of motion, and computational issues.  
Offered: Spring term even-numbered years.  
3 credit hours
MANE 6430  
**Nonlinear Vibrations**  
A fundamental course in nonlinear vibrations and stability. Basic concepts about linear and nonlinear systems; Routh-Hurwitz and Liapunov’s stability criteria; systems with periodic coefficients and Floquet theory; effects of nonlinearities; limit cycles, jump, saturation, nonlinear resonances, modal energy exchange, etc.; perturbation methods: straightforward perturbations, Lindstedt-Poincare, harmonic balancing, multiple time scales; steady-state and transient responses of nonlinear systems. Applications to discrete and structural systems. Use of symbolic manipulation to analyze problems.  
**Offered:** Upon availability of instructor.  
**3 credit hours**

MANE 6450  
**Mechanics of Materials Processing**  
Modeling and analysis of common manufacturing processes. Topics include bulk-forming, sheet-forming, and casting processes. Classical analysis techniques, upper bound analysis, slip-line field theory, asymptotic methods, and the finite element method are investigated.  
**Prerequisite:** MANE 4330 or MANE 6170 or equivalent.  
**Offered:** Upon sufficient demand.  
**3 credit hours**

MANE 6460  
**Fracture Mechanics and Fatigue of Materials**  
**Prerequisites:** ENGR 2530, MANE 4670 or approval of instructor.  
**Offered:** Spring term odd-numbered years.  
**3 credit hours**

MANE 6480  
**Health Physics and Medical Aspects of Radiation**  
Use of radioisotopes and radiation in nuclear medicine, radiation chemistry, basis of dosimetry, ionizing and nonionizing energy transfer processes in living tissue and cells. Radiation effects on the structure of nucleic acids, proteins, and cell membranes with emphasis on mechanisms by which cell viability is lost. Background in radiation chemistry is developed in particular for engineering majors. Applications are given in nuclear medicine, cancer therapy, and radiation in the environment.  
**Offered:** Spring term odd-numbered years.  
**3 credit hours**

MANE 6490  
**Plasticity**  
**Offered:** Fall term annually.  
**3 credit hours**

MANE 6500  
**Non-Newtonian Fluid Mechanics**  
Flow of non-Newtonian fluids such as polymeric liquids, granular mixtures, etc. Flow phenomena and material functions. Integral and differential constitutive equations for generalized Newtonian, linear viscoelastic, and ordered fluids.  
**Offered:** Upon sufficient demand.  
**3 credit hours**

MANE 6530  
**Turbulence**  
Navier-Stokes equations, linear stability, vorticity and its origin, transition in wall-bounded and free-shear flows, statistics and Reynolds averaging, homogeneous turbulence, coherent structures, laboratory methods for study of turbulence, including turbulence measurements and turbulence modeling.  
**Prerequisite:** MANE 4800 or equivalent.  
**Offered:** Spring term annually.  
**3 credit hours**

MANE 6540  
**Advanced Thermodynamics**  
**Offered:** Upon availability of instructor.  
**3 credit hours**

MANE 6550  
**Theory of Compressible Flow**  
**Prerequisite:** MANE 4070 or equivalent.  
**Offered:** Fall term annually.  
**3 credit hours**
MANE 6560
Incompressible Flow
Graduate fluid mechanics course on classical and modern approaches to hydrodynamics. Topics cover three areas, (1) surface waves, (2) flow instability, and (3) vortex dynamics. Wave topics include linear dispersive and nondispersive waves, weakly nonlinear waves, and viscous effects, with special attention to surface tension phenomena. Flow instabilities include gravitational, capillary, thermal, centrifugal, and viscous instabilities. Topics in vortex dynamics include vortex laws and flow invariants, generation and decay of vorticity, and vortex-boundary interaction.
Offered: Fall term odd-numbered years.
3 credit hours

MANE 6600
Systems Analysis Techniques
Methods of analysis for continuous and discrete-time linear systems. Convolution, classical solution of dynamic equations, transforms and matrices are reviewed. Emphasis is on the concept of state space. Linear spaces, concept of state, modes, controllability, observability, state transition matrix. State variable feedback, compensation, decoupling.
Prerequisite: MANE 4050 or ECSE 2410 or equivalent.
Offered: Fall term annually.
3 credit hours

MANE 6630
Conduction Heat Transfer
An introduction to the mathematics of conduction heat transfer. Applications of results illustrated by examples from furnace design, cooling of electric components, building design, heat exchanger design.
Offered: Fall term annually.
3 credit hours

MANE 6640
Radiation Heat Transfer
An introduction to radiation heat transfer in diathermanous media and participating media. Selected applications from spacecraft design, furnace design, meteorology, temperature measurement, environmental control.
Offered: Fall term even-numbered years.
3 credit hours

MANE 6650
Convective Heat Transfer
Fundamental study of convection heat transfer in laminar and turbulent internal and external flows. Unsteady flows, combined heat and mass transfer, conjugated unsteady heat transfer, and buoyancy induced convection. Selected applications from aeronautics and heat exchanger design.
Prerequisite: MANE 4800 or equivalent.
Offered: Spring term annually.
3 credit hours

MANE 6660
Fundamentals of Finite Elements
Graduate-level course on the fundamental concepts and technologies underlying finite element methods for the numerical solution of continuum problems. The course emphasizes the construction of integral weak forms for elliptic partial differential equations and the construction of the elemental level matrices using multi-dimensional shape functions, element level mappings, and numerical integration. The basic convergence properties of the finite element method will be given. This course serves as preparation for students working on finite element methods.
Prerequisite: MATH 2400 or equivalent.
Offered: Fall term annually.
Cross listed: CIVL 6660. Students cannot obtain credit for both this course and CIVL 6660.
3 credit hours

MANE 6670
Nonlinear Finite Element Methods
The formulations and solution strategies for finite element analysis of nonlinear problems are developed. Topics include the sources of nonlinear behavior (geometric, constitutive, boundary condition), derivation of the governing discrete equations for nonlinear systems such as large displacement, nonlinear elasticity, rate independent and dependent plasticity and other nonlinear constitutive laws, solution strategies for nonlinear problems (e.g., incrementation, iteration), and computational procedures for large systems of nonlinear algebraic equations.
Prerequisite: CIVL 6660 or MANE 6660.
Offered: Fall term odd-numbered years.
Cross listed: CIVL 6670. Students cannot obtain credit for both this course and CIVL 6670.
3 credit hours

MANE 6680
Finite Element Programming
Examines the implementation of finite element methods. Consideration is first given to the techniques used in classic finite element programs. Attention then focuses on development of a general geometry-based code which effectively supports higher order adaptive technique. Technical areas covered include: effective construction of element matrices for p-version finite elements, ordering of unknowns, automatic mesh generation, adaptive mesh improvement, program and database structures. Implementation of automated adaptive techniques on parallel computers is also covered.
Prerequisite: CIVL 6660, MANE 6660, CSCI 6860, or MATH 6860.
Offered: Spring term odd-numbered years.
Cross listed: CIVL 6680. Students cannot obtain credit for both this course and CIVL 6680.
3 credit hours
MANE 6690  
Advanced Finite Element Formulations  
This course focuses on generalized weighted residual methods and multi-field variational principles for constructing approximate solutions to sets of governing differential equations and associated boundary conditions. Topics include hybrid and mixed methods, boundary element formulations, p-version finite elements, global/local procedures, and penalty methods. Problem areas include solid mechanics (nearly incompressible solids, plates, and shells), fluid mechanics including compressible flows, and heat transfer.  
Prerequisite: CIVL 6660 or MANE 6660.  
Offered: Spring term even-numbered years.  
Cross listed: CIVL 6690. Students cannot obtain credit for both this course and CIVL 6690.  
3 credit hours

MANE 6700  
Finite Element Methods in Structural Dynamics  
Solutions to the free vibration and transient dynamic responses of two- and three-dimensional structures by the finite element method are considered. The governing finite element matrix equations are derived and numerical aspects of solving these time-dependent equations considered. Topics include the formulation of the eigenvalue problem, algorithms for eigenvalue extraction, time integration methods including stability and accuracy analysis, and finite elements in time. Modal analysis and direct time integration techniques are compared for a variety of two- and three-dimensional problems.  
Prerequisite: CIVL 6660 or MANE 6660.  
Offered: Fall term odd-numbered years.  
Cross listed: CIVL 6700. Students cannot obtain credit for both this course and CIVL 6700.  
3 credit hours

MANE 6720  
Computational Fluid Dynamics  
Course focuses on computational approaches to solve the Navier-Stokes equations. Course assumes knowledge of numerical methods and therefore directly attacks the obstacles to applying these methods to the Navier-Stokes equations. Issues concerning implementation of finite difference methods (FDM), finite volume methods (FVM) and finite element methods (FEM) will be discussed. These issues include: the discrete formulation, nonlinear equation iterator (steady)/marcher (time-accurate), linear equation formation, boundary condition prescription, and linear equation solution.  
Prerequisite: MANE 6660 or equivalent.  
Offered: Spring term even-numbered years.  
3 credit hours

MANE 6730  
Tribology  
A basic course in tribology that covers both the fundamental and applied aspects of the subject. Content includes viscometry, the Reynolds equation, thrust and journal bearings (including design), thermal effects, dynamic loading and instability of bearings, rolling contact bearings, dry bearings, and theories of wear. This course includes design principles and data and is basic to other courses offered in tribology. Restricted to graduate students.  
Offered: Fall term odd-numbered years.  
3 credit hours

MANE 6740  
Advanced Topics in Tribology  
A course for students already versed in the basic concepts of hydrodynamic lubrication. Advanced topics of current interest in the field are stressed. Material may be drawn from the literature and taught by experts in the particular field. Recent areas covered include elastohydrodynamic lubrication, bearing and rotor dynamics, inertia and turbulence effects. Restricted to graduate students.  
Prerequisite: MANE 6730 or permission of instructor.  
Offered: Spring term annually.  
3 credit hours

MANE 6750  
Generalized Finite Element Methods  
Fundamentals of modern numerical techniques (e.g., partition of unity methods) which overcome longstanding difficulties associated with traditional FEM (e.g., mesh generation and resolution of singularities). Topics include scattered data interpolation, weighted residual methods, integral equation methods for exterior problems (applications to MEMS modeling), multiscale solution techniques using wavelets.  
Prerequisite: MANE 4240 or CIVL 4240 or equivalent.  
Offered: Spring term odd-numbered years.  
3 credit hours

MANE 6760  
Finite Element Methods for Fluid Dynamics  
Analysis of finite element methods for basic classes of problems in fluid mechanics. Starting with scalar transport equations and building to compressible and incompressible Navier-Stokes equations. Emphasis on developing and analyzing formulations that are stable and higher-order accurate such as Galerkin/least-squares methods and SUPG methods. Unsteady formulations are proposed using space-time methods and semi-discrete methods.  
Prerequisite: MANE 6660.  
Offered: Spring term odd-numbered years.  
3 credit hours
MANE 6770
Multiscale Computational Modeling
This course will introduce a unified approach of modeling in science and engineering across spatial and temporal scales using particles as well as continuum fields, specifically focusing on methods and algorithms that will facilitate this bridging. Topics include two categories of multiscale approaches: information-passing and concurrent-bridging approaches. Our goal is to algorithmically develop these methods, and in the process teach the underlying simulation techniques. Applications to realistic problems will highlight the strengths of these approaches, while stressing the challenges that still need to be surmounted.
Prerequisite: MANE 4240 or equivalent.
Offered: Spring term even-numbered years.
3 credit hours

MANE 6780
Numerical Modeling of Failure Processes in Materials
State of the art in computational modeling of failure processes in materials. Topics include numerical modeling of discrete defects, distributed damage and multiscale computational techniques including multiple scale perturbation techniques, boundary layer techniques, and various global-local approaches.
Prerequisite: CIVL 6660 or MANE 6660.
Offered: Spring term even-numbered years.
Cross listed: CIVL 6780. Students cannot obtain credit for both this course and CIVL 6780.
3 credit hours

MANE 6800
Manufacturing Systems Integration
Examination of the basic elements that are used to integrate the design and manufacture of capital and consumer products; manufacturing information systems, CAD/CAM systems, and manufacturability considerations when integrating unit process operations.
Offered: Fall term annually.
3 credit hours

MANE 6820
Finite Deformation Plasticity: Theory and Applications
Kinematics of Finite Deformation
Elastic-plastic and elasto-viscoplastic constitutive behavior for isotropic and strain-induced anisotropic materials. Integration algorithms and finite element formulations for solving practical problems.
Prerequisite: MANE 6170 or equivalent.
Offered: Spring term odd-numbered years.
3 credit hours

MANE 6830
Combustion
Review of fundamentals of thermodynamics, chemical kinetics, fluid mechanics, and modern diagnostics. Discussion of flame propagation, thermal and chain explosions, stirred reactors, detonations, droplet combustion, and turbulent jet flames. Introduction to computational tools for complex equilibrium and kinetic calculations. Application to problems such as pollutant formation.
Prerequisite: Permission of instructor.
Offered: Spring term odd-numbered years.
Cross listed: CHME 6830. Students cannot obtain credit for both this course and CHME 6830.
3 credit hours

MANE 6840
An Introduction to Multiphase Flow and Heat Transfer I
This course is intended to give students a state-of-the-art understanding about single and multicomponent boiling and condensation heat transfer phenomena. Applications include the analysis of nuclear reactors, oil wells, and chemical process equipment.
Prerequisite: A working knowledge of fluid mechanics and heat transfer.
Offered: Full term annually.
Cross listed: CHME 6840. Students cannot obtain credit for both this course and CHME 6840.
3 credit hours

MANE 6850
An Introduction to Multiphase Flow and Heat Transfer II
This course is intended to give students a state-of-the-art understanding in multicomponent flow phenomena. Applications in the chemical process, petroleum recovery, and fossil/nuclear power industries are given. Specific areas of coverage include two-phase: fluid mechanics, pressure drop, modeling and analysis, stability analysis, critical flow and dynamic waves, flow regime analysis, and phase separation and distribution phenomena.
Prerequisite: CHME 6840 or MANE 6840.
Offered: Spring term annually.
Cross listed: CHME 6850. Students cannot obtain credit for both this course and CHME 6850.
3 credit hours

MANE 6880
Product Realization
Concepts and tools that enable engineers and business leaders to jointly make sound business/technology decisions in moving from ideas and designs to real products will be taught using lectures, cases, and a major project that will enhance the change of success of a new venture business. Topics: Disciplined Toll-Gate Processes, Customer Contract, Technical Risk Management, Design Decisions, Quality Management, Sourcing, Product Launch.
Prerequisites: Engineering B.S. or MGMT 6040 and MGMT 6050 or MGMT 6620 or permission of the instructor.
Offered: Spring term annually.

MANE 6900
Seminar
Offered: Fall and spring terms annually.
0 credit hours
MANE 6940
Individual Projects in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
Prerequisite: Permission of instructor.
Offered: Fall and spring terms annually.
3 to 6 credit hours

MANE 6960
Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
Offered: Fall and spring terms annually.
3 credit hours

MANE 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.
1 to 9 credit hours

MANE 6980
Master’s Project
Active participation in a Master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the library. Grades will then be listed as S.
1 to 9 credit hours

MANE 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
1 to 9 credit hours

MANE 7000
Advanced Engineering Mathematics II
A continuation of the advanced presentation of mathematical methods useful in engineering practice. The course covers the Frobenius method for the solution of boundary value problems; the representation of arbitrary functions by characteristic functions; calculus of functions of more than one variable including the study of extreme; overview of calculus of variations; principles of vector and tensor analysis; analytical and numerical techniques for the solution of initial and boundary value problems in partial differential equations. Symbolic manipulation and scientific computation software used extensively. Emphasis on reliable computing is made throughout.
3 credit hours

MANE 7100
Mechanical Engineering Foundations II
A presentation of the most common physical and mathematical modes used in the description of the mechanical behavior of materials. The course covers the microstructural and thermodynamic foundations of constitutive material behavior of interest in mechanical engineering applications; overview of elasticity and plasticity and their relationship to microstructural features; principles of rheology; viscoelasticity and creep; failure mechanisms including fracture crack propagation and fatigue crack growth. Particular attention throughout is given to the development of the ability to utilize the mathematical models to assess the reliability and life of mechanical engineering components at the design state.
3 credit hours

MANE 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
1 to 15 credit hours
MATH Mathematics (SOS)

MATH 1010
Calculus I
Functions, limits, continuity, derivatives, implicit differentiation, related rates, maxima and minima, elementary transcendental functions, introduction to definite integral with applications to area and volumes of revolution.
Offered: Fall and spring terms annually.
4 credit hours

MATH 1020
Calculus II
Techniques and applications of integration, polar coordinates, parametric equations, infinite sequences and series, vector functions and curves in space, functions of several variables, and partial derivatives.
Prerequisite: MATH 1010.
Offered: Fall and spring terms annually.
4 credit hours

MATH 1500
Calculus for Architecture, Management, and HASS
Basic concepts in differential and integral calculus for functions of one variable. Topics will include functions, limits, continuity, derivatives, integration, exponential and logarithmic functions, and techniques of integration. Application areas will include topics in Management, Architecture, and Social Sciences with special emphasis on the role of calculus in introductory probability. Students who have passed MATH 1010 cannot obtain credit for MATH 1500.
Prerequisite: Major in Management, Architecture, or HASS.
Offered: Fall term annually.
1 credit hour

MATH 1520
Mathematical Methods in Management and Economics
Functions of several variables, introductory linear algebra, and other analytical techniques needed for further study in probability, statistics, and operations research. Topics covered include improper integrals, probability density functions, partial derivatives and optimization techniques for functions of several variables, matrix algebra, linear systems, lines and planes in 3-space, linear inequalities, introductory linear programming, introductory combinatorics, and some probability. Students who have passed MATH 1020 cannot register for this course.
Prerequisites: MATH 1010 or MATH 1500 and major in Management or Economics, or permission of instructor.
Offered: Spring term annually.
4 credit hours

MATH 1620
Contemporary Mathematical Ideas in Society
An application-oriented course introducing contemporary mathematical concepts that pertain to areas of Architecture and Humanities, Arts, and Social Sciences. The course will cover growth and form, symmetry, patterns, tilings, linear programming, information coding, voting systems, game theory, logic, probability and statistics.
Prerequisites: Major in Architecture or Humanities, Arts, and Social Sciences and MATH 1010 or MATH 1500 or permission of instructor.
Offered: Spring term annually.
4 credit hours

MATH 1900
Art and Science of Mathematics I
A seminar for first-year math majors. The weekly student-faculty discussions will vary but examples of topics are: unsolved math problems, countability and the arithmetic of the infinite, topology and the concept of dimension, geometry and one-sided surfaces, and the theory underlying topics currently covered in calculus. This course cannot be used to help satisfy the eight credit hours of mathematics bachelor’s degree requirement.
Prerequisite: First-year math majors.
Offered: Fall term annually.
1 credit hour

MATH 1910
Art and Science of Mathematics II
A seminar for first-year math majors. The weekly student-faculty discussions will vary but examples of topics are: unsolved math problems, countability and the arithmetic of the infinite, topology and the concept of dimension, geometry and one-sided surfaces, and the theory underlying topics currently covered in calculus. This course cannot be used to help satisfy the eight credit hours of mathematics bachelor’s degree requirement.
Prerequisite: First-year math majors.
Offered: Spring term annually.
1 credit hour

MATH 2010
Multivariable Calculus and Matrix Algebra
Directional derivatives, maxima and minima, double integrals, line integrals, div and curl, and Green’s Theorem; matrix algebra and systems of linear equations, vectors and linear transformations in \( \mathbb{R}^n \), eigenvectors and eigenvalues, applications in engineering and science.
Prerequisite: MATH 1020.
Offered: Fall and spring terms annually.
4 credit hours
MATH 2400
Introduction to Differential Equations
First-order differential equations, second-order linear equations, eigenvalues and eigenvectors of matrices, systems of first-order equations, stability and qualitative properties of nonlinear autonomous systems in the plane, Fourier series, separation of variables for partial differential equations.
Prerequisites: MATH 1020 and some knowledge of matrices. Offered: Fall and spring terms annually.
4 credit hours

MATH 2800
Introduction to Discrete Structures
Introduction to the mathematical foundation of computer science. Topics include logic and set theory; methods of proof; mathematical induction and wellordering; principles of counting; relations and graphs; recurrences; discrete probability.
Prerequisite: MATH 1010 or MATH 1500 or equivalent. Offered: Spring term annually.
4 credit hours

MATH 2940
Readings in Mathematics
1 to 4 credit hours

MATH 2960
Topics in Mathematics
1 to 4 credit hours

MATH 4010
Abstract Algebra
Groups, rings, polynomial rings, fields, integral domains, with emphasis on group theory; homomorphisms and isomorphisms; normal subgroups, cosets, ideals, modules; quotient groups and quotient rings; other topics chosen from number theory, polynomials and Galois Theory.
Prerequisite: MATH 4090 or graduate standing or permission of the instructor. Offered: Spring term annually.
4 credit hours

MATH 4020
Introduction to Number Theory
Topics include the history of number representation systems, divisibility, greatest common divisor and prime factorization, linear Diophantine equations, congruences, and condition congruences. Additional topics may be chosen from cryptography, the perpetual calendar, hashing functions, computer operations and complexity, continued fractions, multiplicative functions, primitive roots, pseudo-random numbers, nonlinear Diophantine equations, Fermat’s last theorem, algebraic numbers, and approximation of numbers by rationals.
Prerequisite: MATH 1020. Offered: Spring term odd-numbered years.
4 credit hours

MATH 4030
Computability and Logic
A team-based, project-oriented, hands-on introduction to great concepts and discoveries in logic and computability, including Turing Machines, first order logic, the limitations of computing machines, Godel’s incompleteness results and so forth. A hands-on laboratory component is included.
Prerequisite: PHIL 2140. Offered: Spring term annually.
Cross listed: PHIL 4420. Students cannot obtain credit for both this course and PHIL 4420.
4 credit hours

MATH 4040
Introduction to Topology
Topics include general topological spaces, connectedness, compactness, continuity, and product spaces. Additional topics may be chosen from identification spaces, homotopy, the fundamental group, covering maps, lifts, classification of surfaces, Baire category, dimension, and the Jordan curve theorem.
Prerequisite: MATH 4090 or graduate standing or permission of the instructor. Offered: Fall term even-numbered years.
4 credit hours

MATH 4090
Foundation of Analysis
The course provides an opportunity for the development of theorem-proving skills in the field of mathematical analysis. Expansion of a knowledge base comes as a by-product of energy expended in theorem proving and subsequent exposition. Analysis topics included are: sets, functions, the real numbers, cardinality, induction, decimal representations of real numbers, Euclidean spaces, abstract vector spaces, and metric spaces. This is a communication-intensive course.
Prerequisite: Mathematics major, Corequisite: MATH 2010 or permission of instructor. Offered: Fall and spring terms annually.
4 credit hours

MATH 4100
Linear Algebra
The theory underlying vector spaces, algebra of subspaces, bases; linear transformations, dual spaces; eigenvectors, eigenvalues, minimal polynomials, canonical forms of linear transformations; inner products, adjoints, orthogonal projections and complements.
Prerequisite: MATH 2010. Offered: Fall term annually.
4 credit hours
MATH 4120
Fundamentals of Geometry
Topics may be chosen from differential geometry of curves and surfaces, involutes and evolutes, order of contact, developable surfaces, Euler’s and Meusnier’s Theorem, mean and Gaussian curvatures, geodesics and parallel transport, The Theorem Egregium of Gauss, Gauss-Bonnet Theorem, computer-aided geometric design, computational geometry, tessellations, tiling and patterns, projective and non-Euclidean geometries, postulates and axiomatic systems, advanced Euclidean geometry, and the history of geometry.
Prerequisites: MATH 2010 and MATH 4600 or permission of the instructor.
Offered: Spring term even-numbered years.
4 credit hours

MATH 4150
Graph Theory
Fundamental concepts and methods of graph theory and its applications in various areas of computing and the social and natural sciences. Topics include graphs as models, representation of graphs, trees, distances, matchings, connectivity, flows in networks, graph colorings, Hamiltonian cycles, traveling salesman problem, planarity. All concepts, methods, and applications are presented through a sequence of exercises and problems, many of which are done with the help of novel software systems for combinatorial computing.
Prerequisite: MATH 2800 and CSCI 1100. Spring term even-numbered years.
Offered: Spring term even-numbered years.
Cross listed: CSCI 4260. Students cannot obtain credit for both this course and CSCI 4260.
4 credit hours

MATH 4200
Mathematical Analysis I
Fundamental concepts of mathematical analysis. This is the first course in a two-term sequence covering such topics as the real number system, limits, sequences, series, convergence, uniform convergence, functions of one variable, continuity, differentiability, Riemann integration, Stone-Weierstrass Theorem, functions of several variables, trigonometric series, differential forms on manifolds, and the higher dimensional Stokes Theorem. Qualified as a writing-intensive course.
Prerequisites: MATH 4200 or graduate standing or permission of the instructor.
Offered: Fall term annually.
4 credit hours

MATH 4210
Mathematical Analysis II
Fundamental concepts of mathematical analysis. This is the second course in a two-term sequence covering such topics as the real number system, limits, sequences, series, convergence, uniform convergence, functions of one variable, continuity, differentiability, Riemann integration, Stone-Weierstrass Theorem, functions of several variables, trigonometric series, differential forms on manifolds, and the higher dimensional Stokes Theorem. Qualified as a writing-intensive course.
Prerequisites: MATH 4200 or graduate standing or permission of the instructor.
Offered: Spring term annually.
4 credit hours

MATH 4300
Introduction to Complex Variables: Theory and Applications
An introduction to the theory and applications of complex variables. Topics include analytic functions, Riemann surfaces, complex integration, Taylor and Laurent series, residues, conformal mapping, harmonic functions, and Laplace transforms. Applications will be to problems in science and engineering such as fluid and heat flow, dynamical systems, and electrostatics.
Prerequisite: MATH 2010 or equivalent.
Offered: Spring term annually.
4 credit hours

MATH 4400
Ordinary Differential Equations and Dynamical Systems
An intermediate course emphasizing a modern geometric approach and applications in science and engineering. Topics include first-order equations, linear systems, phase plane, linearization and stability, calculus of variations, Lagrangian and Hamiltonian mechanics, oscillations, basic bifurcation theory, chaotic dynamics, and existence and uniqueness.
Prerequisite: MATH 2400 or permission of instructor.
Offered: Fall term annually.
4 credit hours

MATH 4500
Methods of Partial Differential Equations of Mathematical Physics
An intermediate course serving to introduce both the qualitative properties of solutions of partial differential equations and methods of solution, including separation of variables. Topics include first-order equations, derivation of the classical equations of mathematical physics (wave, potential, and heat equations), method of characteristics, construction and behavior of solutions, maximum principles, energy integrals.
Prerequisite: MATH 4600 or permission of instructor.
Offered: Spring term annually.
4 credit hours

MATH 4600
Advanced Calculus
Topics include differentials and derivatives of functions of several variables, Jacobians, Lagrange multipliers, line, surface and volume integrals, independence of path, curvilinear coordinates, vector calculus, calculus of variations, theorems of Green, Gauss, and Stokes.
Prerequisites: MATH 2010.
Offered: Fall and spring terms annually.
4 credit hours
MATH 4700
Foundations of Applied Mathematics
Mathematical formulation of models for various processes. Derivation of relevant differential equations from conservation laws and constitutive relations. Use of dimensional analysis, scaling, and elementary perturbation methods. Description of basic wave motion. Examples from areas including biology, elasticity, fluid dynamics, particle mechanics, chemistry, geophysics, and finance.
Prerequisite: MATH 2400 or equivalent.
Offered: Fall term annually.
4 credit hours

MATH 4720
Mathematics in Medicine and Biology
An introduction to mathematics used in biology, biophysics, biomedical engineering, and medicine. The mathematical topics covered are selected from calculus, linear algebra, differential equations, numerical methods, and Fourier analysis. The biological applications covered are selected from human physiology (heart, lung, brain), population models (microorganisms, cells, animals), and the diagnosis and treatment of disease (heart, cancer).
Prerequisite: MATH 1020.
Offered: Fall term annually.
4 credit hours

MATH 4740
Introduction to Financial Mathematics and Engineering
This course is designed to introduce students to mathematical and computational finance. Topics include a mathematical approach to risk analysis, portfolio selection theory, futures, options and other derivative investment instruments. Finite difference and finite element methods for computing American option prices are discussed. A working knowledge of MAPLE or MATLAB is required to compute optimal portfolios.
Prerequisite: MATH 1020.
Offered: Fall term annually.
4 credit hours

MATH 4800
Numerical Computing
A survey of numerical methods for scientific and engineering problems. Topics include numerical solution of linear and nonlinear algebraic equations, interpolation and least squares approximations, numerical integration and differentiation, eigenvalue problems, and an introduction to the numerical solution of ordinary differential equations. Emphasis placed on efficient computational procedures including the use of library and student written procedures using high-level software such as MATLAB.
Prerequisites: CSCI 1100 and MATH 2010 or ENGR 1100. Corequisite: MATH 2400.
Offered: Fall and spring terms annually.
Cross listed: CSCI 4800. Students cannot obtain credit for both this course and CSCI 4800.
4 credit hours

MATH 4820
Introduction to Numerical Methods for Differential Equations
Derivation, analysis, and use of computational procedures for solving differential equations. Topics covered include ordinary differential equations (both initial value and boundary value problems) and partial differential equations. Runge-Kutta and multistep methods for initial value problems. Finite difference methods for partial differential equations including techniques for heat conduction, wave propagation, and potential problems. Basic convergence and stability theory.
Prerequisite: MATH 4800 or CSCI 4800.
Offered: Spring term annually.
Cross listed: CSCI 4820. Students cannot obtain credit for both this course and CSCI 4820.
4 credit hours

MATH 4940
Readings in Mathematics
1 to 4 credit hours

MATH 4950
Senior Research
Undergraduate mathematics projects that utilize students’ mathematical knowledge will result in formal reports and final presentations. Examples are research projects or critical in-depth mathematical literature reviews. Information about projects will be exchanged in weekly meetings. Students wishing to work on research should make arrangements with faculty in advance. Students already engaged in research may extend and present their results. This is a communication-intensive course. To be graded S/U.
Prerequisite: Open to mathematics seniors only.
Offered: Fall term annually.
4 credit hours

MATH 4960
Topics in Mathematics
1 to 4 credit hours

MATH 4980
Undergraduate Project in Mathematics
1 to 4 credit hours

MATH 6190
Topics from Pure Mathematics
The course is intended to provide a mathematical perspective on one or more topics chosen from algebra, geometry, and/or topology. Topics may include combinatorial matrix theory, classification of surfaces, Lie groups, Galois theory, geometric analysis, computational geometry, homology, and/or fixed point theorems.
Prerequisites: Vary with topic.
Offered: Spring term even-numbered years.
4 credit hours
MATH 6200
Real Analysis
A careful study of measure theory, including abstract and Lebesgue measures and integration, absolute continuity and differentiation, $L^p$ spaces, Fourier transforms and Fourier series, Hilbert spaces and normed linear spaces.
Prerequisite: MATH 4210 or equivalent or permission of instructor.
Offered: Spring term even-numbered years.
4 credit hours

MATH 6220
Introduction to Functional Analysis
A basic course in the concepts of linear functional analysis, including such topics as linear functionals, bounded linear operators, unbounded linear operators, graphs, adjoints, spectral theory of linear operators, and applications to differential equations and mathematical physics.
Prerequisites: MATH 4210, MATH 4300, or permission of instructor; MATH 6200 or equivalent also desirable.
Offered: Fall term annually.
4 credit hours

MATH 6240
Functional Analysis and Analysis for Nonlinear Operators
A continuation of material presented in MATH 6220. Covers such topics as inverse and implicit function theorems, fixed point theorems, Riesz bases, distributions and Sobolev spaces, variational methods, degree theory, and applications to differential equations. and mathematical physics.
Prerequisite: MATH 6220 or equivalent or permission of instructor.
Offered: Spring term odd-numbered years.
4 credit hours

MATH 6300
Complex Analysis
A basic graduate course covering Cauchy’s Theorem, residues, infinite series and products, partial fractions, conformal mapping and the Riemann mapping theorem, analytic continuation, zeros and growth of analytic functions, approximation by rational functions, Phragmen-Lindelof Theorems, inverse-scattering theory, elliptic functions, and Riemann Surfaces.
Prerequisites: MATH 4210 and MATH 4300 or equivalent or permission of instructor.
Offered: Fall term odd-numbered years.
4 credit hours

MATH 6400
Ordinary Differential Equations
A basic graduate course introducing the fundamental concepts of modern evolution equations theory in the setting of ordinary differential equations. Topics include existence and uniqueness, integral equations, stability of equilibria, stable manifolds, Floquet theory, Poincare-Bendixson theory, bifurcation theory, center manifolds, normal forms, averaging theory, Hamiltonian mechanics and calculus of variations, chaotic dynamics, KAM theory, and soliton theory.
Prerequisite: MATH 4400 or permission of instructor.
Offered: Spring term even-numbered years.
4 credit hours

MATH 6490
Topics in Ordinary Differential Equations
Mathematical foundations and/or applications of ordinary differential equations. Possible topics include: stability and chaos in dynamics, mathematical methods of classical mechanics, stochastic differential equations, and soliton equations. Listing of topics offered to date.
Prerequisites: Vary with topic.
Offered: Spring term odd-numbered years.
4 credit hours

MATH 6500
Partial Differential Equations
A course dealing with the basic theory of partial differential equations. It includes such topics as properties of solutions of hyperbolic, parabolic, and elliptic equations in two or more independent variables; linear and nonlinear first order equations; existence and uniqueness theory for general higher order equations; potential theory and integral equations.
Prerequisite: MATH 4210 or equivalent or permission of instructor.
Offered: Fall term annually.
4 credit hours

MATH 6590
Topics in Partial Differential Equations
Mathematical foundation and/or applications of partial differential equations. Possible topics include: soliton theory and applications, wavelets and PDEs, scattering theory, hyperbolic conservation laws.
Prerequisites: Vary with topic.
Offered: Spring term annually.
4 credit hours

MATH 6600
Methods of Applied Mathematics
Linear vector spaces; eigenvalues and eigenvectors in discrete systems; eigenvalues and eigenvectors in continuous systems including Sturm-Liouville theory, orthogonal expansions and Fourier series, Green’s functions; elementary theory of nonlinear ODEs including phase plane, stability and bifurcation; calculus of variations. Applications will be drawn from equilibrium and dynamic phenomena in science and engineering.
Prerequisites: MATH 2400 and MATH 4600.
Offered: Fall term annually.
4 credit hours
MATH 6620
Perturbation Methods
This course is devoted to advanced methods rather than theory. Content includes such topics as matched asymptotic expansions, multiple scales, WKB, and homogenization. Applications are made to ODEs, PDEs, difference equations, and integral equations. The methods are illustrated using currently interesting scientific and engineering problems that involve such phenomena as boundary or shock layers, nonlinear wave propagation, bifurcation and stability, and resonance. 
Prerequisites: MATH 2400 and MATH 4600 or equivalent. Offered: Spring term even-numbered years. 
4 credit hours

MATH 6640
Complex Variables and Integral Transforms with Applications
Review of basic complex variables theory; power series, analytic functions, singularities, and integration in the complex plane. Integral transforms (Laplace, Fourier, etc.) in the complex plane, with application to solution of PDEs and integral equations. Asymptotic expansions of integrals (Laplace method, methods of steepest descent and stationary phase), with emphasis on extraction of useful information from inversion integrals of transforms. Problems to be drawn from linear models in science and engineering. 
Prerequisites: MATH 4600 and familiarity with elementary ordinary and partial differential equations. Offered: Spring term odd-numbered years. 
4 credit hours

MATH 6660
Stochastic Processes and Modeling
A course which will introduce methods and concepts to model and analyze the dynamics of system with uncertain inputs or too many variables to track explicitly. Topics may include Markov processes, point processes, renewal processes, and/or stochastic differential equations. Applications will be developed and illustrated on examples drawn from physics, biology, chemistry, industry, and finance. 
Prerequisites: MATH 2400. Offered: Spring term even-numbered years. 
4 credit hours

MATH 6740
Financial Mathematics and Simulation
This course is the second mathematical and computational finance course in a new one-year sequence for mathematics, DSES and engineering majors, and graduate students. It will cover the basics of stochastic processes, and current methods in the simulation of stochastic problems such as Monte Carlo algorithms and variance reduction tools. It will also focus on teaching the application of these stochastic simulation methods to finance. 
Prerequisite: MATH 4740. Offered: Spring term annually. 
4 credit hours

MATH 6790
Topics in Applied Mathematics
Advanced methods and/or applications of mathematics. Possible topics include: nonlinear continuum mechanics, nonlinear waves, inverse problems, nonlinear optics, combustion, acoustic wave propagation, similarity methods for differential equations, quantum field theory and statistical mechanics, stability of fluid flows, biomathematics, and finance. 
Prerequisites: Vary with topic. Offered: Spring term annually. 
4 credit hours

MATH 6800
Computational Linear Algebra
Gaussian elimination, special linear systems (such as positive definite, banded, or sparse), introduction to parallel computing, iterative methods for linear systems (such as conjugate gradient and preconditioning), QR factorization and least squares problems, and eigenvalue problems. 
Prerequisite: MATH 4800 or CSCI 4800 or permission of instructor. Offered: Fall term annually. Cross listed: CSCI 6800. Students cannot obtain credit for both this course and CSCI 6800. 
4 credit hours

MATH 6820
Numerical Solution of Ordinary Differential Equations
Numerical methods and analysis for ODEs with applications from mechanics, optics, and chaotic dynamics. Numerical methods for dynamical systems include Runge-Kutta, multistep and extrapolation techniques, methods for conservative and Hamiltonian systems, methods for stiff differential equations and for differential-algebraic systems. Methods for boundary value problems include shooting and orthogonalization, finite difference and collocation techniques, and special methods for problems with boundary or shock layers. 
Prerequisite: MATH 4800 or CSCI 4800 or permission of instructor. Offered: Spring term odd-numbered years. Cross listed: CSCI 6820. Students cannot obtain credit for both this course and CSCI 6820. 
4 credit hours
MATH 6840
Numerical Solution of Partial Differential Equations
Numerical methods and analysis for linear and nonlinear PDEs
with applications from heat conduction, wave propagation, solid
and fluid mechanics, and other areas. Basic concepts of stability
and convergence (Lax equivalence theorem, CFL condition, energy
methods). Methods for parabolic problems (finite differences,
method of lines, ADI, operator splitting), methods for hyperbolic
problems (vector systems and characteristics, dissipation and disper-
sion, shock capturing and tracking schemes), methods for elliptic
problems (finite difference and finite volume methods).
Prerequisite: MATH 4800 or CSCI 4800 or permission of
Instructor.
Offered: Fall term odd-numbered years.
Cross listed: CSCI 6840. Students cannot obtain credit for both
this course and CSCI 6840.
4 credit hours

MATH 6860
Finite Element Analysis
Galerkin's method and extremal principles, finite element approxi-
mations (Lagrange, hierarchical and 3-D approximations, inter-
polation errors), mesh generation and assembly, adaptivity (h-, p-,
hp-refinement). Error analysis and convergence rates. Perturbations
resulting from boundary approximation, numerical integration, etc.
Time dependent problems including parabolic and hyperbolic PDEs.
Applications will be selected from several areas including heat
conduction, wave propagation, potential theory, and solid and fluid
mechanics.
Prerequisite: MATH 4800 or CSCI 4800 or permission of
instructor.
Offered: Spring term even-numbered years.
Cross listed: CSCI 6860. Students cannot obtain credit for both
this course and CSCI 6860.
4 credit hours

MATH 6890
Topics in Computational Mathematics
Advanced methods and/or applications in scientific computing.
Possible topics include computational fluid dynamics, parallel
computing, computational acoustics, and computer applications in
medicine and biology.
Prerequisites: Vary with topic.
Offered: Fall term even-numbered years.
4 credit hours

MATH 6940
Readings in Mathematics
1 to 4 credit hours

MATH 6950
Teaching Seminar for Teaching Assistants
A seminar required for first-year TAs in mathematics.
Prerequisite: First-year math TA.
Offered: Fall term annually.
1 credit hour

MATH 6951
Introduction to Research in Mathematics
This seminar introduces first-year graduate students in mathe-
matics to the faculty and their research. Each week a different faculty
member from math will give introductory presentations of their
current research areas in a setting that is conducive for significant
student-faculty discussions of the material.
Prerequisite: Graduate student in mathematics.
Offered: Spring term annually.
1 credit hour

MATH 6960
Topics in Mathematics
1 to 4 credit hours

MATH 6970
Master's Practicum in Mathematics
Active participation in a professional experience in mathematics,
under the supervision of a faculty adviser. A Master's Practicum
may serve as the capstone professional experience for the M.S.
degree. A Master's Practicum may result in documentation as re-
quired by the adviser, but is not submitted to the Office of Graduate
Education and is not archived in the library. Grades of A, B, C, or F
are assigned if credit is awarded for the Master's Practicum.
Students may not receive credit for both MATH 6970 and
MATH 6980.

MATH 6980
Master's Project
Active participation in a master's-level project under the supervi-
sion of a faculty adviser, leading to a master's project report. Grades
of IP are assigned until the master's project has been approved by
the faculty adviser. If recommended by the adviser, the master's
project may be accepted by the Office of Graduate Education to be
archived in the Library. Grades will then be listed as S.
1 to 6 credit hours

Math 6990
Master's Thesis
Active participation in research, under the supervision of a faculty
adviser, leading to a master's thesis. Grades of S or U are assigned by
the adviser each term to reflect the student's research progress for
the given semester. Once the thesis has been presented, approved
by the adviser, and accepted by the Office of Graduate Education, it
will be archived in a standard format in the library. Grades will then be listed as S.
1 to 9 credit hours

MATH 9990
Dissertation
Active participation in research, under the supervision of a faculty
adviser, leading to a doctoral dissertation. Grades of IP are assigned
until the dissertation has been publicly defended, approved by the
doctoral committee, and accepted by the Office of Graduate Educa-
tion to be archived in a standard format in the library. Grades will
then be listed as S.
Variable credit hours

512 COURSE DESCRIPTIONS
MATP Mathematical Programming, Probability, and Statistics (SOS)

**MATP 4600**
Probability Theory and Applications
Axioms of probability, joint and conditional probability, random variables, probability density and distribution functions, expectation, functions of random variables, and limit theorems. Applications of probability to models in operations research, including queuing theory and Markov chains. 
Prerequisite: MATH 1020 or equivalent or permission of instructor.
Offered: Fall term annually.
4 credit hours

**MATP 4620**
Mathematical Statistics
A course in the theory of statistics that will provide students with a basic foundation for more specialized statistical methodology courses. Topics include sampling and sampling distributions; point estimation including method of moments, maximum likelihood estimation, uniform minimum variance estimation, and properties of the associated estimators; hypothesis testing including uniformly most powerful, likelihood ratio, chi-square goodness-of-fit tests, and tests for independence. The course concludes with an introduction to linear statistical models.
Prerequisite: MATP 4600 or equivalent calculus-based course.
Offered: Spring term annually.
Cross listed: ISYE 4760. Students cannot obtain credit for both this course and ISYE 4760.
4 credit hours

**MATP 4700**
Mathematical Models of Operations Research
Introduction to deterministic models of operations research including linear programming formulations, the simplex algorithm, degeneracy, geometry of convex polyhedra, duality theory, and sensitivity analysis. Special linear programming models for assignment, transportation, and network problems. Integer programming formulations along with branch and bound solution. Dynamic programming.
Prerequisites: MATH 1020, and MATH 2010 or ENGR 1100, or equivalent, or permission of instructor.
Offered: Fall term annually.
4 credit hours

**MATP 4820**
Computational Optimization
An introduction to nonlinear programming. Models, methods, algorithms, and computer techniques for nonlinear optimization are studied. Students investigate contemporary optimization methods both by implementing these methods and through experimentation with commercial software. Nonmajors wishing to gain practical optimization skills are welcomed in this course. A course project will allow students to explore optimization methods and practical problems directly related to their interests. Students cannot obtain credit for both this course and MATP 6610.
Prerequisites: MATH 2010 or ENGR 1100, and CSCI 1100 or permission of instructor.
Offered: Spring term annually.
4 credit hours

**MATP 4940**
Readings in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

**MATP 4960**
Topics in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

**MATP 4980**
Undergraduate Project in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

**MATP 6600**
Nonlinear Programming
Convex sets and functions, optimality conditions in nonlinear programming, Lagrangian duality, quadratic programming; algorithms for nonlinear programming including Newton's method, quasi-Newton methods, conjugate gradient methods, together with proofs of convergence.
Prerequisite: MATH 4200 or equivalent or permission of instructor.
Offered: Fall term annually.
Cross listed: ISYE 6780. Students cannot obtain credit for both this course and ISYE 6780.
4 credit hours

**MATP 6610**
Computational Optimization
An introduction to nonlinear programming. Models, methods, algorithms, and computer techniques for nonlinear optimization are studied. Students investigate contemporary optimization methods both by implementing these methods and through experimentation with commercial software. Nonmajors wishing to gain practical optimization skills are welcomed in this course. A course project will allow students to explore optimization methods and practical problems directly related to their interests. A computer implementation and a research presentation will be required. Students cannot obtain credit for both this course and MATP 4820.
Offered: Spring term annually.
4 credit hours
MATP 6620
Combinatorial Optimization and Integer Programming
Exact and heuristic methods for solving discrete problems, including the traveling salesman problem, the knapsack problem, packing and covering problems. Algorithm complexity and NP-completeness, cutting plane methods and polyhedral theory, branch and bound, simulated annealing, tabu search, Lagrangian duality.
Prerequisite: MATP 4700.
Offered: Spring term odd-numbered years.
Cross listed: ISYE 6760. Students cannot obtain credit for both this course and ISYE 6760.
4 credit hours

MATP 6640
Linear Programming
A unified development of linear systems and linear programming, polyhedral theory, the simplex method, interior point methods, decomposition methods for large-scale linear programming problems, the ellipsoid method, column generation algorithms for stochastic programming, and other problems.
Prerequisite: MATP 4700.
Offered: Spring term even-numbered years.
Cross listed: ISYE 6770. Students cannot obtain credit for both this course and ISYE 6770.
4 credit hours

MATP 6940
Readings in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

MATP 6960
Topics in Optimization
Advanced methods and/or applications in optimization. Possible topics include stochastic programming, learning theory, cone programming, optimization of medical treatment, and network flows.
Prerequisites: Vary with topics and/or instructor.
Offered: Fall term annually.
4 credit hours

MATP 6980
Master’s Project
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.
1 to 6 credit hours

MGMT Management (LSOM)

MGMT 696X
Craig Professional Development Seminar
This course assists students in developing those skills and techniques needed to be an effective manager. Topics include business writing and communication, presentation skills, agenda setting and meeting skills, stress management, and time management.
0 credit hours

MGMT 1100
Introduction to Management
This is a required first course for management majors and minors. In a case-based format, it emphasizes broad, basic principles of managerial functions and processes using an interdisciplinary approach to goal-oriented situations of private and public organizations. This is a communication-intensive course.
Offered: Fall and spring terms annually.
4 credit hours

MGMT 1240
Management Leadership I
The overall content focuses on skills, body of knowledge, and theories of leadership development. It involves discussion and practice to give students well-rounded skills necessary for personal and professional success. The course emphasizes the following themes: communication, ethics, values and self-awareness, leadership and followership.
Offered: Fall and spring sequences annually.
2 credit hours

MGMT 1250
Management Leadership II
The overall content focuses on skills, body of knowledge, and theories of leadership development. It involves discussion and practice to give students well-rounded skills necessary for personal and professional success. The course emphasizes the following themes: communication, ethics, values and self-awareness, leadership and followership.
Offered: Fall and spring sequences annually.
2 credit hours

MGMT 1260
Business Law and Ethics
This course focuses on legal and ethical considerations in management. Topics include torts, contracts, criminal and property law, constitutional and administrative law, dispute resolution, business formation, and equal opportunity. Students will also develop an awareness of ethics in managerial decision making, including recognizing and analyzing ethical issues in the workplace, promoting ethical behavior in corporations and recognizing social responsibilities of business.
Offered: Fall and spring terms annually.
4 credit hours
MGMT 2100
Statistical Methods
This course develops an understanding of concepts in business statistics and focuses on application of concepts in problem-solving situations. In particular, students learn to present and describe data, analyze probability distributions, make statistical inferences based on data samples, and develop models for prediction and forecasting.
Prerequisites: MATH 1500 and MATH 1520.
Offered: Fall and spring terms annually.
4 credit hours

MGMT 2300
Fundamentals of Accounting for Decision Making
An introduction to financial accounting and managerial accounting. The financial accounting includes preparation of the three primary financial statements: the income statement, the balance sheet, and the cash flow statement. The introduction to managerial accounting includes profit-volume relationships, cost systems, evaluation and control, and budgeting.
Offered: Fall and spring terms annually.
4 credit hours

MGMT 2320
Managerial Finance
An introduction to corporate financial analysis and decision making. This course covers the following topics: financial statement analysis, valuation principles, risk and return analysis, working capital management, capital budgeting, cost of capital, capital structure, and dividend policy.
Prerequisite: MGMT 2300 or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

MGMT 2510
Microcomputers and Applications
An introduction to the fundamentals of microcomputer technology and its application in management and information systems. Topics include hardware, software, communications, and elements of the system design life cycle, database concepts, and data processing. Students build systems using spreadsheet and database packages. Restricted to management majors.
Offered: Fall and spring terms annually.
4 credit hours, 5 contact hours

MGMT 2940
Studies in Management
Student plans a course of selected topics in management theory or practice not listed in this catalog. The instructor who will supervise and grade the student must approve the plan. Lectures, discussions, conferences, or seminars may be used in conjunction with the independent study. A written report is required; examinations may be required by the instructor.
Prerequisite: Permission of instructor.
Offered: Fall and spring terms annually.
1 to 4 credits per course, not to exceed 12 for this course number

MGMT 2960
Topics in Management
4 credit hours

MGMT 2990
Topics in Management
4 credit hours

MGMT 2996
Topics in Management
4 credit hours

MGMT 2997
Topics in Management
4 credit hours

MGMT 4040
Mathematical and Statistical Foundation for Finance
This course is designed to strengthen students’ ability to prepare for the graduate finance courses, especially the ones with quantitative applications. The course will provide basic learning in mathematical and statistical skills necessary for the required and elective courses in the finance program. It will provide an understanding of the fundamental process of applying statistical techniques to business problems involving uncertainty. The course will introduce basic calculus (derivative, optimization), matrix algebra (multiplication, inversion), power function (compounding, power series), probability theory, multiple linear regressions (model fitting, forecasting) applied to financial theories. The focus of the course, in general, is on integrating quantitative skills with key concepts in finance and economics. The ultimate goal is to prepare students to apply these lessons in financial decision-making.

MGMT 4100
Quantitative Methods for Business
This course introduces the student to the business management of production and operations systems. The concepts are related to inventory control, forecasting, scheduling, man-powers, and facilities planning. Computer usage includes Excel and specialized packages.
Offered: Fall and spring terms annually.
4 credit hours

MGMT 4110
Operations Management
This course introduces the student to the operations function in services and manufacturing-oriented firms. Students develop an appreciation of the concepts, principles, and techniques used for decision making in the operations function. The course takes a managerial perspective.
Prerequisite: MGMT 2100.
Offered: Fall and spring terms annually.
4 credit hours

MGMT 4130
Enterprise IT Integration
This course provides a capstone and professional experience through an in-depth study of major issues in enterprise information architecture. The course emphasizes both management and technical issues. Topics include information architecture evaluation, strategic information technology alignment, information technology valuation techniques, application interfaces, system and data integration, data warehousing, and decision support systems. Course concepts are developed through case studies and projects.
Prerequisites: CSCI 2300 or equivalent or MGMT 4240 or equivalent, or permission of the instructor.
Offered: Spring term annually.
4 credit hours
MGMT 4140  
**Computer Information Systems**  
This course provides the undergraduate management student with an introduction to the concept and components of computer-based "management information systems" (MIS) and their integration into organizational processes to gain competitive advantage. This course will examine approaches for developing and using information systems in support of business processes. Topics include: the impact of computer-based information systems on organizations; the basic technology components of modern information systems; the process by which information systems are created and changed; and selected management and technology issues.  
**Offered:** Fall and spring terms annually.  
**4 credit hours**

MGMT 4150  
**IT Project Management**  
This capstone concentration course provides the student with conceptual and applied material focusing on the effective implementation of information. A central theme underlying this course is that information system implementation is best thought of as a bridge between systems design and utilization and that it must be understood in the context of the development process as a whole. The course examines a wide array of interrelated issues not generally covered in a systems analysis and design course including: process development life cycle; project management and systems engineering; process reengineering and maturity; organizational learning and evaluation.  
**Offered:** Fall and spring terms annually.  
**4 credit hours**

MGMT 4160  
**Telecommunications for Business**  
Rapid advancements in telecommunications technology and the convergence of computing and telecommunications have created unique opportunities for organizations to derive competitive advantage. Telecommunications technology has become an essential feature of the business environment and is embodied in both operations and products/services of organizations. This course aims to analyze how telecommunications can be employed to enhance the benefits and reduce the costs through the value web. A wide variety of telecommunications technologies ranging from narrowband to broadband and from wired to wireless will be examined in detail. The primary emphasis will be on issues related to their application in different business contexts.  
**Offered:** Fall and spring terms annually.  
**4 credit hours**

MGMT 4170  
**Data Resource Management**  
This course introduces both technical and managerial aspects of a wide range of data-driven technologies used by modern organizations to solve business problems. This course provides the fundamental technical data management skills expected of any MIS professional as well as improved knowledge and understanding of the managerial issues that arise in applying different data management technologies to business problems.  
**Prerequisite:** MGMT 4140 or permission from instructor.  
**Offered:** Spring term annually.  
**4 credit hours**

MGMT 4220  
**Accounting Information Systems**  
This course provides the background for understanding how the accounting system works and also how the accounting system fits into the overall information system of the firm.  
**Prerequisite:** MGMT 2300.  
**Offered:** Upon availability of instructor.  
**4 credit hours**

MGMT 4230  
**Cost Accounting**  
This course is the upper level of managerial accounting course. Cost accounting provides information for both managerial accounting and financial accounting. It is useful for managers for planning and controlling, as well as costing products, services, and customers.  
**Prerequisites:** MGMT 2300 with at least a grade of C.  
**Offered:** Spring term annually.  
**4 credit hours**

MGMT 4240  
**Systems Analysis and Design**  
This course presents conceptual material on the analysis and design of business information systems. The focus is on understanding business information processing requirements and developing information systems solutions to meet these requirements. Key stages of the systems development life cycle including planning, analysis, and design are the focus of this course. Models and procedures for understanding and modeling an organization's existing and planned information systems are presented. Computer-aided software engineering tools are used to provide hands-on experience in designing information systems.  
**Offered:** Fall and spring terms annually.  
**4 credit hours**

MGMT 4250  
**Managerial Accounting**  
The aim of the course is to develop a thorough understanding of managerial accounting concepts and the awareness of the impact of managerial accounting on management decision making. As such students will acquire knowledge of accounting techniques used by internal management to aid in planning, directing, controlling, and decision-making activities. They will also gain experience with computerized spreadsheets and other electronic tools used in business problem-solving, budgeting, and financial analysis.  
**Prerequisite:** MGMT 2300.  
**Offered:** Spring term annually.  
**4 credit hours**
MGMT 4260
Financial Statement Analysis
This course is designed to strengthen students’ ability to correctly analyze, interpret, and evaluate financial statements and their accompanying disclosures. The course is aimed at anyone whose career might involve working with accounting data, and should be especially useful for those interested in consulting and financial analysis. Throughout the semester we will discuss how to use financial accounting information for evaluating past performance and predicting future performance of a company or division. The course revolves around a number of topics of recent interest to the business community including accounting and financial analysis, performance forecasting, the quality of earnings, mergers and acquisitions, post-employment benefits, executive compensation, and intangible assets. This course assumes that you have a basic knowledge of accounting, finance, economics, and business strategy. The focus is on integrating key concepts from each of these areas and applying them to financial decision-making. Half of the course time will be devoted to case analysis. Students are responsible for reading each case thoroughly, and familiarizing themselves with the relevant accounting issues, before the class.

MGMT 4270
Intermediate Accounting I
This is the first intermediate course on the theory and practice of accounting and financial reporting. Designed for both accounting and finance majors, this course combines a study of the theory, rationale, and objectives of corporate financial reporting with an examination of current reporting principles. The aim is to develop a realistic understanding of the strengths and weaknesses of corporate financial reporting, particularly from the viewpoint of the consumer of such financial information.
Prerequisites: MGMT 2300 with at least a grade of C.
Offered: Spring term annually.
4 credit hours

MGMT 4280
Intermediate Accounting II
As the second course in the Intermediate Accounting sequence, this course is designed for both accounting and finance majors. This course combines a study of the theory, rationale, and objectives of corporate financial reporting with an examination of current reporting principles. The aim is to develop a realistic understanding of the strengths and weaknesses of corporate financial reporting, particularly from the viewpoint of the consumer of such financial information.
Prerequisites: Completion of MGMT 4270 Intermediate Accounting I with a grade of C or better.
Offered: Fall term annually.
4 credit hours

MGMT 4310
Financial Trading and Investing
This course introduces interactive trading in financial instruments. Students learn the principles of asset price discovery through real-time trading in a variety of markets, including equities, bonds, options, derivatives. Topics addressed include asset valuation, portfolio management, and risk management in the context of real-time trading of financial instruments. The course uses the facilities of the Lally School’s Virtual Trading Room.
Prerequisites: MGMT 2320 and two upper-level finance courses or permission of the instructor.
Offered: Spring term annually.
4 credit hours

MGMT 4320
Investments I
Introduction to financial markets, financial instruments, and basic investment principles. The course provides students with an understanding of how to value securities, how to assess risk and return tradeoffs, how to make investment decisions, and how to measure investment performance. Topics include market microstructure and impact of technology on securities markets, principles of investment banking, valuation of stocks and bonds and hybrid instruments, portfolio theory, asset pricing models, bond portfolio management, and derivative securities.
Prerequisites: MGMT 2320.
Offered: Fall and spring terms annually.
4 credit hours

MGMT 4330
Investments II
Advanced course in investment decision making. Analysis of investment strategies in national and international equity markets including emerging markets. Other topics include arbitrage pricing principles, portfolio insurance, study of the term structure of interest rates and interest rate forecasts, duration analysis, and bond portfolio management, including immunization and active strategies. Principles of option and futures pricing and strategies in options and futures markets.
Prerequisites: MGMT 2320 and MGMT 4320.
Offered: Fall and spring terms annually.
4 credit hours

MGMT 4340
Advanced Corporate Finance
Advanced topics in financial theory and corporate policy as they are applied to the modern corporation. Emphasis in blending theory with application. Case studies are used to illustrate relevance of theoretical concepts. Topics include corporate financial decision making under uncertainty, financial forecasting, application of option pricing principles to capital budgeting decision making, mergers and acquisitions, leveraged buyouts and takeovers, leasing, financial engineering.
Prerequisites: MGMT 2320 and MGMT 4320 or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours
MGMT 4350  
Financial Markets and Institutions  
This course investigates the roles financial markets and financial intermediaries play in the flow of funds in the world economy. The course provides a conceptual framework for why markets exist and the important functions of intermediaries in the global markets. Major topics include interest rates; roles of Central Bank; debt, equity, and derivatives; commercial banking; and the increasing importance of non-bank financial intermediaries such as pension funds, insurance companies and mutual funds.  
**Prerequisite:** MGMT 2320. Students cannot receive credit for both this course and MGMT 6340.  
**Offered:** Fall term annually.  
**4 credit hours**

MGMT 4360  
International Financial Management  
The objective of this course is to provide a conceptual understanding of the international financial markets and instruments and how corporations and investors use them in their financial decision-making process. The course coverage includes the international financial environment, foreign exchange markets, offshore financial markets, derivative securities markets, and international capital markets. Class sessions will be devoted to lectures and case discussions on topics outlined in the class schedule. Equipped with the background provided in the classroom, students solve problems and analyze cases representing real-life situations.

MGMT 4370  
Risk Management  
Overview of risk management, and the concept and measurement of risk; types of risks (market, credit, liquidity, operational, business, strategic). Concepts, tools, and instruments available for risk management. Specific issues related with managing specific risk types — market, credit, interest-rate, liquidity risk, and operational risk. Securitization, asset-liability management. Concepts underlying insurance and role of insurance for risk management.  
**Prerequisite:** MGMT 2320 or permission of instructor.  
**Offered:** Fall term annually.  
**4 credit hours**

MGMT 4380  
Derivatives Markets  
This course introduces the institutional structure of the financial markets for derivatives. It also covers hedging and basis risk, interest rate, and stock-index derivatives with financial management applications. Other topics covered include an introduction to options, rational option pricing restrictions, binomial option pricing model, and put and call option strategies.  
**Prerequisites:** MGMT 2320 and MGMT 4320 or permission of instructor.  
**Offered:** Spring term annually.  
**Cross listed:** MGMT 6370.  
**4 credit hours**

MGMT 4430  
Marketing Principles  
This course provides students with an understanding of marketing principles and the role of the marketing discipline. The course is intended to help students learn the basic concepts and practices of marketing and to familiarize them with the terminology and techniques for properly framing and analyzing marketing problems. In addition to marketing concepts, processes, and strategy, issues such as the social consequences of marketing are discussed.  
**Offered:** Fall and spring terms annually.  
**4 credit hours**

MGMT 4440  
Financial Simulation  
**Prerequisites:** MGMT 2320, MGMT 4040.  
**Offered:** Spring term annually.  
**4 credit hours**

MGMT 4450  
Internet Marketing  
Technology is a vital link in how modern corporations identify, acquire, transact with, and keep their customers. This course provides an introduction to both the technology infrastructure most relevant to the customer relationship as well marketing issues that result from the application of computers and communication networks. Topics include issues related to social media, search, online advertising, blogging, customer relationship management, online market segmentation, and marketing of IT products.  
**Prerequisites:** MGMT 4430 or permission of instructor.  
**Offered:** Spring term annually.  
**4 credit hours**

MGMT 4460  
Consumer Behavior and Product Design  
This course introduces the motivations and related factors that shape consumers’ purchasing decisions. Also considered is the consumer perceptual process and how it affects purchasing behavior and consumer reaction to product designs. The relationship between perception and product design is extended to topics such as design for understanding, universal product design, aesthetics, and industrial design.  
**Prerequisites:** MGMT 4430 or permission of the instructor.  
**Offered:** Spring term annually.  
**4 credit hours**
MGMT 4470  
Marketing Research  
A course on identifying and solving marketing problems through the systematic gathering and analysis of market information. Course focuses on careful definition of marketing problems, specification of information needs, sampling theory, research design, statistical methods, and marketing management implications. A major project involving marketing research for an off-campus “client” is a key part of the final grade.  
Prerequisite: MGMT 4430.  
Offered: Fall term annually.  
4 credit hours

MGMT 4490  
Advertising Strategy and Promotions  
Development of branding strategies to accomplish marketing objectives. The development of media plans and schedules to deliver advertising promotions element in the marketing mix.  
Prerequisite: MGMT 4430 or permission of instructor.  
Offered: Spring term annually.  
4 credit hours

MGMT 4510  
Invention, Innovation, and Entrepreneurship  
This course focuses on three key goals: providing increased insight into the cognitive foundations of entrepreneurship, offering practice in applying creative thinking to the task of formulating ideas for new products or services, and presenting basic information about the organizational process of commercializing such innovations. These goals will be achieved through a combination of assigned readings, in-class exercises, and individual and team projects. In addition, the course will include contributions from guest speakers who will share with the class their own experiences and expertise.  
4 credit hours

MGMT 4520  
Introduction to Technological Entrepreneurship  
An introductory course for initiating a new business venture and developing it into a self-sustaining and profitable enterprise. Provides understanding of the process whereby a person decides to become an entrepreneur, screens opportunities, selects an appropriate product/market target, and obtains the necessary resources. Also, provides the theoretical and practical knowledge for the preparation of formal business plans for the development of new products, processes, and services and for the financing of new enterprises.  
Offered: Fall and spring terms annually.  
4 credit hours

MGMT 4530  
Starting Up a New Venture  
An understanding of the critical issues related to starting up a new business is gained through team-based experiential learning. Small teams of students develop a comprehensive business plan that can be used to raise money for a new or relatively new venture. The business plans are eligible for submission to the Rensselaer Business Plan Competition. The experiential learning process is enhanced through team meetings with faculty and/or course advisers and through oral presentations to the entire class.  
Offered: Fall and spring terms annually.  
4 credit hours

MGMT 4540  
Venture Capital Finance  
This course covers the theory and practice of venture capital financing of entrepreneurial firms. Topics to be discussed include the structure and governance of venture capital funds, venture capital financial contracting, valuation of entrepreneurial firms, staging, syndication, capital structure, and exits (IPOs, acquisitions, secondary sales, buybacks, and liquidations). International differences in venture capital markets will also be studied.  
Prerequisite: MGMT 2320.  
Offered: Fall term annually.  
4 credit hours

MGMT 4590  
Commercializing Advanced Technologies  
This course views potential breakthrough innovation from the perspective of the project manager, either in the firm or as a start up organization. The course offers methods and frameworks for commercializing nascent technologies that offer potentially breakthrough value to the market and, therefore, enormous reward for the firm. Additionally, legal and ethical consequences are considered.  
Prerequisites: MGMT 1100 or ENGR 4100.  
Offered: Spring term annually.  
4 credit hours

MGMT 4640  
Hedge Funds and Financial Markets  
The topics covered include an overview of the hedge fund industry; legal and regulatory issues; in depth analysis of a number of hedge fund trading and investment strategies including equity long/short, fixed income arbitrage, credit and high yield fixed income arbitrage, commodity and currency trend-following strategies, and private equity “crossover” hedge funds. The course will also cover the role of hedge funds in an overall investment portfolio and in asset allocation framework.  
Prerequisites: MGMT 2300, MGMT 2320, MGMT 4320/4330.  
Offered: Fall and spring terms annually.  
Cross listed: MGMT 7640; students cannot obtain credit for both courses.  
3 credit hours

Cross listed: MGMT 7640; students cannot obtain credit for both courses.  
3 credit hours
MGMT 4650
Advanced Hedge Funds and Financial Markets
This course is designed to advance the skills and knowledge gained in the Hedge Funds and Financial Markets by applying these to in-depth exploration of specific hedge fund trading and investment strategies, including trend following quantitative models; long/short equity analysis and market neutral quantitative strategies; fixed income and credit derivatives hedge funds. For each broad topic, advanced financial and market techniques, including relevant quantitative and computer models are used, to gain a thorough understanding of the techniques, assumptions, models, and risks of each strategy.
Prerequisites: MGMT 4640, MGMT 2300, MGMT 4320/4330 or equivalent.
Offered: Fall and spring terms annually.
Cross listed: MGMT 7650; students cannot obtain credit for both courses.
4 credit hours

MGMT 4850
Organizational Behavior in High Performance Organizations
This course provides an overview of basic processes in human behavior that influence the effectiveness of individuals, groups and organizations. Its focus is on understanding what happens during interpersonal interactions in work situations, and what can be done to make employees more effective. Topics covered include organizational socialization, motivation, decision-making, team dynamics, virtual teams, influence, and conflict management. Numerous exercises and case analyses are used in class to help provide students with insights into these processes.
Offered: Fall and spring term annually.
4 credit hours

MGMT 4860
Human Resources in High Performance Organizations
This course provides an overview of human resources principles and practices in business organizations. Students are given tools for understanding how people are managed on a day-to-day basis. Topics include: the recruiting and hiring process; self-, peer-, and managerial evaluations; training and development; and legal issues related to the work setting and the job-search process. Students come away with an understanding of the difficulties and challenges associated with workforce management. This course utilizes a combination of lecture, discussion, and experiential exercises.
Offered: Fall and spring terms annually.
4 credit hours

MGMT 4870
Strategy and Policy
This is a course that integrates the functional fields of management. The first part of the course focuses on the tools and discipline commonly used in strategy formulation. The second part focuses on the implementation of strategy in a variety of contexts.
Prerequisite: MGMT 4860; recommended senior standing.

Offered: Fall and spring terms annually.
4 credit hours

MGMT 4900
Practicum in Management
A problem-solving experience in a business enterprise or public organization in which the student works individually or in a team project. Prior to the start of the internship a list of the learning objectives for this internship will be provided by the student to the faculty mentor. Upon completion of the internship, a written report of the outcomes of the internship and a detailed description of how the learning objectives were met will be provided by the student to the faculty mentor. Course to be graded on an S/U basis.
1 to 4 credit hours, this course can be taken multiple times with a maximum of 8 credit hours applied toward a student’s degree.

MGMT 4940
Studies in Management
1 to 8 credit hours

MGMT 4960
Topics in Management
4 credit hours

MGMT 6010
Heroes, Leaders, and Innovators
This course provides an introduction to the “heart and soul” of managerial leadership, teamwork, and innovation by focusing on the behavior and characteristics of those exceptional individuals whose impact extends far beyond their own persona — inside and outside of business. Leaders/innovators are those whose vision, creativity, and charisma allow them to transform their organizations and to change the lives of large numbers of people. Using a combination of case studies and simulations, the course offers a week-long immersion experience into the mindset, actions, and concerns of true business innovators.
0 credit hours

MGMT 6020
Financial Management I
The purpose of this course is to develop a working understanding of the major investment and financial decisions of the firm. Emphasis will be placed upon identifying and solving the problems commonly faced by financial managers. The course presents the needed theory and develops financial problem solving skills through individualized problem solving, structured case analysis, and industry and company analysis using Internet sources.
Prerequisite: MGMT 7740.
Offered: Fall term annually.
3 credit hours
MGMT 6030  
**Financial Management II**  
This course, built on the Economic & Financial Analysis I, provides a conceptual framework whereby accounting, corporate finance, and investment decisions can be viewed and understood in a unified context of risk and return as it is applicable to all types of businesses and organizations. The course prepares students for future specialized courses in advanced accounting, corporate finance, financial institutions and markets, investment theory, and entrepreneurial finance. The contemporary issues covered in this course include risk and diversification; asset pricing models; capital structure and financing alternatives; dividend and stock repurchases; corporate governance; mergers, acquisitions, and takeovers; financial distress and reorganization; and different international financial topics.  
*3 credit hours*

MGMT 6040  
**Talent Management**  
This course is designed to develop skills in understanding human behavior in organizations and how to effectively manage the talent that resides within employees. Students will learn about essential aspects of managing and developing talent, including individual differences, employee hiring, motivation, team dynamics, leadership, and influencing others. Through a discussion of concepts in human behavior students will learn useful analytical frameworks for understanding the complexities of managing talent in order to best achieve organizational success.  
*Offered: Fall term annually.  
3 credit hours*

MGMT 6050  
**Organizational Design and Change**  
This course is focused on developing, evolving, and managing organizations during high impact change involving advanced and disruptive technology. The primary focus is on managing change, reimagining business processes, and designing organizational structures that can compete in the era of globalization. This includes understanding the importance of cultural differences, an entrepreneurial mindset, and the role of innovation.  
*Offered: Spring term annually.  
3 credit hours*

MGMT 6060  
**Business Implications of Emerging Technologies**  
This course investigates the business dimensions of major technological advances, highlighting how industry structures an organization, the dynamics of competition, patterns of innovation, operational decisions, and financial investment are all influenced by various types of technical breakthrough. Students also get to explore the interplay between emerging technology development and commercialization. The challenges associated with intellectual property protection and utilization, as well as the socio-economic and ethical dimensions of new technology adoption, are explored. Each year, a different set of key technologies will be examined and analyzed.  
*3 credit hours*

MGMT 6080  
**Networks, Innovation, and Value Creation**  
This course considers the evolving new models of value creation and business growth being introduced across different industries and examines such critical issues as product and process technology strategy, operational innovation, IT strategies and infrastructures, networks and organization, and finance. Utilizing a series of case studies from across a range of industry networks, students will have a chance to learn how companies can participate in such networks and what unique business resources and capabilities they can employ to enhance their probability of commercial success.  
*3 credit hours*

MGMT 6090  
**Networks, Innovation, and Value Creation II**  
This course focuses on the execution and implementation issues arising from the growing role of networks as the organizing concept for business value creation. Topics include analyzing the different opportunities, how and where value can be created, the alternate value creation roles a firm can assume in the value creation process, an examination of the varying economic rents that can be generated, the organizational resources and capabilities that are needed to be effective, and the implications for the overall strategy of the firm.  
*3 credit hours*

MGMT 6100  
**Statistics and Operations Management I**  
Management, finance, technology, operations, general business operations, and statistical topics are integrated from the point of view of extracting, interpreting, and communicating information. One- and higher dimensional graphical methods and tabular arrays are used to show that statistical models are natural consequences of business and technology management. Design of investigations and time-related phenomena are covered in depth throughout the course. Statistical simulation of service and production facilities are principal tools for developing information for system design and improvement. Regression methodologies are used for summarization and improvement. Multidimensional techniques are heavily utilized.  
*Prerequisite: Familiarity with calculus. (Limited to part-time MBA and M.S. students).  
Offered: Summer term annually.  
3 credit hours*
MGMT 6110
Statistics and Operations Management II
This course continues the study of collection, analysis, and use of information in a technologically advanced setting. This course shifts focus from statistical methods to other problem-solving approaches, including linear programming, network models, queuing systems, and simulation. The emphasis is on application drawn from production, finance, project management, and system design. Case studies are used to supplement traditional homework assignments. 
Prerequisite: MGMT 6100. (Limited to part-time MBA and M.S. students).
Offered: Summer term annually. 
3 credit hours

MGMT 6130
Research Seminar in Management Information Systems
This doctoral seminar examines the major streams of theory and research in information management and information systems. The course will explore the major issues, theories, and research methods in information systems, research through classic readings, information management, and reference disciplines. Key areas in information systems research will be covered, such as strategic and economic perspectives of information management, adoption and diffusion theory, information technology and organizational design, and how research methods are employed in information systems research. Students will gain an understanding of what theory is and how to develop and evaluate theory in the area of information management and information systems. 
Prerequisites: Doctoral student standing or permission of the instructor.
Offered: Fall term annually. 
3 credit hours

MGMT 6140
Information Systems for Management
Analyzes the use of information and communications technology to improve performance and to achieve organizational goals. Examines information systems in sales, marketing, finance, and operations. Provides a framework for understanding and evaluating IS contributions to product services and managerial effectiveness. Focuses upon the implementation of information technology as a strategic weapon for productivity and competitive advantage. Lectures, case discussion, projects, and technical supplements. 
Prerequisites: Familiarity with spreadsheet and database software.
Offered: Spring term annually. 
3 credit hours

MGMT 6170
Advanced Systems Analysis and Design
This is an advanced course in systems analysis and design that presents conceptual material about both traditional approaches to systems development such as process oriented and data-oriented methodologies and evolving approaches such as object-oriented development methods. Key stages of the systems development life cycle including planning, analysis, and design are the focus of this course. Models and procedures for understanding and modeling an organization's existing and planned information systems are presented. Computer-aided software engineering tools are used to provide hands-on experience in designing information systems. A case-based approach is used to provide students an opportunity to apply the analytical and design techniques covered in the course. In addition, students are expected to do a real-life systems development project. The course also focuses on the issues and challenges in managing systems development. 
Prerequisite: MGMT 6140 or equivalent.
Offered: Spring term annually. 
3 credit hours

MGMT 6180
Strategic Information Systems Management
Information technology (IT) is a strategic asset that is being used to mold competitive strategies and change organizational processes. As IT and its uses become more complex, developing strategies and systems to deliver the technology has become more difficult. The net result is a growing need for guidance on the issues, strategies, and tactics for managing the use of information technology. This course is designed to partially fulfill this need and to enable students to integrate concepts and theories learned in previous IT courses. 
Prerequisite: MGMT 6140.
Offered: Spring term annually. 
3 credit hours

MGMT 6190
Introduction to Accounting and Financial Management
This course introduces accounting and financial management to first-semester MS students. The interpretation and preparation of basic financial statements such as the balance sheet and income statement are introduced along with relevant regulation and practice. In addition, the course introduces the student to basic financial concepts and techniques such as time value, risk, equilibrium asset pricing models, capital budgeting, cost of capital, and capital structure and discusses their applications in practice. 
Prerequisite: MGMT 4040 or equivalent.
Offered: Fall term annually. 
3 credit hours

MGMT 6200
Advanced Financial and Managerial Accounting
This course teaches advanced theory and practice of contemporary accounting issues. The course deals with advanced financial accounting, inter-corporate investments, business combinations, financial statements, foreign currency translation, leases, pensions, and stock options. Advanced managerial accounting, accounting information systems, advanced costing models, activity-based costing, balanced scorecard, and economic value added (EVA) will also be studied. 
Prerequisite: MGMT 6020 or equivalent.
Offered: Spring term annually. 
3 credit hours
MGMT 6240
Financial Trading and Investing
This course introduces interactive trading in financial instruments. Students learn the principles of asset price discovery through real-time trading in a variety of markets, including equities, bonds, options, derivatives. Topics addressed include asset valuation, portfolio management and risk management in the context of real-time trading of financial instruments. The course uses the facilities of the Lally School’s Virtual Trading Room. Students will work in teams of two in many trading assignments.
Prerequisites: MGMT 6020 and MGMT 6030; or permission of instructor.
Offered: Spring term annually.
3 credit hours

MGMT 6250
Financial Theory and Its Links to Behavioral Sciences
This course addresses the behavioral sciences background of modern finance theory; the inclusion of risk and future uncertainty in general economic equilibrium; efficient markets; investor utility, objectives, and behavior; rational expectations and prospect theory; asset pricing in the context of general economic equilibrium; transaction costs, markets and institutions; information asymmetry and agency theory; capital structure and corporate finance. Other topics will be selected from corporate governance; futures and options; international exchange and risk management. The topics dealt with in depth will vary as the content responds to important issues in the field.
Prerequisites: Doctoral student standing or permission of the instructor.
Offered: Spring term annually.
3 credit hours

MGMT 6260
Entrepreneurial Finance
The overall objective of this course is to understand how entrepreneurs and investors create value, noting that their interests do not always coincide. This involves learning about topics which trace out the “venture capital cycle”: opportunity recognition; valuation and evaluation; negotiation; structuring financing contract; managing investment; exit strategy. This course is structured into three modules: valuation, private equity market, and harvesting entrepreneurial value.
Offered: Fall term annually.
3 credit hours

MGMT 6270
Microeconomic Theory for Management
This doctoral-level course introduces microeconomics to first-semester doctoral students in management. Rather than provide formal training for professional research economists, this course seeks to provide a theoretical introduction to microeconomic methods for academics and researchers in business, management, and finance. Topics covered in the course include consumer theory; theory of production, markets, and equilibrium; decision-making under uncertainty; theory of information; agency theory; and game theory.
Prerequisite: Enrollment in the doctoral program in management or economics at Rensselaer (or permission from the course instructor), calculus, and matrix mathematics.
Offered: Fall term annually.
3 credit hours

MGMT 6280
Seminar in Economic Theory
This course covers the tools and concepts used in microeconomic analysis and will study the behavior of the basic building blocks of a market — consumers and firms and different market structures and their welfare properties. These models help with understanding the functioning of a capitalist market system and provide a useful framework to analyze various policy interventions. This course also provides a foundation for studying public finance, game theory, labor economics, etc.
Offered: Fall term annually.
3 credit hours

MGMT 6290
Macroeconomics and International Environments of Business
This course identifies major forces acting on the enterprise from the macroeconomic and international environment. Key factors include national income and output, interest rates, economic growth and business cycles, international trade and balance of payment, exchange rates, monetary and fiscal policy. Factors are analyzed in terms of their impact on the economic and technological decisions of the enterprise.
3 credit hours

MGMT 6320
Investment Analysis I
Introduction to investment instruments and modern methods of pricing them. Basic components of viable investment programs are outlined. Topics include expected utility theory and risk aversion, modern portfolio theory, equilibrium in capital markets (CAPM, APT), index models, futures and options, theory of active portfolio management.
Prerequisite: MGMT 6020. This course is available to Hartford students only.
Offered: Fall term annually.
3 credit hours
MGMT 6330
Investment Analysis II
Advanced study in investment analysis, decision making, and practice. Emphasis on bond market analysis and bond portfolio management, including asset-backed securities, high-yield bonds, venture capital, and derivative securities. Topics include bond pricing, the term structure and risk structure of interest rates, duration concepts and immunization strategies, analysis of embedded options in fixed income securities. Application of strategies to real data set.
Prerequisite: MGMT 6320 or permission of instructor. This course is available to Hartford students only.
Offered: Spring term annually.
3 credit hours

MGMT 6340
Financial Markets and Institutions
Focus on financial markets, new instruments and techniques for financing, risk management and its application to financial institutions. Overview of U.S. financial system, the Federal Reserve system, and monetary policy. Emphasis on impact of technology on securities markets and banks. Discussion of current issues in securities markets and banking, such as securitization, financial derivatives, junk bonds, bank failures, mergers and acquisitions, and international banking.
Prerequisites: MGMT 6020.
Offered: Fall term annually.
3 credit hours

MGMT 6360
International Finance
Course analyzes trends and themes in international financial management, especially how financial management and corporate strategies are carried out in international environments. Topics include foreign exchange markets and risk management, analysis of operating and transaction exposure, international financial markets and banking, international financing and investment. Working capital management and capital budgeting of multinational corporations. Case studies are used.
Prerequisites: MGMT 6020 and MGMT 7730.
Offered: Spring term annually.
3 credit hours

MGMT 6370
Options, Futures, and Derivatives Markets
The purpose of this course is to provide an introduction to second generation financial instruments including forward and futures contracts, options, futures options, and swaps on a variety of underlying instruments including fixed income securities. The fixed income markets will be integrated with the discussion of IRDs (interest rate derivatives).

MGMT 6380
Advanced Corporate Finance
The overall objective of this course is to study advanced corporate finance issues and test empirically the stock market reaction to financing decisions and the issuance of securities. Corporate finance topics include shareholder value and economic value added concepts, as well as corporate governance issues. Financing decisions include venture capital and initial public offerings, seasoned equity offerings, stock splits, corporate bonds and bank loans, stock listings on foreign exchanges. Other topics are mergers and acquisitions, pension fund management, financial analysis, and planning. Real stock prices and case studies are used to apply the theoretical concepts.
Prerequisites: MGMT 6020 and MGMT 6030.
Offered: Fall term annually.
3 credit hours

MGMT 6390
International Operations
This course provides a foundation in the facts and ideas underlying the globalization of production and delivery of goods and services. Topics include: designing global supply chains, managing risks of cross border business relationships, international logistics, establishing world class manufacturing service and R&D in developing countries, integrating superior operating practices and technologies from across the world in diverse national environments, and political and societal issues associated with global operations.
Prerequisite: MGMT 4100 or equivalent.
Offered: Spring term annually.
3 credit hours

MGMT 6400
Financial Econometrics Modeling
This course addresses financial modeling as an empirical activity. Several key issues and assumptions of finance are addressed through empirical modeling. Topics may include asset pricing, event studies, exchange rate movements, term structure of interest rates, and international linkages among financial markets. Computers are used extensively both in and out of class.
Prerequisites: Students should have taken at least two finance courses and MGMT 6100.
3 credit hours

MGMT 6410
Investments I
The objectives of this course are: 1) to introduce the student to the most important investment instruments currently traded in U.S. financial markets, including forward and futures contracts, options, futures options and swaps on a variety of underlying instruments including fixed income securities; 2) to discuss the major distributions of modern financial economics in pricing them; 3) to discuss their uses by the investment community in practical investment strategies.
Prerequisites: MGMT 6020.
Offered: Spring term annually.
3 credit hours
MGMT 6420  
Financial Theory  
This is an introductory course of theoretical research in corporate finance. The course will examine the fundamentals of corporate finance theory (e.g., capital structure choice, dividend policy, etc.), as well as various tool areas (e.g., moral hazard and agency problems, and adverse selection and signaling). Knowledge of corporate finance at the MBA level, or its equivalent, is required.  
Prerequisites: Doctoral student standing or permission of the instructor.  
Prerequisites: Students should have basic calculus and statistics knowledge at the undergraduate level or permission of the instructor.  
Offered: Fall term annually.  
3 credit hours

MGMT 6430  
Financial Statement Analysis  
This course is designed to strengthen students’ ability to correctly analyze, interpret, and evaluate financial statements and their accompanying disclosures. The course is aimed at anyone whose career might involve working with accounting data, and should be especially useful for those interested in consulting and financial analysis. Throughout the semester we will discuss how to use financial accounting information for evaluating past performance and predicting future performance of a company or division. We will also discuss the key disclosure rules in the United States, the communication methods available to managers, managers’ incentives and ability to exert discretion over reported earnings, and the interplay between a company’s corporate strategy and its financial reporting policies and practices. The course revolves around a number of topics of recent interest to the business community including accounting and financial analysis, performance forecasting, the quality of earnings, mergers and acquisitions, purchased R&D, post-employment benefits, executive compensation, and intangible assets. This course assumes that students have a basic knowledge of accounting, finance, economics, and business strategy. The focus is on integrating key concepts from each of these areas and applying them to financial decision-making. Half of the course time will be devoted to case analysis. Students are responsible for reading each case thoroughly and familiarizing themselves with the relevant accounting issues before the class.

MGMT 6440  
Financial Simulation  
Prerequisites: MGMT 2320, MGMT 4040.  
Offered: Spring term annually.  
3 credit hours

MGMT 6450  
Manufacturing Systems Management  
An overview of how product and service requirements are translated into manufacturing facilities, procedures, and organizations. The control systems considered include demand forecasting, inventory planning, production scheduling, quality control, MRP, and project control. In addition, a management perspective is used to examine decisions having a long-term manufacturing impact: capacity planning, location, and distribution, manufacturing processes, factory layout, and factory focus. The course concludes with an introduction to manufacturing policy.  
3 credit hours

MGMT 6470  
Management of Quality, Processes, and Reliability  
This course provides in-depth coverage of the quality management field by covering many of the qualitative, management aspects of quality, as well as some of the traditional quantitative measurement and control techniques. The emphasis is on the application of the quality principles to develop an understanding of concepts in quality and apply these concepts in problem solving situations. Six Sigma methodology is highlighted. Some coverage of international considerations, via ISO-9000, and reliability topics is given. The aim will be to show students how companies have found solutions to problems and improved their processes, products, and services using quality management concepts.  
Offered: Fall term annually.  
3 credit hours

MGMT 6480  
Service Operations Management  
This course discusses the role of services in an economy, managing services for competitive advantage, structuring the service enterprise, managing service operations, service productivity, quality, and growth.  
Offered: Spring term annually.  
3 credit hours

MGMT 6490  
Competitive Advantage and Operations Strategy  
This course includes topics such as manufacturing as a competitive weapon; management of quality; manufacturing technology implementation; strategic impact of advanced manufacturing technologies; and manufacturing’s role in new product development.  
Offered: Fall term annually.  
3 credit hours
MGMT 6510
Financial Computation
This course introduces computational techniques for financial analysis, with foci on risk, hedging and portfolio techniques, fixed income instruments, and derivatives analysis. The course covers computational techniques for portfolio optimization, plain vanilla and exotic derivatives valuation and replication, along with interest rate and fixed income instruments. This course will introduce numerical analysis, interpolation, Monte Carlo and finite difference methods, lattices, linear and dynamic programming, optimization and MATLAB, all in a financial computational context.
Prequisite: MGMT 4040 or undergraduate courses in statistics and calculus.
Offered: Fall term annually.
3 credit hours

MGMT 6520
Financial Modeling
This course introduces quantitative analysis for financial markets and instruments. The course covers applications of linear math to hedging and valuation, applications of calculus to valuation and risk analysis, introduces differential equations and their applications to hedging and valuation and introduces stochastic processes in a financial markets context. Course coverage will also extend to portfolio analysis and standard equilibrium asset pricing models.
Prequisite: MGMT 4040 or undergraduate courses in statistics and calculus.
Offered: Fall term annually.
3 credit hours

MGMT 6530
Making Business Happen
Analyze the process of identifying prospective markets and customers, developing channels, defining the value proposition, selling products and services, and managing a sales force. Learn about tools ranging from customized consultative sales to commodity brokering, customer relationship management systems to trade press articles. Develop the skills to effectively listen, recognize opportunity, verbally persuade, handle objections, and prospect. Develop an understanding of customer needs, approach strategies, and effective presentations.
Offered: Fall term annually.
3 credit hours

MGMT 6540
Marketing Communication and Branding Strategies
Advanced study of the promotion management process including market situation analysis, media selection, spending plans, copy strategy, and advertising research methods. The focus is on integrating promotion strategies with buyer needs in terms of unifying brand strategies. Other brand elements include product conceptualization, distribution strategies, and new communication technologies.
Prequisites: Permission of instructor.
Offered: Fall term annually.
3 credit hours

MGMT 6550
Marketing Research
Marketing strategy decisions are developed in the framework of many case studies. Marketing research techniques, including questionnaire development and data analysis, are introduced and utilized in a team project.
Prequisites: MGMT 6100 or permission of instructor.
Offered: Spring term annually.
3 credit hours

MGMT 6580
Marketing High-Tech Products
This course deals with the peculiarities of marketing products and services in high-tech environments. High-tech environments are characterized by high dynamism, high uncertainty, and compressed time cycles. The course consists of case studies, computer simulations, and a team project.
Offered: Spring term annually.
3 credit hours

MGMT 6590
Commercializing Advanced Technologies
This three-credit course views potential breakthrough innovation from the perspective of the project manager, either in the firm or as a start up organization. The course offers methods and frameworks for commercializing nascent technologies that offer potentially breakthrough value to the market and, therefore, enormous reward for the firm. Additionally, legal and ethical consequences are considered.
Offered: Spring term annually.
3 credit hours

MGMT 6600
Research and Development Management
The course deals with the responsibilities of and operating problems faced by managers of research and development. The following areas are included: technology forecasting, technology planning, selection and evaluation of R&D projects, resource allocation, planning, control, and measuring results of R&D. Particular attention is given to creative problem solving, motivating and managing creative individuals, barriers to innovation, and organization alternatives for R&D, including matrix and project organizations.
Offered: Fall term annually.
3 credit hours
**MGMT 6610**
Global Strategic Management of Technological Innovation

The course helps develop an understanding of and the method for managing technology as a strategic resource of the firm. In doing so, an understanding of the process, roles, and rewards of technological innovation are developed. Integrating the strategic relationship of technology with strategic planning, marketing, finance, engineering, and manufacturing are covered. Governmental, societal, and international issues are briefly covered. The course uses a variety of cases, readings, reports, and lectures.

*Offered:* Fall term annually.

*3 credit hours*

**MGMT 6620**
Principles of Technological Entrepreneurship

An introductory graduate course in initiating new technology-based business ventures and developing them into self-sustaining and profitable enterprises. Examines the process whereby a person decides to become an entrepreneur, screens opportunities, selects an appropriate product/market target, and obtains the necessary resources. Provides the theoretical and practical knowledge for the preparation of formal business plans. Students enrolled in the full-time MBA program cannot use this course on the Plan of Study. This course is intended for students enrolled in the part-time MBA, M.S. in MGT or those seeking degrees in other schools at Rensselaer.

*Offered:* Fall term annually.

*3 credit hours*

**MGMT 6630**
Starting Up A New Venture

An understanding of the critical issues related to starting up a new business is gained through team-based experiential learning. Small teams of students develop a comprehensive business plan that can be used to raise money for a new or relatively new venture. The experiential learning process is enhanced through team meetings with faculty and/or course advisers and through oral presentations to the entire class.

*Prerequisite:* MGMT 6620.

*Offered:* Spring term annually.

*3 credit hours*

**MGMT 6640**
Invention, Innovation, and Entrepreneurship

Creativity is the starting point for technological entrepreneurship. Through interaction with faculty and guest speakers, students increase their understanding of the creative process and some of the tools that can be implemented to stimulate and/or manage individual and collective creativity. In addition, through application of these techniques in course activities, students explore and attempt to enhance their own creativity.

*Offered:* Spring term annually.

*3 credit hours*

**MGMT 6650**
Technology and Competitive Advantage

A capstone sequence in policy and strategy aimed at developing students' understanding of the relationship between business strategy and technology. The process of converting technological opportunity into competitive advantage is viewed from the perspective of both large, established companies and new ventures.

*Prerequisite:* Course is taken towards the end of the program.

*Offered:* Fall term annually.

*3 credit hours*

**MGMT 6660**
Strategy, Technology, and Entrepreneurship

This is part two of the two-course sequence that begins with MGMT 6650. This course is about strategy implementation and fundamental concepts in implementing strategy both at the corporate level and the business unit level.

*Prerequisite:* MGMT 6650 or permission of instructor.

*Offered:* Spring term annually.

*3 credit hours*

**MGMT 6670**
Practicum in Technological Entrepreneurship

Provides students with opportunities to learn by text, discussion, and practical fieldwork, how successful new technological ventures are created, developed, and financed. Students work alone or in small teams with guidance from experienced entrepreneurs. Students wishing to take this course are required do so in their first year of study.

*Offered:* Spring term annually.

*3 credit hours*

**MGMT 6680**
Strategy, Technology, and Global Competitive Advantage

This course emphasizes the linkage between technology, strategy, and achieving global competitive advantage. This course develops the concept and practical tools of strategy, strategic planning, and implementation both at the business unit and at corporate levels. The strategies of technology intensive international companies such as Intel, Microsoft, Netscape, Apple, Rhone-Poulenc, Toshiba, Xerox, MCI, ABB, and MapInfo are investigated and compared. The study of the evolution of General Electric’s strategies from 1970 to 2000 completes the course. Students work in teams to develop a five-year strategic plan for a company or business unit of their choice, with a minimum of three strategic alternatives, and recommend the chosen alternative. This course cannot be taken by MBA students or taken with MGMT 6650 or 6660.

*Offered:* Spring term annually.

*3 credit hours*
MGMT 6690
Negotiations
This course is designed to help develop essential expertise in managing negotiations that occur in a broad array of settings. Students will learn to recognize types of negotiation, and gain proficiency in helping to shape beneficial outcomes. Students will develop negotiation skills experientially using a variety of exercises and case studies while implementing useful analytical frameworks.
Offered: Fall or spring terms annually.
3 credit hours

MGMT 6700
Corporate Entrepreneurship
Organizations that increase their capacity for entrepreneurship build a foundation for long term competitiveness. This course examines how organizations can build management systems to enable entrepreneurial activities while simultaneously addressing current operational concerns. This tension differentiates the corporate entrepreneurial challenge from the start-up venture. The course focuses on both the organizational and project levels, studying how organizations can build an entrepreneurial capacity, and how project champions can ensure their projects are effectively evaluated, supported, and managed.
Offered: Spring term annually.
3 credit hours

MGMT 6720
Internet Marketing
Technology is a vital link in how modern corporations identify, acquire, transact with, and keep their customers. This course provides an introduction to both the technology infrastructure most relevant to the customer relationship as well marketing issues that result from the application of computers and communication networks. Topics include issues related to social media, search, online advertising, blogging, customer relationship management, online market segmentation, and marketing of IT products.
Prerequisites: MGMT 4430 or permission of instructor.
Offered: Spring term annually.
3 credit hours

MGMT 6730
Technological Change and International Competitiveness
Analysis of the differences among technical systems and interactions with industrial growth is undertaken with regard to nation states, industrial sectors, and companies. To develop tools of analysis regarding technological change, industrial policy, and corporate performance. The impact of technological change on industrial growth and competitiveness is viewed from three perspectives: the general manager, the technical professional, and the public official. This course is available to Hartford students only.
Offered: Fall term annually.
3 credit hours

MGMT 6750
Legal Aspects of E-Business and Information Technology
Legal, regulatory, and public policy issues related to e-commerce/e-business, the Internet, and information technology are explored through an analytic, critical thinking approach. Topics include: e-contracts, digital signatures, B2B and B2C agreements; ownership, protection, and exploitation of intellectual capital including patents, trademarks, copyrights and trade secrets; regulatory issues; ISP and Web site liability including defamation; copyright infringement, securities regulation, and criminal acts; policy issues including privacy, security and encryption, and obscene materials. Global e-commerce will be explored. This course is available to Hartford students only.
Offered: Fall term annually.
3 credit hours

MGMT 6770
Complex Organizations and Organization Theory
A macro approach to understanding organizations. Topics include organizational design, contingencies of design, organizational processes, such as culture, environmental interfaces and influences, information processing approaches to design, decision making, and organizational change and development.
Prerequisite: Doctoral course or permission of instructor.

MGMT 6800
Ethical, Political, and Legal Context of Business

MGMT 6810
Management of Technical Projects
The purpose of this course is to enable the technically oriented manager to select projects of value to the organization, develop a project plan including staffing, perform a risk analysis on the project, and successfully execute the project. Students, working alone or in teams, practice the project management process by planning a current project in the area of new product development, process reengineering, information systems, or any other project with business implementation.
Offered: Fall term annually.
3 credit hours
MGMT 6820
Communications in Organizations
Covers the skills and techniques in effective communications in organizations, including defining the problem and purpose of the communications, the audience, and the intended result. Introductory communications theory is covered; the focus is primarily on written communications, but limited coverage is given to oral techniques, visual representations, and the like. Students prepare and are critiqued on various forms of communications in organizations.
3 credit hours

MGMT 6840
Practicum in Management
This practicum provides students with the opportunities to put their knowledge to work in a field project in their area of concentration, including entrepreneurship, finance, marketing, information systems, production and operations management, environmental management policy. Projects are conducted in collaboration with companies in the Rensselaer Incubator Center, the Technology Park, and the Capital Region. Project teams make presentations before a panel.
Prerequisite: All first year MBA courses and faculty adviser approval.
3 to 6 credit hours

MGMT 6850
Organizational Behavior Theory and Research Seminar
This course is designed to introduce students to theories and principles in organizational behavior research. Students will investigate important theoretical perspectives, concepts, and research methods in behavioral research, with an emphasis on developing an understanding of how research in the field is conducted and how further contributions to this field might be made. Through in-depth discussions of selected research articles, students will gain some proficiency in framing meaningful research questions and deriving testable hypotheses.
Prerequisite: Good standing as a Ph.D. student.
Offered: Fall or spring term annually.
3 credit hours

MGMT 6870
Empirical Issues in Management Research
The course focuses on the empirical issues of academic research in different business disciplines. It broadly encompasses a number of key research topics emphasizing the theoretical underpinnings and the empirical frontiers. The course will concentrate on the use of statistical approaches relevant for engaging in empirical research. Overall, the course attempts to develop skills such as synthesizing research, developing research designs, building theories, and using appropriate empirical methodology and techniques.
Offered: Fall term annually.
3 credit hours

MGMT 6880
Management Research Workshop
The course focuses primarily on empirical issues in academic research. Students will learn to use theoretical and empirical skills acquired in previous courses and seminars in developing research in general, and academic papers in particular, in their respective fields.
Prerequisite: MGMT 6870.
Offered: Spring term annually.
3 credit hours

MGMT 6900
Doctoral Research Methods I
The objectives of this beginning doctoral course are to introduce students to social science theory development, expose students to a broad array of research techniques, and help students design research programs and write about them. The underpinnings of scientific theory are reviewed along with a range of quantitative and qualitative research methods. Drawing on their own interests, students write one research proposal and two research papers illustrating the application of two different research methodologies.
Offered: Spring term annually.
3 credit hours

MGMT 6910
Doctoral Research Methods II
This course develops empirical tools and their applications to key areas of business analysis, including finance, human resource analysis, marketing, organizational behavior, and production appropriate theories. Empirical techniques emphasized include advanced regression and structural equations methods. Specialized statistical tools will be used.
Prerequisite: MGMT 6900.
Offered: Fall term annually.
3 credit hours

MGMT 6920
Strategic Management Theory Seminar
This is a reading course designed to introduce first-year Ph.D. students in management to the theory families and empirical research in the field of Strategic Management. Strategic Management theories draw from parent disciplines of economics, psychology, sociology, anthropology, evolutionary biology, and political science.
This puts the field at the nexus of all management studies.
Prerequisites: Doctoral student standing, Doctoral Research Methods sequence, or permission of doctoral program director.
Offered: Fall term annually.
3 credit hours

MGMT 6940
Independent Study
1 to 6 credit hours

MGMT 6960
Topics in Management
3 credit hours
MGMT 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

3 credit hours

MGMT 7030
Strategy, Technology, & Competition I
This course covers the fundamentals of business and corporate strategy, integrating these concepts into an environment of technological change, competition, and entrepreneurship. The course includes the following areas of emphasis: concepts of strategy, industry environment, resources and capabilities of the firm, organization and systems of the firm, the dynamics of competitive advantage, strategic alternative analysis, and strategies in different contexts. The course uses business cases and a project to enrich the theoretical concepts.

3 credit hours

MGMT 7050
Design, Manufacturing, and Marketing I
This course immerses students in the practices and activities that lead to the creation of innovative new products and services. Through a team-based learning experience, students generate an idea for a new product or service and follow the development process from conception through planning for commercialization. Through lectures, cases, and practical exercises, students learn how to overcome hurdles inherent in new product and service development. Students apply this knowledge in all phases of product development, including concept testing, product design, production planning, and market strategy. The project undertaken in this course provides student teams with an opportunity to create a new venture that may then be carried forward utilizing Rensselaer's technological resources such as the Incubator Program and Rensselaer's Technology Park.

3 credit hours

MGMT 7060
Design, Manufacturing, and Marketing II
This course immerses students in the practices and activities that lead to the creation of innovative new products and services. Through a team-based learning experience, students generate an idea for a new product or service and follow the development process from conception through planning for commercialization. Through lectures, cases, and practical exercises, students learn how to overcome hurdles inherent in new product and service development. Students apply this knowledge in all phases of product development, including concept testing, product design, production planning, and market strategy. The project undertaken in this course provides student teams with an opportunity to create a new venture that may then be carried forward utilizing Rensselaer's technological resources such as the Incubator Program and Rensselaer's Technology Park.

3 credit hours

MGMT 7070
Managing on the Edge: Corporate Innovation for the Coming Years
This course investigates the challenges of managing and leading organizations in situations characterized by their non-linear, unpredictable nature. Students will be challenged to develop innovative responses and solutions, drawing upon the full array of knowledge, skills, and insights they have gained from their two years of MBA study. Along with learning to deal with risk and uncertainty, the soon-to-be MBA graduates will be prepared for addressing the increasing degrees of fluidity and turbulence found in today's business, economic, and competitive environments.

3 credit hours

MGMT 7120
International Marketing
Theoretical and practical overview of International Marketing; discussion and analysis of International Marketing issues, problems, and solutions using text, case studies, and examples. This course is designed for professionals involved in corporate strategic planning, export sales, marketing, and international management.

MGMT 7210
Acquisition and Venture Analysis
Recent years have seen an accelerated commitment to growth and asset reallocation through acquisitions and corporate restructurings. Indeed the accounting profession is taking a fresh look at how these deals are accounted for in the firms' financial statements. The rate of deals is exponential and covers the full spectrum from established industries to high technology, computer, biotechnology, and Internet firms. Topics covered in this course are reasons for acquisitions, valuing, and structuring a transaction. Determining the currency to be used, achieving strategic and organizational alignment, takeover defenses, and post-deal integration. Students study a recent transaction of their own choosing and prepare an oral and written report focusing on those aspects that made the deal successful.

Prerequisite: MGMT 6020 or permission of instructor.

3 credit hours
MGMT 7230  
Professional Development Workshop I  
This course is the first in a three part series of Professional Development Workshops that teach practical skills in laboratory settings. Over the first three semesters, the MBA cohort student will be exposed to professional skills training, distinguished speakers, and leadership development. This first part will concentrate on building writing and presentation skills, and practicing those skills in the conceptual environment of Leadership, Followership, and Membership.  
Prerequisite: MBA Cohort.  
Offered: Fall term of the first year of the MBA cohort, every other week, for six weeks.  
0 credit hours

MGMT 7240  
Professional Development Workshop II  
This course is the second in a three part series of Professional Development Workshops that teach practical skills in laboratory settings, in the context of Leadership, Followership, and Membership. Over the first three semesters, the MBA cohort student will be exposed to professional skills training, distinguished speakers, and critical leadership development. This second workshop will concentrate on building leadership skills through exercises, corporate site visits, and audiences with distinguished speakers.  
Prerequisite: MBA Cohort.  
Offered: Spring term of the first year of the MBA cohort, every other week, for six weeks.  
0 credit hours

MGMT 7250  
Professional Development Workshop III  
This course is the last in a three part series of Professional Development Workshops that teach practical skills in laboratory settings, in the context of Leadership, Followership, and Membership. Over the first three semesters, the MBA cohort student will be exposed to professional skills training, distinguished speakers, and critical leadership development. This third workshop will concentrate on building leadership skills through exercises, personal and professional awareness, and group interactions and exercises.  
Prerequisite: MBA cohort.  
Offered: Fall term of the second year of the MBA cohort for five days prior to semester start.  
0 credit hours

MGMT 7500  
Managing Supply Networks  
An overview of the key concepts related to the flow of information, goods, and services, from product or service design, through production to end-use customer. Focuses on the planning, data, analysis, evaluation, and decision-making processes used to manage supply networks in order to gain competitive advantage and improve customer satisfaction. Compares and contrasts supply strategies and methods based on batch-and-queue and Lean principles and practices. Emphasis is on business-to-business relationships, the application of practices that eliminate waste, and inter-organizational capability building.  
Prerequisites: MGMT 6040 and MGMT 6100. Recommend MGMT 6450.  
3 credit hours

MGMT 7640  
Hedge Funds and Financial Markets  
The topics covered include an overview of the hedge fund industry; legal and regulatory issues; in depth analysis of a number of hedge fund trading and investment strategies including equity long/short, fixed income arbitrage, credit and high yield fixed income arbitrage, commodity and currency trend-following strategies, and private equity “crossover” hedge funds. The course will also cover the role of hedge funds in an overall investment portfolio and in asset allocation framework.  
Prerequisites: MGMT 6020; MGMT 7740.  
Offered: Fall and spring term annually.  
Cross listed: MGMT 4640; students cannot obtain credit for both courses.  
3 credit hours

MGMT 7650  
Advanced Hedge Funds and Financial Markets  
This course is designed to advance the skills and knowledge gained in the Hedge Funds and Financial Markets by applying these to in-depth exploration of specific hedge fund trading and investment strategies, including trend following quantitative models; long/short equity analysis and market neutral quantitative strategies; fixed income and credit derivatives hedge funds. For each broad topic, advanced financial and market techniques, including relevant quantitative and computer models are used to gain a thorough understanding of the techniques, assumption, models, and risks of each strategy.  
Prerequisite: MGMT 7640.  
Offered: Fall and spring term annually.  
Cross listed: MGMT 4650.  
3 credit hours

MGMT 7700  
International Negotiations  
Examines international negotiation techniques, practice, and styles. Students are given an in-depth profile questionnaire to assess individual strengths and weaknesses in international negotiations. Profiles of international negotiations are examined. Negotiations and group presentations are video taped and analyzed.  
Prerequisite: MGMT 6390.
MGMT 7710
Cultural Environment of International Business
The emerging role of the international manager, cultural impact of international management, managing culture shock, organizational responsibilities, and cultural differences. Foreign deployment, cultural specifics for managerial effectiveness, cultural themes and patterns, American macro- and micro-cultures, working with the global market environment.
Prerequisite: MGMT 6390.

MGMT 7730
Economics and Institutions
Main course objective is to introduce students to basic economics principles and establish economics as a managerial decision-making framework. The course will draw on economic analysis of such concepts as cost, demand, profit, competition, pricing strategy, and market protection and tie them to operational business decisions.
Offered: Fall term annually.
3 credit hours

MGMT 7740
Accounting for Reporting and Control
This course introduces theories and practices of financial as well as managerial accounting. The financial accounting sessions provide an overview of external financial statements. The managerial accounting sessions focus on how accounting information is used in the internal managerial decision making process within a firm as well as cover cost accounting, budgeting, and performance evaluation tools.
Offered: Fall term annually.
3 credit hours

MGMT 7750
Global Business and Social Responsibility
The course examines different responses of American, European, and Asian firms to a global economy, within an historic and evolving context. Models of economic, social, political, technological, and national development will be introduced. Various conflicting demands of national governments, interest groups, corporations, unions, NGOs and consumers are often expressed in terms of corporate, ethical, and social responsibility. Cases will be analyzed in terms of models of global business practices and conflicting claims will be critically evaluated.
Offered: Fall term annually.
3 credit hours

MGMT 7760
Risk Management
Overview of risk management and the concept and measurement of risk; types of risks (market, credit, liquidity, operational, business, strategic). Concepts, tools, and instruments available for risk management. Specific issues related with managing specific risk types — market, credit, interest-rates, liquidity, risk and operational risk. Securitization, asset-liability management. Concepts underlying insurance and role of insurance for risk management.
Prerequisite: MGMT 6020 or permission of instructor.
Offered: Fall term annually.
3 credit hours

MGMT 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
Variable credit hours

MTLE Materials Science and Engineering (SOE)

MTLE 1200
Introduction to Materials Engineering
A one credit course comprising class lectures, laboratory visits and group projects. The course will provide an overview of the field of materials science and engineering, highlighting how understanding the structures, properties and processing of materials provides scientific and engineering advances that sustain the progress of technology.
Offered: Fall term annually.
1 credit hour

MTLE 2020
Introduction to Ceramic Materials
Structure and properties of crystalline ceramic materials. Atomic bonding, crystal structure, structural imperfections, nonstoichiometry, surfaces, and interfaces. Reactions in ceramic systems in terms of phase equilibria, nucleation and crystal growth, diffusion, grain growth, and sintering. Ceramic microstructures and various properties.
Offered: Upon availability of instructor.
3 credit hours

MTLE 2100
Structure of Engineering Materials
The first course in Materials Science and Engineering. Structures of metals, ceramics, and polymers and experimental techniques for their determination are discussed. Laboratory experience is included.
Prerequisite: ENGR 1600 or equivalent.
Offered: Spring term annually.
4 credit hours

MTLE 2940
Readings in Materials
3 credit hours
MTLE 2980
Senior Project
3 credit hours

MTLE 4030
Glass Science
Glasses are used in optical communications (optical fibers), electronics (insulator), and nuclear waste processing in addition to conventional use as windows, light bulbs, and containers. Subjects covered include: Formation and structure of inorganic glasses. The relationship between properties and cooling rate. Viscosity and structural relaxation. Phase separation and crystallization. Ionic diffusion and electrical properties. Mechanical strength and fatigue. Glass surface and chemical durability. Optical properties.
Offered: Fall term annually.
3 credit hours

MTLE 4050
Introduction to Polymers
A first course on polymer physics and structure-property relationships. Topics include molecular structure; morphology of amorphous and crystalline polymers; physical properties of polymers in relation to structure, including rubber elasticity, viscoelasticity, and glass transition; mechanical testing. This is a companion course to CHEM 4620. Course is open to advanced juniors, seniors, and graduate students in science or engineering and others by permission of instructor.
Offered: Fall term annually.
3 credit hours

MTLE 4100
Thermodynamics of Materials
Rigorous development of classical thermodynamics as applied to prediction of materials properties. Nonideal gases, solutions, phase equilibria, chemical equilibria, defects.
Prerequisites: ENGR 2250, CHEM 1100, ENGR 1600 or equivalent.
Offered: Fall term annually.
4 credit hours

MTLE 4150
Kinetics in Materials Systems
Kinetic processes in materials. Overview of kinetics in relation to equilibrium thermodynamics, atomistics and mathematics of diffusion, phase transformations, and microstructural evolution. All materials classes, including metals and alloys, ionic and intermetallic compounds, glasses, semiconductors, and polymers, will be considered in terms of similarities and differences. Includes laboratory component.
Prerequisites: MTLE 4100, CHEM 1100, ENGR 1600.
Offered: Spring term annually.
4 credit hours

MTLE 4160
Semiconducting Materials
Review of electronic properties of materials. Growth and structure of semiconductors. Diffusion, ion implantation, oxidation, microlithography, plasma etching, thin film deposition, metallization, with emphasis on Si technology. Introduction to compound semiconductors. Students cannot obtain credit for both this course and ECSE 4250.
Prerequisite: MTLE 4200 or equivalent.
Offered: Upon availability of instructor.
3 credit hours

MTLE 4200
Properties of Engineering Materials I
Prerequisites: ENGR 1600, MTLE 2100, PHYS 1200.
Offered: Fall term annually.
4 credit hours

MTLE 4250
Properties of Engineering Materials II
This is a required departmental course, but is also appropriate for biomedical engineers and other engineering disciplines as an elective. This course teaches the mechanical properties of metals, ceramics, and polymers from both the macroscopic and atomistic or micromechanical viewpoints. An introduction to three-dimensional stresses and strains. Elastic behavior, plastic behavior, strengthening mechanisms, fracture, creep, and fatigue are all addressed. Includes laboratory component.
Prerequisites: ENGR 1600, MTLE 2100.
Offered: Spring term annually.
4 credit hours

MTLE 4260
High Temperature Alloys
Offered: Upon availability of instructor.
3 credit hours

MTLE 4310
Corrosion
Corequisite: MTLE 4910.
Offered: Upon availability of instructor.
3 credit hours
MTLE 4400
Materials Synthesis and Processing I
Emphasis is on materials synthesis, with four instructional modules
drawn from aspects of melt and extractive metallurgy and from the
synthesis of polymers, ceramics and glasses, electronic materials,
composite materials and nanophase materials.
Prerequisites: MTLE 4200, MTLE 4150, MTLE 4250.
Offered: Fall term annually. Includes laboratory experience.
4 credit hours

MTLE 4410
Welding Processes and Metallurgy
Fundamental principles, primary variables, and metallurgical chang-
es associated with both fusion and nonfusion welding processes.
Energy sources, rates and modes of energy transfer to the work, and
distribution of energy in the work as these affect plastic softening
or melting, plastic flow or solidification, post-solidification trans-
f ormations, heat-affected zone microstructures, residual stresses
and distortion, defect formation, and resultant properties; attention
to the effects of weldment material, joint design, process, and
procedural variables. Physical metallurgy is emphasized throughout.
Prerequisite: ENGR 1600.
Offered: Upon availability of instructor.
3 credit hours

MTLE 4420
Joining of Advanced Materials
Individual joining processes including mechanical fastening, ad-
hesive bonding, welding, brazing, soldering, thermal spraying, and
variants or hybrids of these. Advantages and disadvantages, mecha-
nisms for attaining joint strength, various specific methods and
procedures, joint design and analysis, expected properties, practical
issues in production, safety, and economics, and special problems
with each process. Joining of similar and dissimilar combinations of
metals and alloys, intermetallics, ceramics, glasses, polymers, and
composites, with special attention to attaining optimum properties.
Team term project.
Prerequisite: ENGR 1600.
Offered: Upon availability of instructor.
3 credit hours

MTLE 4450
Materials Synthesis and Processing II
Emphasis is on materials processing, with four instruction modules
drawn from aspects of casting and molding, deformation processing,
 powder processing, joining and additive processes, cutting and re-
 moval processes, and annealing/heat treatment processes. Includes
laboratory component.
Prerequisite: MTLE 4400.
Offered: Spring term annually.
4 credit hours

MTLE 4470
Processing of Biomaterials
Processing of biomaterials gives an overview of the most advanced
techniques to process biomaterials into structures that satisfy next
generation applications. All materials classes will be covered includ-
ing polymers, ceramics, metals, composites, and cells and tissues. In
each case, the material-specific processing and the properties and
potential applications will be covered.
Prerequisite: ENGR 1600.
Offered: Upon availability of instructor.
Cross listed: MTLE 6470.

MTLE 4910
Materials Selection
This class covers basic materials selection concepts and the under-
lying structure-property-process-performance interaction. Engineer-
ing materials, structures and properties, principles and process of
materials selection, generation of materials performances indices,
assessment and optimization of performance, processing routes and
manufacturing issues, role of reverse engineering and failure analysis
in design are covered. Materials selection against yielding, fracture,
flexure, buckling, fatigue, creep, corrosion, and wear are addressed.
Decomposition of engineering problems into functional, geometric,
and materials constraints are emphasized. Materials selection based
on simple and complex or conflicting constraints will be developed.
Students will perform written assignments and oral presentations
to develop communication skills. Enrollment for MS&E majors is
restricted to juniors, seniors, or graduates.
Prerequisites: CHEM 1100 and ENGR 1600.
Offered: Spring and fall terms annually.
3 credit hours

MTLE 4920
Design and Applications of Materials
A capstone experience to afford seniors in MS&E the unique and
invaluable opportunity to participate as a vital member of a truly
multidisciplinary design team (comprised of engineering students
from other disciplines, as well as MBAs) and function just as they
will as professionals in practice, in preparation for practice. This
course acquaints students with all the phases of the design process
from recognizing the need through a detailed conceptual design.
Students work in teams on a semester-long project with the as-
sistance of faculty consultants. The design projects require students
to draw upon their engineering background, experience, and other
pertinent resources. Oral and written presentations are required.
This is a communication-intensive course.
Prerequisite: Satisfactory completion of MTLE 4910.
Offered: Spring and fall terms annually.
3 credit hours

MTLE 4960
Topics in Materials Engineering
Offered: Spring term annually.
3 credit hours
MTLE 6010
Defects in Solids
Point defects, nonstoichiometry, diffusion and defects, electronic defects, elastic properties of dislocations, dislocation-point defect interactions, dislocation arrays, grain boundaries, stacking faults, phase stability, twin boundaries, epitaxial interfaces.
Prerequisite: MTLE 2100 or equivalent.
Offered: Upon availability of instructor.
3 credit hours

MTLE 6030
Advanced Thermodynamics
Review of classical thermodynamics. Development of basic concepts of statistical thermodynamics. Application of both classical and statistical techniques to the determination of phase and chemical equilibrium in real systems.
Prerequisite: MTLE 4100 or equivalent.
Offered: Fall term annually.
4 credit hours

MTLE 6040
Principles of Crystallography and X-Ray Diffraction
Symmetry operations, point groups and space groups, x-ray and electron diffraction techniques, reciprocal lattice, Ewald sphere, mathematics of diffraction, crystal chemistry, crystal structure-property relationships.
Offered: Upon availability of instructor.
3 credit hours

MTLE 6060
Advanced Kinetics of Materials Reactions
Prerequisite: MTLE 4100 or MTLE 6030 or equivalent.
Offered: Spring term annually.
3 credit hours

MTLE 6080
Electron Microscopy of Materials
Introduction to electron optics, electron diffraction contrast mechanisms, specimen preparation, and microanalysis. Theory and operating fundamentals of the SEM, TEM, STEM, and the electron microprobe. Analysis of images from crystalline materials using kinematical and dynamical theories of electron diffraction. Includes laboratory component.
Prerequisite: MTLE 2100 or MTLE 6040.
Offered: Upon availability of instructor.
3 credit hours

MTLE 6110
Diffusion in Solids
The diffusion process in metals and alloys. Solution to Fick’s law.
Offered: Upon availability of instructor.
3 credit hours

MTLE 6120
Advanced Electronic Properties of Materials
Offered: Spring term annually.
3 credit hours

MTLE 6150
Fracture of Solids
Offered: Upon availability of instructor.
3 credit hours

MTLE 6220
Advanced Semiconducting Materials and Processing
Discussion of selected advanced and emerging topics in microelectronics materials and fabrication. These may include metallization, thin film deposition, interconnection technology, microlithography, plasma etching and processing.
Offered: Upon availability of instructor.
3 credit hours

MTLE 6250
Advanced Mechanical Properties of Materials
The phenomenological, mechanistic, and micro-structural aspects of the mechanical properties of materials are developed, with particular emphasis on the similarities and differences among various material systems including metals, ceramics, and polymers. Phenomenological aspects of the three-dimensional characteristics of stress and strain, various yield criteria, elastic behavior, viscoelastic behavior, plastic behavior, statistical aspects of brittle fracture and fracture mechanics are presented. Mechanistic and micro-structural topics include edge and screw dislocation behavior, slip systems, critical resolved shear stress, dislocation multiplication and interactions, barriers to motion, polymer chain conformation and entropy.
Offered: Upon availability of instructor.
4 credit hours
MTLE 6300
Integrated Circuit Fabrication Laboratory
Theory and practice of IC fabrication in a research laboratory environment. Test chips are fabricated and the resulting devices and circuits evaluated. Processes and fabrication equipment studied and used include oxidation/diffusion, CVD reactors, photolithography, plasma etching, vacuum evaporator, ion implantation, etc. Instruments used in process monitoring and final testing include thin film profilometer, ellipsometer, resistivity probe, scanning electron microscope, capacitance-voltage system, etc. The fundamentals of hazardous material handling and clean room procedures are studied.
Prerequisite: ECSE 4250 or equivalent.
Offered: Spring term annually.
Cross listed: ECSE 6300. Students cannot obtain credit for both this course and ECSE 6300.
3 credit hours

MTLE 6400
Vacuum Techniques
Offered: Upon availability of instructor.
3 credit hours

MTLE 6420
Surface Phenomena
Offered: Upon availability of instructor.
3 credit hours

MTLE 6430
Materials Characterization
Principles and applications of current techniques for the chemical, structural, and morphological characterization of engineering materials, with an emphasis on materials used in the microelectronics industry. Techniques studied include various electron and ion spectroscopies, electron microscopies, and diffraction techniques.
Offered: Upon availability of instructor.
3 credit hours

MTLE 6450
Melting and Solidification
Offered: Upon availability of instructor.
3 credit hours

MTLE 6460
Advanced Structure and Bonding in Materials
Phenomenological and quantitative descriptions of crystal symmetry and structure. Theories of primary and secondary bonding in crystals. Theory and application of diffraction techniques for structure determination. Models of cohesive forces in solids. Emphasis is placed on the intimate connection between crystal structure, bonding, electronic structure, and properties of solids.
Offered: Fall term annually.
4 credit hours

MTLE 6470
Processing of Biomaterials
Processing of biomaterials gives an overview of the most advanced techniques to process biomaterials into structures that satisfy next generation applications. All materials classes will be covered including polymers, ceramics, metals, composites and cells and tissues. In each case, the material-specific processing and the properties and potential applications will be covered.
Prerequisites: ENGR 1600.
Offered: Upon availability of instructor.
Cross listed: MTLE 4470.

MTLE 6480
Nanostructured Materials
The course introduces students to the building blocks of nanostructured materials, material behavior when they are assembled, and the technological implications of these materials, with emphasis on new developments in this field and future perspectives. Lectures by the instructor and other faculty experts on various aspects of nanomaterials are followed by student lectures in areas of their own particular interest. These lectures then become the basis for students to create online video (YouTube) presentations for broader dissemination. As most experienced science/engineering professionals know, teaching a subject to one’s technical peers is an unparalleled learning experience. It can be even more challenging and rewarding to do so successfully to others who are not as technically aware, such as some managers, potential investors, government officials, etc. These two elements, therefore, not only enhance the student’s learning of the chosen subject matter within the area of nanostructured materials, but also help develop essential presentation skills for their future careers.
Offered: Spring term annually.
3 credit hours
MTLE 6500  
Modeling of Materials  
This course introduces basic concepts used in the modeling of material properties. The course will include classical molecular mechanics, molecular dynamics, Monte Carlo, quantum mechanics based tight binding, continuum level analysis, and multiscale methods as applied to modeling of soft and hard matter. The methods are introduced in a computer laboratory environment. Open to graduates and qualified undergraduates. Suggested: A computer language such as FORTRAN or C is useful.  
Offered: Fall term odd-numbered years.  
3 credit hours

MTLE 6610  
Deformation Processing  
Mechanical metallurgy and mechanics of the classical metal-working operations. Analytical techniques. Friction and lubrication. Workability. Effects on as-worked properties. Technological discussions of forging, rolling, extrusion, drawing, and other unit operations.  
Prerequisite: ENGR 1600 or equivalent.  
Offered: Upon availability of instructor.  
3 credit hours

MTLE 6750  
Special Topics in Ceramics  
A course in physical ceramics, the content of which will be modified in accordance with current interests and technology.  
Offered: Upon availability of instructor.  
3 credit hours

MTLE 6840  
Polymer Engineering  
Survey and engineering analysis of industrial processes and commercial polymers. Topics include introductory fluid mechanics, non-Newtonian fluids, molecular theory of viscoelasticity, analysis of extrusion, and other selected processes. Open to all graduate students majoring in polymer science and engineering.  
Offered: Upon availability of instructor.  
3 credit hours

MTLE 6900  
Graduate Seminar  
Offered: Fall and spring terms annually.  
0 credit hours

MTLE 6930  
Literature Study  
A special course assignment open to graduate students working toward a master’s degree. Applicable where a student cannot reasonably arrange to submit a thesis. A written report on the study must be submitted and defended before a committee of the faculty.  
1 to 3 credit hours
PHIL Philosophy (HSSH)

PHIL 1110
Introduction to Philosophy
An introduction to the major areas of philosophy (ethics, theory of knowledge, philosophy of religion, etc.) and to some of the main problems treated within these fields. Selections from contemporary as well as classical authors are studied and discussed. Students are encouraged to develop a disciplined approach to intellectual problems. Emphasis varies with the instructor.
Offered: Fall and spring terms annually.
4 credit hours

PHIL 1120
Minds and Machines
This course is an introduction to the philosophy of mind. Students will debate and write papers on the nature of mind, free will, personal identity, consciousness, artificial intelligence, and animal cognition. This is a communication-intensive course. Students cannot obtain credit for both this course and IHSS 1964 Minds and Machines.
Offered: Fall term annually.
4 credit hours

PHIL 2100
Critical Thinking
This course provides tools for the identification, analysis, and evaluation of the various patterns of reasoning as they occur in the real world. Patterns of reasoning include deductive reasoning, inductive reasoning, scientific reasoning, statistical reasoning, and causal reasoning. The course also covers some basic psychology and sociology of reasoning and belief, and concludes with a critical discussion of science and the scientific method.
Offered: Spring term annually.
Cross listed: PSYC 2100. Students cannot obtain credit for both this course and PSYC 2100.
4 credit hours

PHIL 2120
Introduction to Cognitive Science
This course is an introduction to the new and quickly growing field of Cognitive Science which studies the various aspects of cognition, including reasoning, learning, memory, and perception and action. Cognitive Science is a highly interdisciplinary field of study at the intersection of philosophy, psychology, computer science, linguistics, neuroscience, and anthropology, and the course hosts a number of guest lectures given by experts in these respective fields. This is a communication-intensive course.
Offered: Spring term annually.
Cross listed: PSYC 2120. Students cannot obtain credit for both this course and PSYC 2120.
4 credit hours

PHIL 2130
Introduction to Philosophy of Science
How does science stimulate philosophical thinking and how has philosophy influenced science? This broad range of interaction is studied with special attention given to the concepts of theory, observation, and scientific method. Special attention is given to issues basic to psychology, in particular, reductionism, behaviorism, functionalism, and cognitivism. This is a communication-intensive course.
Offered: Spring term annually.
Cross listed: STSH 2130. Students cannot obtain credit for both this course and STSH 2130.
4 credit hours

PHIL 2140
Introduction to Logic
Introduction to first-order logic as a tool to be used in engineering, computer science, philosophy, etc., and as procedural knowledge helpful in puzzle-solving environments (e.g., standardized tests). A hands-on laboratory component is included. No previous logic or math presupposed.
Offered: Fall term annually.
4 credit hours

PHIL 2300
Asian Philosophies
Asia has a long and rich history of philosophical thought. Much of this philosophy has been associated with great religious traditions, such as Hinduism, Jainism, Buddhism, Confucianism, and Daoism. This course will examine a number of philosophical positions and schools of thought associated with these traditions. Comparisons will be drawn between different Asian traditions, and between Asian and Western traditions.
Offered: Fall and spring terms annually.
4 credit hours

PHIL 2500
Bioethics
This course involves a philosophical analysis of some of the basic moral issues raised by recent and anticipated developments in the areas of biology and medicine. The general question “What are moral problems, and how does one resolve them?” is examined in the context of concrete cases involving issues such as abortion, euthanasia, organ transplants, experimentation on human patients, cloning, genetic engineering, behavior control and modification. This is a communication-intensive course.
Offered: Spring term annually.
Cross listed: STSH 4250. Students cannot obtain credit for both this course and STSH 4250.
4 credit hours
PHIL 2600
Moral Development
An analysis of psychological research on how our commonsense moral beliefs develop from early childhood through old age and their application to daily problems. A major focus is on the conflict between themes of justice or individual rights and caring compassion and its relation to gender differences (the Kohlberg/Gilligan debate). This is a communication-intensive course.
Offered: Spring term annually.
Cross listed: PSYC 2600. Students cannot obtain credit for both this course and PSYC 2600.
4 credit hours

PHIL 2830
Introduction to Philosophy of Religion
Central to philosophy is a careful examination of our reasons for holding our beliefs. Given the complexity/ineffability of religious experience, philosophy of religion's examination of reasons is especially difficult. This course will analyze and evaluate Western monotheism both generally and as it relates to the traditional questions of faith and reason, the problem of evil, fate, and free will and the existence of miracles. Time permitting, non-Western as well as Western religions will be considered.
Offered: Fall term annually.
4 credit hours

PHIL 2940
Philosophy Studies
Independent study of a particular topic.
Prerequisite: Permission of instructor.
1 to 4 credit hours

PHIL 2960
Topics in Philosophy
Experimental courses on subjects to be announced in advance.
1 to 4 credit hours

PHIL 4140
Intermediate Logic
This course is a continuation of PHIL 2140, covering basic metatheory of logic (including formal syntax and semantics, model theory, and soundness and completeness of proof systems), applications of logic (including automated theorem proving, deductive problem solving, and the axiomatization of various branches of mathematics), and alternative systems of logic (including sequent systems, diagrammatic logic, and modal logic).
Prerequisite: PHIL 2140.
Offered: Spring term odd-numbered years.
4 credit hours

PHIL 4220
Social and Political Philosophy
An exploration of such concepts as freedom, rights, and consent and their interrelationship; and a consideration of their bearing on questions of justice, law, and human welfare.
Offered: Spring term annually.
4 credit hours

PHIL 4240
Ethics
A critical examination of traditional and contemporary works in ethical theory by considering what these theories have to say about how we should live, what rights and obligations we have, what things are intrinsically valuable. Typically this includes such topics as ethical and cultural relativism, egoism, freedom, and responsibility. Often the focus will be on contemporary issues such as war, abortion, equality, or punishment. This is a communication-intensive course.
Offered: Fall or spring term annually.
4 credit hours

PHIL 4260
Philosophy of Artificial Intelligence
This course may be roughly divided into two general areas: philosophical problems in AI and philosophical issues that arise because of AI. An example from the first area is the Knower Paradox, a paradox in which an apparently desirable formalism for handling an agent’s knowledge leads to inconsistency; an example from the second area is John Searle's attack on so-called “Strong” AI by way of his Chinese Room argument, wherein he claims that because a computer at bottom just manipulates symbols it cannot genuinely understand.
Prerequisite: PHIL 2140.
Offered: Fall term annually.
4 credit hours

PHIL 4300
Environmental Philosophy
While concepts such as quality of life, environment, nature, global ecology, and the like figure heavily in contemporary discussions, they are seldom integrated into an environmental philosophy. The course tries to achieve this integration by understanding some of the religious, mythic-poetic, and scientific dimensions of the man-nature matrix. Some specific environmental problems are examined in order to illustrate the system of values implied by various solutions.
Prerequisite: Junior or senior standing or permission of instructor.
Offered: Upon availability of instructor.
Cross listed: STSH 4340. Students cannot obtain credit for both this course and STSH 4340.
4 credit hours
PHIL 4310
Scientific Revolutions
What is progress in science? How has our concept of progress been influenced by science? Are there significant differences between scientific and technological revolutions? These questions are explored in order to shed light on the complex dynamics of academic and industrial research.
Prerequisite: PHIL 1110 or PHIL 2130/STSH 2130.
Offered: Upon availability of instructor.
4 credit hours

PHIL 4360
Philosophical Problems of Space and Time
Relevant aspects of the work of Kant, Leibniz, and Newton; Gauss, Riemann, and Poincaré; Faraday, Maxwell, and Einstein. Special attention is given to the historical development of non-Euclidean geometries and the distinction between mathematical and physical geometry. Ultimately, the aim is to clarify the conceptual structure of special and general relativity by showing the problem context in which they evolved. This is a communication-intensive course.
Prerequisite: PHIL 2130 or permission of instructor.
Offered: Spring term annually.
4 credit hours

PHIL 4380
Philosophy of Mathematics
Basic schools of thought about the nature of mathematical reality are described and critically analyzed. Special topics include artificial intelligence, randomness, and the work of George Cantor on transfinite numbers. This is a communication-intensive course.
Prerequisite: PHIL 1110 or PHIL 2130.
Offered: Upon availability of instructor.
4 credit hours

PHIL 4420
Computability and Logic
A team-based, project-oriented, hands-on introduction to the great concepts and discoveries in logic and computability, including Turing Machines, first-order logic, the limitations of computing machines, Gödel’s incompleteness results, and so forth. A hands-on laboratory component is included.
Prerequisite: PHIL 2140.
Offered: Spring term annually.
Cross listed: MATH 4030. Students cannot receive credit both this course and MATH 4030.
4 credit hours

PHIL 4440
Knowledge and Rationality
We claim to know many things but what does this knowledge come to and, indeed, can we know that we know anything at all? Most agree that knowledge is more than “mere belief” — it requires “justification.” This course looks at traditional and contemporary theories of justification and asks the question “Can our commonsense views of knowledge and rationality survive in light of our contemporary scientific understanding of the nature of knowers?”
Prerequisite: One course in philosophy.
Offered: Spring term odd-numbered years.
4 credit hours

PHIL 4480
Metaphysics and Consciousness
Daydreams about some tropical paradise.... The smell of freshly baked bread.... The flash of anger when someone cuts you off.... Your seeing of an albino squirrel on the campus green.... Humans take all of these to involve activities or states of consciousness. But what is this consciousness with which we claim to be so intimately familiar? What are its metaphysical implications and can we reconcile those implications with our current, scientific understanding of the world? This is a communication-intensive course.
Prerequisite: One course in philosophy.
Offered: Spring term odd-numbered years.
4 credit hours

PHIL 4520
Existentialism
An examination of the works of such writers as Kierkegaard, Nietzsche, Heidegger, Sartre, and Jaspers. Attention is also given to the thought of Husserl and to the phenomenological movement. This is a communication-intensive course.
Prerequisite: One course in philosophy or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

PHIL 4570
Buddhism
A study of the conditions of human suffering and human perfection according to Buddhism. The course ranges from the original teaching of Buddha to the development of Buddhism throughout Asia, including China, Tibet, and Japan. Buddhist, Chinese, and Western views of the nature of causation, freedom, existence, and human nature are compared.
Prerequisite: One course in philosophy or senior standing.
Offered: Upon availability of instructor.
4 credit hours

PHIL 4740
Philosophy of Law
The course examines the following questions: What is law? What is the relationship between law and morality? Is there a moral obligation not to break the law? Detailed examination is given to the concepts of liberty, justice, responsibility, and punishment.
Prerequisite: One philosophy or STS course or permission of instructor.
Offered: Upon availability of instructor.
Cross listed: STSH 4320. Students cannot obtain credit for both this course and STSH 4320.
4 credit hours
PHIL 4940
Topics in Philosophy
Experimental courses on subjects to be announced in advance.
Prerequisite: Permission of instructor.
1 to 4 credit hours

PHIL 4990
Capstone Experience in Philosophy
Students conduct original scholarly projects: original research, theoretical or analytical reviews of the literature, or computer simulations. Working either alone or in groups, students prepare written reports relating to this project, under the supervision of a faculty member.
Prerequisite: Permission of a supervising faculty member.
Offered: Fall, spring, and summer terms annually.
3 to 6 credit hours

PHIL 6360
Foundations of Science
This seminar explores the issues of confirmation, semantics, and interpretations of scientific theories. Positivism, realism, and the logic of scientific discovery are discussed with special attention given to foundational problems in physics and psychology. Students should have some background in philosophy of science.
Offered: Upon availability of instructor.
4 credit hours

PHIL 6740
Philosophy of Mind
A study of some current issues in philosophical psychology and philosophy of psychology. The following are representative of the questions discussed: Is a person identical with his body? Is consciousness a brain process? Can computers think? Do avowals have truth-value? Is psychology possible? Occasionally additional topics are selected from such areas as phenomenology (Merleau-Ponty, Sartre) and structuralism (Levi-Strauss, Barthes).
Offered: Upon availability of instructor.
4 credit hours

PHYS Physics (SOS)

PHYS 1010
A Passion for Physics
A weekly one-hour seminar by physics department faculty members, in which they describe their scientific and research interests, at a level suitable for first-year college students. This course is graded satisfactory/unsatisfactory.
Offered: Fall term annually.
1 credit hour

PHYS 1050
General Physics
A one semester calculus-based overview of physics fundamentals with an emphasis on applications. Mechanics, including equilibrium and statics, fluids, oscillations, and waves. Basics of thermodynamics and heat flow. Electrical circuits. Electromagnetic radiation and optics. Recommended for all students who intend to take only one semester of physics. Credit cannot be obtained for both Physics 1050 and Physics 1100.
Corequisite: MATH 1010 or equivalent or permission of instructor.
Offered: Spring term annually.
4 credit hours

PHYS 1100
Physics I
The first semester of a two-semester sequence of interactive courses. Topics include linear and angular kinematics and dynamics, work and energy, momentum and collisions, forces and fields, gravitation, oscillatory motion, waves, sound and interference.
Corequisite: MATH 1010 or equivalent or permission of instructor. Credit cannot be obtained for both Physics 1050 and Physics 1100.
Offered: Fall and spring terms annually.
4 credit hours

PHYS 1150
Honors Physics I
Introductory physics for students seeking a more intensive experience. Newton's laws are introduced using differential calculus, with solutions based on integral calculus. Material on fluids, thermodynamics, and special relativity is included. Laboratory exercises are carried out emphasizing measurement uncertainty and clear, concise reporting. Recommended for students intending to major in physics.
Corequisite: MATH 1010.
Offered: Fall term annually.
4 credit hours

PHYS 1200
Physics II
The second semester of the two-semester sequence of interactive courses. Topics include electric and magnetic forces and fields, Gauss's Law, dc and ac circuits, Ampere's Law and Faraday's Law, electromagnetic radiation, physical optics, and quantum physics.
Prerequisite: PHYS 1100 or equivalent or permission of instructor.
Corequisite: MATH 1020.
Offered: Fall and spring terms annually.
4 credit hours
**PHYS 1250**
**Honors Physics II**
Introductory physics for students seeking a more intensive experience. Electricity and magnetism is discussed making use of multivariable differentiation and integration. AC and DC circuits. Electromagnetic waves, optics, and selected topics in modern physics. Laboratory exercises are carried out emphasizing measurement uncertainty and clear, concise reporting. Recommended for students intending to major in physics.
Prerequisite: PHYS 1100 or equivalent, or permission of instructor. Corequisite: MATH 1020.
Offered: Spring term annually.
4 credit hours

**PHYS 1500**
**Physical Modeling**
An introductory physics course in which students learn by constructing computer models of physical systems and then examining the behavior of the models. Whenever possible, the models will be compared to real systems. Spreadsheets will be the main tools used to construct the models, and no prior programming experience is required.
Prerequisite: High school physics.
Offered: Consult department.
4 credit hours

**PHYS 1960**
**Topics in Physics**
1 credit hour

**PHYS 2210**
**Quantum Physics I**
Introduction to the formalism of Special Relativity, Schrodinger wave mechanics, and spin-1/2 particles. Solutions to Schrodinger’s Equation in one, two, and three dimensions. One-electron atoms and quantum mechanical magnetic dipole moments.
Prerequisite: PHYS 1200 or PHYS 1250, MATH 1020.
Offered: Fall term annually.
4 credit hours

**PHYS 2220**
**Quantum Physics II**
Prerequisite: PHYS 2210, MATH 2010.
Offered: Spring term annually.
4 credit hours

**PHYS 2350**
**Experimental Physics**
Experiments in mechanics, optics, electricity and electrodynamics, oscillations and waves, atomic, nuclear, and solid-state physics. Experimental methods, quantitative observations, and interpretation of data. This is a communication-intensive course.

**PHYS 2620**
**Fundamentals of Optics**
A survey of optics and optical phenomena and their applications. A modern laboratory is part of the course. Topics include geometrical optics and instruments, wave and Fourier optics, and polarization of light. Applications of modern optics to communications and manufacturing are stressed.
Prerequisite: PHYS 1200 or equivalent.
Offered: Spring term annually.
4 credit hours

**PHYS 2940**
**Special Projects in Physics**
Reading and study in various fields of physics to develop interest in and ability for independent study.
Prerequisite: Permission of instructor.
3 credit hours

**PHYS 2960**
**Topics in Physics**
4 credit hours

**PHYS 2990**
**Thesis**
An independent investigation.
Prerequisite: Permission of instructor.
3 or 4 credit hours

**PHYS 4100**
**Introductory Quantum Mechanics**
Quantum mechanics beyond Schrodinger wave mechanics. The postulates of quantum mechanics. Second quantization, Dirac notation, Hilbert spaces, perturbation theory, and applications to simple systems.
Prerequisites: PHYS 2220.
Offered: Spring term annually.
4 credit hours

**PHYS 4210**
**Electromagnetic Theory**
Field theory of electricity and magnetism with emphasis on solving boundary value problems. Dielectric and magnetic materials. Maxwell’s equations and wave propagation with applications to optics. Relativistic electrodynamics.
Prerequisites: PHYS 2220 and MATH 4600.
Offered: Spring term annually.
4 credit hours
**PHYS 4240**  
**General Relativity**  
Introduction to the physics of gravitation and spacetime. Special relativity, tensor calculus, and relativistic electrodynamics. General relativity with selected applications of Einstein’s field equations (gravitational time dilation; gravitational lensing; frame dragging; gravitational radiation). The physics of nonrotating and rotating black holes. Relativistic models for the large-scale structure of the Universe. Observational constraints on the cosmological parameters. Big Bang nucleosynthesis, the Cosmic Background Radiation. (Meets with ASTR 4240).  
**Prerequisite:** PHYS 4330 and MATH 4600.  
**Cross listed:** ASTR 4240. Students cannot receive credit for both PHYS 4240 and ASTR 4240.  
3 credit hours

**PHYS 4330**  
**Theoretical Mechanics**  
Particle and rigid body dynamics using Newtonian, Lagrangian, and Hamiltonian methods. Motion of particle systems. Central force motion. Rotating coordinate systems. Rigid body motion using the inertia tensor and Euler angles. Coupled systems and normal coordinates. Introduction to continuum mechanics and the mechanics of deformable media. Introduction to Hamiltonian Mechanics, including proof and applications of Liouville’s Theorem. Formalism of Special Relativity. Introduction to nonlinear dynamics and chaotic behavior.  
**Prerequisites:** PHYS 1250 or PHYS 1200, MATH 2400, and MATH 2010. Corerequisite: MATH 4600.  
**Offered:** Fall term annually.  
4 credit hours

**PHYS 4420**  
**Thermodynamics and Statistical Mechanics**  
The principles and physical applications of classical thermodynamics are developed. Basic concepts in classical and quantum statistical mechanics are introduced and their relations to thermodynamics are developed.  
**Prerequisite:** PHYS 2220, also MATH 2400, and MATH 2010  
**Offered:** Spring term annually.  
4 credit hours

**PHYS 4510**  
**Quantum Mechanics I**  
Classical mechanics: from Lagrangian to Hamiltonian, single particle formalism, small oscillations, normal modes, Hamilton-Jacobi theory, Hamilton’s equation, review of wave mechanics: Schroedinger equation, barrier tunneling, quantum wells, Mathematical foundation of quantum mechanics: ket space, representations, observables, eigenstates and diagonalization, quantum postulates, application of quantum postulates to two-level systems, harmonic oscillators, creation and annihilation operators. Quantization of angular momentum, spherical harmonics, rotation operators, Landau levels, central force: hydrogen atom. Path Integral formalism for quantum theory. Students cannot obtain credit for both this course and PHYS 6510.  
**Prerequisite:** PHYS 4100 or equivalent.  
**Offered:** Fall term annually.  
4 credit hours

**PHYS 4620**  
**Elementary Particle Physics**  
**Prerequisite:** PHYS 4100.  
3 credit hours

**PHYS 4630**  
**Lasers and Optical Systems**  
Optical physics and applications of lasers. Design of optical systems. Topics include: wave optics and beam propagation, Gaussian beams, resonators, optical properties of atoms and laser gain media, laser amplifiers, pulsed laser systems, applications of lasers, nonlinear optics.  
**Prerequisite:** PHYS 2620 recommended.  
**Offered:** Fall term odd-numbered years.  
**Cross listed:** ECSE 4630. Students cannot obtain credit for both this course and ECSE 4630.  
4 credit hours

**PHYS 4640**  
**Optical Communications and Integrated Optics**  
Phenomena, materials, and devices for optical communications and computing. Topics include: guided wave and fiber optics, integrated optics, electro-optic and nonlinear optical switching, pulse and soliton propagation, sources and detectors.  
**Prerequisite:** PHYS 2620.  
**Offered:** Fall term even-numbered years.  
**Cross listed:** ECSE 4640. Students cannot receive credit for both this course and ECSE 4640.  
4 credit hours

**PHYS 4720**  
**Solid-State Physics**  
**Prerequisite:** PHYS 2220 or equivalent.  
**Offered:** Fall term annually.  
**Cross listed:** ECSE 4720. Students cannot receive credit for both this course and ECSE 4720.  
4 credit hours
PHYS 4810
Computational Physics
Computational physics studies the implementation of numerical algorithms to solve problems of physics which do not have analytical solutions. Upon completion of this course, students will be able to solve physics problems from a variety of fields under realistic conditions, using modern architectures such as graphical processing units and supercomputers. This course makes extensive use of computers but remains a physics course where students enrich their understanding of physical phenomena.
Prerequisites: CSCI 1100, PHYS 1100, and PHYS 1200 or permission of instructor.
Offered: Spring term annually.
4 credit hours

PHYS 4910
Culminating Experience Project
Independent study to accompany designated capstone courses in Physics and Astronomy. Designated courses are: ASTR 4220 Astrophysics; ASTR 4240 Gravitation and Cosmology; ASTR 4510 Origins of Life: a Cosmic Perspective; PHYS 4810 Computational Physics; PHYS 4620 Elementary Particle Physics; PHYS 4240 General Relativity; ASTR 4120 Observational Astronomy; PHYS 4630 Lasers and Optical Systems; PHYS 4640 Optical Communications and Integrated Optics; PHYS 4720 Solid State Physics.
Corequisite: Must be concurrently registered in one of the following: ASTR 4220, ASTR 4240, ASTR 4510, PHYS 4810, PHYS 4620, PHYS 4240, ASTR 4120, PHYS 4630, PHYS 4640, or PHYS 4720, or by instructor permission.
1 credit hour

PHYS 4960
Topics in Physics
4 credit hours

PHYS 6410
Electrodynamics
Prerequisite: Permission of the instructor.
Offered: Spring term annually.
4 credit hours

PHYS 6510
Quantum Mechanics I
Classical mechanics: from Lagrangian to Hamiltonian, single particle formalism, small oscillations, normal modes, Hamilton-Jacobi theory, Hamilton's equation, review of wave mechanics: Schroedinger equation, barrier tunneling, quantum wells, mathematical foundation of quantum mechanics: ket space, representations, observables, eigenstates and diagonalization, quantum postulates, application of quantum postulates to two-level systems, harmonic oscillators, creation and annihilation operators. Quantization of angular momentum, spherical harmonics, rotation operators, Landau levels, central force: hydrogen atom. Path integral formalism for quantum theory. Students cannot obtain credit for both this course and PHYS 4510.
Prerequisite: PHYS 4100 or equivalent.
Offered: Fall term annually.
4 credit hours

PHYS 6520
Quantum Mechanics II
Prerequisite: PHYS 6510.
Offered: Spring term annually.
4 credit hours

PHYS 6530
Quantum Mechanics III
Prerequisite: PHYS 6520.
Offered: Consult department about when offered.
3 credit hours

PHYS 6590
Statistical Mechanics
Prerequisite: PHYS 6510.
Offered: Full term annually.
4 credit hours
PHYS 6710
Theory of Solids I
Prerequisite: PHYS 6520.
Offered: Fall term annually.
3 credit hours

PHYS 6720
Theory of Solids II
More detailed application of solid-state theory to electrical, magnetic, and optical properties of matter. Consideration of particular materials; semiconductors, ferrites, ferroelectrics, and superconductors.
Prerequisite: PHYS 6710.
Offered: Upon availability of instructor.
3 credit hours

PHYS 6810
Nonlinear and Quantum Optics
Prerequisite: PHYS 6510.
Offered: Consult department about when offered.
3 credit hours

PHYS 6900
Seminar
Selected topics.
Credit hours to be arranged

PHYS 6940
Readings in Physics
Supervised reading and study in various fields of physics.
3 credit hours

PHYS 6960
Topics in Physics
Variable credit hours

PHYS 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

PHYS 6980
Master’s Project
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s Project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the library. Grades will then be listed as S.
1 to 9 credit hours

PHYS 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
1 to 9 credit hours

PHYS 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
1 to 9 credit hours

PSYC Psychology (HSSH)

PSYC 1200
General Psychology
An introduction to psychology. Topics covered vary with instructor but may include physiological bases of behavior, sensation, perception, learning, memory, child and adult development, motivation, personality, psychological disorders, social behavior. Introduction to basic methods of psychological research is a course requirement that can be met in several ways (described during the first class meeting). There is a significant experiential component that varies with the instructor but will include interactive computer simulations, class demonstrations, group projects.
Offered: Fall, spring, and summer terms annually.
4 credit hours
PSYC 2100
Critical Thinking
This course provides tools for the identification, analysis, and evaluation of the various patterns of reasoning as they occur in the real world. Patterns of reasoning include deductive reasoning, inductive reasoning, scientific reasoning, statistical reasoning, and causal reasoning. The course also covers some basic psychology and sociology of reasoning and belief, and concludes with a critical discussion of science and the scientific method.
Offered: Spring term annually.
Cross listed: PHIL 2100. Students cannot obtain credit for both this course and PHIL 2100.
4 credit hours

PSYC 2120
Introduction to Cognitive Science
This course is an introduction to the new and quickly growing field of Cognitive Science which studies the various aspects of cognition, including reasoning, learning, memory, and perception and action. Cognitive Science is a highly interdisciplinary field of study at the intersection of philosophy, psychology, computer science, linguistics, neuroscience, and anthropology, and the course hosts a number of guest lectures given by experts in these respective fields. This is a communication-intensive course.
Offered: Spring term annually.
Cross listed: PHIL 2120. Students cannot obtain credit for both this course and PHIL 2120.
4 credit hours

PSYC 2220
Human Factors in Design
This course provides a broad introduction to the theories and principles of human performance, man-machine interfaces, and systems designs. It also emphasizes the applications of these theories and principles to the design of controls, work space, data entry devices, training systems, and the human-computer interface.
Prerequisite: PSYC 1200 or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

PSYC 2600
Moral Development
An analysis of psychological research on how our common sense moral beliefs develop from early childhood through old age, and their application to daily problems. A major focus is on the conflict between themes of justice or individual rights and caring compassion and its relation to gender differences (the Kohlberg/Gilligan debate).
Offered: Spring term annually.
Cross listed: PHIL 2600. Students cannot obtain credit for both this course and PHIL 2600.
4 credit hours

PSYC 2730
Social Psychology
This is a survey course covering theories, methods, and empirical research on personal and situational factors influencing social behavior. Topics covered include social perception, the construction of social reality, decision making, group influences on behavior, and attitudes. This is a communication-intensive course.
Prerequisite: PSYC 1200.
Offered: Fall and spring terms annually.
4 credit hours

PSYC 2800
Introduction to Sports Psychology
An introduction to psychology as applied to sport; the topics covered include history of sport behavior, principles of learning and their application, anxiety and arousal, motivation, leadership, cohesion, audience effects, aggression, personality assessment, female athletes, youth in sport, coach behavior, and physical activity for all.
Prerequisite: PSYC 1200.
Offered: Fall term annually.
4 credit hours

PSYC 4110
Motivation and Performance
This course encompasses a broad spectrum of theories concerned with the biological, psychological, and social components of motivation. Throughout the course, students relate theoretical issues to both recent research evidence and potential practical applications to enhance performance. Group projects, focus group discussions, and interactive guest speakers are used to establish links between theory and performance.
Prerequisite: PSYC 1200.
Offered: Fall and spring terms annually.
4 credit hours

PSYC 4160
Human Factors Seminar
A comprehensive, project-oriented survey of special topics in human factors. Applied, experimental, and/or field research will be required.
Prerequisite: PSYC 2220 or permission of instructor.
Offered: Upon sufficient demand.
4 credit hours

PSYC 4170
Professional Development II: Leadership Theories
This course examines the major theories of leadership, as well as provides the opportunity to apply these theories to actual or symbolic leaders. Students wishing to become effective managers or leaders will benefit from this course, since the focus is on providing students with information about the traits, behaviors, power and influence, and charisma of effective leaders.
Prerequisite: ENGR 2050. Restricted to junior and senior engineering majors.
Offered: Fall and spring terms annually.
2 credit hours
PSYC 4200
Industrial and Organizational Psychology
A broad introduction to the field of Industrial and Organizational Psychology. Topics covered include personnel selection, job analysis, training, performance appraisal, work-related attitudes, employee motivation, leadership, decision making, and organizational theory.
Prerequisite: PSYC 1200.
Offered: Fall and spring terms annually.
4 credit hours

PSYC 4260
Psychological Tests and Measurements
Methods, techniques, and instruments for measuring individual differences are surveyed. Topics include representative methods of test construction, a critical analysis of representative tests, criteria for evaluating and selecting tests, and the value and limitations of tests.
Prerequisite: PSYC 1200.
Offered: Fall term annually.
4 credit hours

PSYC 4310
Experimental Methods and Statistics
This course provides an introduction to basic methods of psychological research and the use of statistics to analyze and interpret psychological data. Topics include experimental methodology and research design, data collection and analysis, and written communication of results. Students will also gain proficiency with SPSS software. Each student will be expected to propose and carry out a significant research project and prepare a formal report that comports with formatting guidelines promulgated by the American Psychological Association. This is a communication-intensive course.
Prerequisite: PSYC 1200 and/or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

PSYC 4320
Behavioral Neuroscience
This course is an introduction to the role of physiological mechanisms in behavioral processes. There will be detailed examination and discussion of the involvement of biological systems in feeding and drinking, sexual behavior, sleep and arousal, learning and memory, psychopathology and psychopharmacology.
Prerequisite: PSYC 1200 or PHIL/PSYC 2120.
Offered: Spring term annually.
4 credit hours

PSYC 4330
Introduction to Cognitive Neuroscience
This survey course is intended as an introduction to Cognitive Neuroscience. The topics covered will focus on exploring the neural underpinnings for cognitive processes, such as sensation, language, attention, motor control, executive functions, social communication, emotions, consciousness, and learning/memory. Basic aspects of nervous system function and neuroanatomy, brain development/evolution, structural and functional imaging techniques, and other research methods used in Cognitive Neuroscience will be discussed.
Prerequisites: PSYC 1200 or permission of instructor.
Offered: Spring term annually.
Cross listed: COGS 4330.
4 credit hours

PSYC 4340
Human Sexuality
This course provides biological, cultural, historical, and psychological perspectives of sexuality. Basic information on human development and reproductive physiology is provided. In addition, current topics such as marriage, alternate lifestyles, contraception, and pornography are discussed. Small group focus discussions, media-based discussions, and interactive guest speakers are used to link course material to responsible sexuality and understanding of diversity.
Prerequisite: PSYC 1200.
Offered: Spring term annually.
4 credit hours

PSYC 4370
Cognitive Psychology
The focus of this course is on the flow of information from sensory input to retrieval from long-term memory. Within this framework, topics such as mnemonics, pattern recognition, attention, computer simulation, reasoning, and the relationship between culture and thought are discussed.
Prerequisite: PSYC 1200 or PHIL/PSYC 2100.
Offered: Fall term annually.
4 credit hours

PSYC 4400
Personality
Modern theories of personality are presented and compared. Using these theories, students analyze the processes by which people cope with intrapsychic, interpersonal, and institutional demands. Evidence on adaptive processes from clinical, field, and laboratory studies is evaluated. This is a communication-intensive course.
Prerequisite: PSYC 1200.
Offered: Upon availability of instructor.
4 credit hours
PSYC 4410
Sensation and Perception
What are the processes that allow us to detect information about our surroundings, recognize people and objects, and perceive depth and motion? This course will focus on the physiological and neural mechanisms underlying sensation (sight, hearing, and touch), the qualitative aspects of human perceptual experience, and how perception and action are interconnected. Color perception, object recognition, space and motion perception, and perception and action are all examined.
Prerequisite: PSYC 1200 or PHIL/PSYC 2120.
Offered: Fall term annually.
4 credit hours

PSYC 4450
Learning
The first half of this course is devoted to presentation of traditional theories of learning. Classical and operant conditioning and single-subject methodology are studied in depth. During the second half of the course, students apply their knowledge of operant conditioning principles in the context of a group-based field study.
Prerequisite: PSYC 1200.
Offered: Spring term annually.
4 credit hours

PSYC 4500
Drugs, Society, and Behavior
This course is an exploration of the social and psychological effects of extensive use of pharmacological agents that are salient to daily behavior. There is an emphasis on the effects of addictive drugs such as alcohol, heroin, and cocaine.
Prerequisite: PSYC 1200.
Offered: Fall and spring terms annually.
4 credit hours

PSYC 4510
Cognitive Modeling
Cognitive modeling investigates human cognition by developing computational systems that simulate cognitive processes. Cognitive modeling grew out of Cognitive Psychology and Artificial Intelligence. Cognitive models are used in a number of basic and applied domains including Human-Computer Interaction, Intelligent Tutoring Systems, Computer-Generated Forces, and Synthetic Characters. In this course, students will develop models in ACT-R (a unified theory of cognition) that simulate recent findings in cognitive psychology.
Prerequisites: PSYC 1200 or PHIL/PSYC 2120 and CSCI 2300. Recommended: CSCI 4150 and/or PSYC 4370 or permission of instructor.
Offered: Spring term annually.
4 credit hours

PSYC 4600
Cognition and the Brain
Perception and thought are considered in terms of processes represented in the brain. The localization and lateralization of function are examined, drawing upon research on the behavioral effects of brain damage as well as brain-imaging studies and other approaches. Examples of topics include object recognition, memory, language, emotion, spatial ability, and motor processes.
Prerequisite: PSYC 1200.
Offered: Fall term annually.
4 credit hours

PSYC 4610
Stress and the Brain
This seminar course is a detailed examination of the mind-brain relationship, through study of the stress response. Stress is simply defined as any challenge to an individual’s homeostasis, or balance. This course will explore the neurobiological underpinnings of the stress response, with particular focus on how stressors can alter perception, affective and cognitive processing in the individual, which can in turn feedback to alter the general health of the individual (body and mind/brain).
Prerequisites: PSYC 1200 or permission of instructor.
Offered: Spring term annually.
Cross listed: COGS 4XXX.
4 credit hours

PSYC 4620
Cognitive Engineering
Covers cognitive theory from an applied perspective to understand and predict the interactions among human cognition, artifact (i.e. tools), and task. Cognitive task analysis techniques will be taught and used throughout the course, as well techniques for collecting and analyzing fine-grained behavioral data. Topics covered may include visual search and visual attention, cognitive skills and its acquisition, hard and soft constraints on interactive behavior, human error, soft constraints on judgment and decision-making, and experts and expertise.
Prerequisite: PSYC/PHIL 2120 or PSYC 4370 or permission of instructor.
Offered: Fall term annually.
Cross listed: COGS 4620. Students cannot obtain credit for both this course and COGS 4620.
4 credit hours

PSYC 4720
Abnormal Psychology
The definition, history, major schools of thought, and models of the normal and abnormal personality are presented. Disorders are examined within the framework of D.S.M. and competing schools of thought. The description, etiology, treatment, including pharmacologic, and prevention of each of the disorders are considered. Illustrative cases are presented. Students write a paper on a topic, approved by the instructor, that focuses upon the impact of public policies on psychopathology.
Prerequisite: PSYC 1200.
Offered: Spring term annually.
4 credit hours
PSYC 4740
Psychology and The Law
Since the 1950’s, social science researchers have turned their attention to the courtroom, in order to test theories of human behavior in a real world application. Are the basic assumptions underlying the practice of law in this country valid, given what psychologists know about the fundamentals of human behavior? This course will provide students with instruction regarding how the study of psychology can contribute to a better understanding of the legal system.
Prerequisite: PSYC 1200.
Offered: Fall term annually.
4 credit hours

PSYC 4750
Forensic Psychology
A practical introduction to the field of forensic psychology, a domain within psychology concerned with the production and application of psychological knowledge to the civil and criminal justice systems. In this course, we explore the many ways in which psychological principles play an increasingly important role in influencing various processes and outcomes associated with the field of law.
Prerequisite: PSYC 4740.
Offered: Spring term annually.
4 credit hours

PSYC 4770
Psychopharmacology and Behavioral Toxicology
This course is a detailed examination of the neuroscience and psychology inherent to the development of pharmacological agents for treating psychopathology. There is also an exploration of chemicals that are toxic to the brain as manifest by induction of psychopathology.
Prerequisite: PSYC 1200.
Offered: Spring term annually.
4 credit hours

PSYC 4800
Sport Psychology Seminar
This course expands on topics covered in Introduction to Sport Psychology. Students in the course will work in small groups to identify and read literature in a course-relevant area of their choice. In addition to weekly written progress reports, students will prepare a final report that must be presented orally in class.
Prerequisites: PSYC 1200, PSYC 2800, or permission of instructor.
Maximum enrollment: 24.
Offered: Spring term annually.
4 credit hours

PSYC 4940
Readings in Psychology
An individually arranged independent study course under the supervision of a member of the Psychology Department. The topic is selected by consultation between student and faculty member.
Prerequisite: PSYC 1200 and/or permission of supervising faculty member.
1 to 4 credit hours

PSYC 4960
Topics in Psychology
An advanced course concerned with selected topics in psychology.
Prerequisite: PSYC 1200 or permission of instructor.
1 to 4 credit hours

PSYC 4990
Undergraduate Thesis
Students conduct original scholarly projects: original research, theoretical or analytical reviews of the literature, or computer simulations. Working either alone or in groups, students prepare written reports relating to this project, under the supervision of a faculty member. This is a communication-intensive course.
Prerequisite: Permission of a supervising faculty member.
Offered: Fall, spring, and summer terms annually.
3 to 6 credit hours

STSH Science and Technology Studies – Humanities Courses (HSSH)
(For Science and Technology Studies-Social Sciences Credit, see STSS.)

STSH 1110
Science, Technology, and Society
An introduction to the social, historical, and ethical influences on modern science and technology. Cases include development of the atomic bomb, mechanization of the workplace, Apollo space program, and others. Readings are drawn from history, fiction, and social sciences; films and documentary videos highlight questions about the application of scientific knowledge to human affairs. The class is designed to give students freedom to develop and express their own ideas. This is a communication-intensive course. This course can be used to satisfy either humanities or social sciences distribution requirements.
Offered: Fall and spring terms annually.
Cross listed: STSS 1110. Students cannot obtain credit for both this course and STSS 1110.
STSH 1200  
**Sustainability Debates**  
Efforts to advance environmental sustainability have provoked intense and complicated political debate. In this course, students analyze key stakeholders, issues, and alternative pathways for the future. They also participate in a series of oral debates, focused on environmental regulation, economic growth, industrialism and globalization. Students also work in a group to develop a proposal for a project that responds to concern about environmental sustainability. Throughout the course, students are encouraged to develop (and critically reflect on) their own environmental values and ideas.  
**Offered:** Spring term annually.  
**4 credit hours**

STSH 2130  
**Introduction to Philosophy of Science**  
How does science stimulate philosophical thinking and how has philosophy influenced science? This broad range of interaction is studied with special attention given to the concepts of theory, observation, and scientific method. Special attention is given to issues basic to psychology, in particular, reductionism, behaviorism, functionalism, and cognitivism.  
**Offered:** Fall term annually.  
**Cross listed:** PHIL 2130. Students cannot obtain credit for both this course and PHIL 2130.  
**4 credit hours**

STSH 2310  
**A Century of Environmental Thought**  
This course examines the emergence of environmental consciousness in the United States throughout the 20th century. Students in this course will study the original writings of some of the most important thinkers and activists in the history of environmentalism, examine the social contexts in which their ideas formed, and consider their relevance to contemporary sustainability issues.  
**Prerequisites:** STSS 1110 or IHSS 196x (Environment & Politics) or IHSS 196x (Politics of Global Environment) or IHSS 197x (Nature/Society) or permission of instructor.  
**Offered:** Spring term annually.  
**Cross listed:** STSS 2310. Students cannot obtain credit for both courses.  
**4 credit hours**

STSH 2410  
**Century of the Gene**  
This course details the scientific and social history of genetics, from Darwin and Mendel to the Human Genome Project. Special focus areas include: plant and animal breeding in the early twentieth century; eugenics movements in the U.S. and elsewhere; bacterial and fruit fly genetics; the development of molecular biology; the invention of recombinant-DNA technologies; the emergence of the biotechnology industry; the sociobiology controversies; genetics and evolutionary theory; and the Human Genome Project and contemporary genomics.  
**Offered:** Spring term annually.  
**4 credit hours**

STSH 2510  
**Foundations of American History**  
An examination of the formative period of the nation's development to 1877. Coverage includes the alteration of an Anglo-European culture to an American one; the causes for the colonial break with Britain; the problems of independence; the appearance and impact of American nationalism; Westward expansion and industrialization; and the causes and effects of the sectional clash.  
**Offered:** Fall and spring terms annually.  
**4 credit hours**

STSH 2520  
**History of the United States Since 1877**  
A survey of American history from the end of Reconstruction to the present. The course examines such major themes as industrialization, the rise of the city, and the impact of new technologies; it surveys the progressive movement, Theodore Roosevelt, Wilson, and the United States in World War I; and it concludes by treating the economic depression of the 1930s, the New Deal of Franklin D. Roosevelt, the U.S. in World War II, and political and social developments from Kennedy to Carter.  
**Offered:** Annually.  
**4 credit hours**

STSH 2530  
**World War II**  
A topical survey of the origins, course of events, and results of World War II (1935-1945). The course covers the international economic crisis of the 1930s; the rise of totalitarianism in Europe; the wars in Ethiopia, China, and Spain; German military expansion; the war on the Eastern front and in the Pacific; the Mediterranean campaigns; naval operations; the Grand Alliance of the Allied powers; and the spread of communism in Europe and Asia.  
**Offered:** Annually.  
**4 credit hours**

STSH 2940  
**Readings in Science and Technology Studies**  
With an individual faculty member on an agreed-upon topic.  
**4 credit hours**

STSH 2960  
**Topics in Science and Technology Studies**  
**4 credit hours**
STSH 4210
Engineering Ethics
This course explores the ethical issues that engineers encounter in their professional practice. It also examines social values and law and policy issues that shape engineering and technological decision making. Using case studies, professional codes of conduct, and scholarly literature, the course examines the responsibilities of engineers in relation to their employers, clients, co-professionals, and their responsibility for public safety and welfare. Topics include the history of engineering, professionalism vs. the demands of business, engineering vs. management decision making, whistle-blowing, proprietary rights and trade secrecy, and conflicts of interest.
Prerequisite: STSH 1110/STSS 1110, STSS 2400, or permission of instructor.
Offered: Fall and spring terms annually.
4 credit hours

STSH 4250
Bioethics
This course explores historical perspectives on bioethics through concrete cases and practical problems faced in the design and execution of some of the highest profile biomedical research and most consequential clinical decisions of the twentieth century. Topics include vaccine development; human radiation experiments; new genetic and reproductive technologies; right-to-die, death-with-dignity, and physician-assisted suicide; human experimentation, including prisoners, the sick, and the disabled; neuroethics; animal research; and emergent topics such as stem cell research, prenatal diagnostics, and genetic testing. This is a communication-intensive course.
Prerequisites: STSH/STSS 1110.
Offered: Spring term annually.
4 credit hours

STSH 4320
Philosophy of Law
The course examines the following questions: What is law? What is the relationship between law and morality? Is there a moral obligation not to break the law? Detailed examination is given to the concepts of liberty, justice, responsibility, and punishment.
Prerequisite: One philosophy or STS course or permission of instructor.
Offered: Upon availability of instructor.
Cross listed: PHIL 4740. Students cannot obtain credit for both this course and PHIL 4740.
4 credit hours

STSH 4340
Environmental Philosophy
While concepts such as quality of life, environment, nature, global ecology, and the like figure heavily in contemporary discussions, they are seldom integrated into an environmental philosophy. The course tries to achieve this integration by understanding some of the religious, mythic-poetic, and scientific dimensions of the human-nature matrix. Some specific environmental problems are examined to illustrate the system of values implied by various solutions.

STSH 4420
Biofutures
This course examines the forefronts of genetics and biotechnology, and their social and ethical implications, through multiple lenses: writings of scientists and science fiction writers, and historians, philosophers, and anthropologists of the life sciences. Topics may include: genetic testing and gene therapy; sports medicine; cosmetic psychopharmacology; patents and intellectual property; transgenic organisms; organ transplants and artificial organs; stem cell research; genetic enhancement; artificial life; cloning; and other related topics.
Prerequisites: Any STS course or permission of the instructor.
Offered: Spring term annually.
4 credit hours

STSH 4430
Drugs in History
This course teaches basic historical, anthropological, and sociological concepts that can be used to make sense of a wide variety of contemporary phenomena students encounter in everyday life. The focus is on analyzing how licit and illicit drugs serve as “technologies” within specific social contexts or subcultures; what drug policy reveals about social, political, and economic organization; and the impacts of biomedical knowledge and practice on specific population groups. The course focuses on the representation of drug use and drug users in popular culture, science and medicine, and history and the social sciences. This is a communication-intensive course.
Prerequisite: 1000-level course (or higher) in STS.
Offered: Spring term odd-numbered years.
Cross listed: STSS 4430. Students cannot obtain credit for both this course and STSS 4430.
4 credit hours

STSH 4510
History of American Technology
Discusses the growth of American technology and its place within the framework of American history as well as the interrelationship of American and foreign technological developments. This course stresses the cultural contexts of technological change. Topics covered include the Erie Canal, the American system of manufacturing, railroads, emergence of engineering professions, corporate R&D, household technology, the technology of modern warfare, and the electronics revolution.
Prerequisite: One course in American history or permission of instructor.
Offered: Annually.
4 credit hours
STSH 4520
China: Past and Present
An introduction to Chinese social organization and politics through readings in primary and secondary sources, class discussion, and student research projects. The class examines the paths of development open to China, and the problems the Chinese people face in choosing among them, along with the historical background of values, symbols, anger, and pride against which these issues are debated.
Prerequisite: A course in STS or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

STSH 4530
Indian Politics and Culture
This course explores the roots and consequences of change in India, examining recent economic reforms, technological development, environmental crisis, increasing religious fundamentalism, poverty, population growth, and trends in literature, film, and art. The objective of the course is to provide students with a nuanced understanding of how social, cultural, and political-economic factors interact, complicating efforts to build sustainable modes of governance in the Third World.
Offered: Upon availability of instructor.
4 credit hours

STSH 4610
Product Design and Innovation Studio V
PDI studio V focuses on an enriched sense of program and user needs definition through methodologies of the humanities and social sciences. Studio projects, presentations and readings explore the relation of race, class, and gender to technology, and the potential of design to address societal problems. The course has often focused on incorporating information technology in educational tools for low-income primary school students.
Prerequisites: ARCH 2200, ENGR 2020, IHSS 2500, and ENGR 2050.
Offered: Fall term annually.
4 credit hours

STSH 4800
Public Service/Professional Careers Internships
This course offers an insight into the public policy process from the vantage point of a part-time internship in the public or private sector as well as an opportunity to explore a career option before actually embarking upon it. The following is a partial list of the large number of possible internships: airport planning, architecture, banking, biological research, clinical psychology, computer science, consumer protection, corporate management, engineering, environmental planning, geology, local government, materials and mechanical engineering, noise pollution abatement, personnel management review, premedical, public finance and taxation, public health management, public relations, social work, state legislature, stock market, transportation planning, and urban planning.
Prerequisites: STSH 1110/STSS 1110; IHSS 1960; or permission of instructor.
Offered: Fall and spring terms annually.
Cross listed: STSS 4800. Students cannot obtain credit for both this course and STSS 4800.
4 credit hours

STSH 4850
The Phelan Seminar on Technology and Society
An undergraduate honors-style seminar examining interactions between technology and modern society. Particular attention will be given to the historical origins and contemporary contexts of technological change in America, especially the Hudson/Mohawk region of New York. The specific topic of the seminar will change each year, coordinated with visiting lecturers and other scholarly events, publicized during the fall term.
Prerequisite: Any 2000-level STS course and permission of instructor.
Offered: Spring term annually.
4 credit hours

STSH 4940
Readings in Science and Technology Studies
With an individual faculty member on an agreed-upon topic.
4 credit hours

STSH 4960
Topics in Science and Technology Studies
4 credit hours

STSH 4980
Senior Project
Ordinarily consists of independent research, supervised by a faculty member, culminating in a written thesis. A creative endeavor such as a videotape or computer program may be substituted with departmental permission. This is a communication-intensive course. Restricted to S&S majors with senior standing.
Offered: Fall, spring, and summer terms annually.

STSH 6020
Values and Policy
This course examines the ways in which policy decisions are influenced by values and the ways in which values and value issues are affected by policy decisions. Normative concepts and theories including theories of social justice, the role of individual autonomy, democratic process, and paternalism are examined for their implications for social policies. Case studies of particular policy controversies are used.
Offered: Spring term annually.
3 credit hours
STSH 6040
Cultures of Inquiry
An historical overview of the contrast between universal and local theories of knowledge. Readings begin with classic philosophy (Descartes, Hume, Kant, etc.), and the break from these universalist frameworks through modernist theories for cross-cultural comparison of knowledge systems (indigenous, national, folk, etc.). These in turn are critiqued through postmodern cultural theory, including popular culture studies, cyberculture, and postcolonial studies.
Offered: Upon availability of instructor.
3 credit hours

STSH 6940
Readings in Science and Technology Studies
With an individual faculty member on an agreed-upon topic.
3 credit hours

STSH 6960
Topics in Science and Technology Studies
3 credit hours

STSH 6970
Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not archived in the library. Grades of A,B,C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

STSS Science and Technology Studies – Social Sciences Courses (HSSH)

(For Science and Technology Studies-Humanities Credit, see STSH.)

STSS 1110
Science, Technology, and Society
An introduction to the social, historical, and ethical influences on modern science and technology. Cases include development of the atomic bomb, mechanization of the workplace, Apollo space program, and others. Readings are drawn from history, fiction, and social sciences; films and documentary videos highlight questions about the application of scientific knowledge to human affairs. The class is designed to give students freedom to develop and express their own ideas. This is a communication-intensive course. This course can be used to satisfy either humanities or social sciences distribution requirements.
Offered: Fall and spring terms annually.
Cross listed: STSH 1110. Students cannot obtain credit for both this course and STSH 1110.

4 credit hours

STSS 1200
Sustainability Debates
Efforts to advance environmental sustainability have provoked intense and complicated political debate. In this course, students analyze key stakeholders, issues, and alternative pathways for the future. They also participate in a series of oral debates, focused on environmental regulations, economic growth, industrialism and globalization. Students also work in a group to develop a proposal that responds to concern about environmental sustainability. Throughout the course, students are encouraged to develop (and critically reflect on) their own environmental values and ideas.
Offered: Spring term annually.
4 credit hours

STSS 1310
Principles and Practices of American Government
An analytical survey of the essential features of American government within the national setting of environmental and historical factors. Among the topics included are the foundations and characteristics of American constitutionalism; the principles of federalism and the boundaries of federal, state, and local governments; the structure and dynamics of political parties; the activities and interrelations of the legislative and executive branches on all levels of American government; the judicial process and judicial review.
Offered: Upon availability of instructor.
4 credit hours
STSS 1330
International Relations
The world today faces enormous problems: the bloody horrors of war, the unconscionable and widening economic gap between rich and poor countries, and the looming threat of catastrophic environmental degradation. This course examines the causes and consequences of these problems, wonders what a world beyond greed and hate would look like, and considers what it will take to build a better world. Toward these ends, several themes are explored, including the nature of the international system, contemporary challenges to the state system, and alternatives to hunger, exploitation, and international violence.
Offered: Annually.
4 credit hours

STSS 1510
Cultural Anthropology
An introduction to human societies and cultures in comparative perspective, from tribal societies to complex societies such as the United States. Emphasis on ethnographic descriptions of other cultures such as on the interpretation of cultural symbolism and on topical issues such as medical anthropology.
Offered: Annually.
4 credit hours

STSS 1520
Sociology
A study of the principles and concepts of sociology and their application to the study of society and self. Students are introduced to the scope, materials, and methods of sociology. The issues and problems to be studied come from basic social institutions such as the family, science, and religion. Other topics may include love, crime, political economy, power, population growth, social class, and minority and ethnic relations.
Offered: Fall and spring terms annually.
4 credit hours

STSS 1620
Design, Innovation, and Society
The course will cover fundamental concepts in the social sciences that are relevant to design and innovation; an introduction to ways of thinking about technology, design, values, and society; basic concepts relevant to innovation in the global economy; and an introduction to entrepreneurship with a focus on social entrepreneurship and triple-bottom-line or “social” businesses.
Offered: Fall term annually.
4 credit hours

STSS 1960
Topics in Science and Technology Studies, Anthropology/ Archaeology, History, Political Science, or Sociology

STSS 2200
Engineering, Design, and Society
What is engineering? How should engineering design relate to society? How do the social and technical aspects of design relate to each other? This course will explore answers to these questions through a variety of perspectives and case studies.
Offered: Upon availability of instructor.
4 credit hours

STSS 2210
Design, Culture, and Society
This course allows students to develop a critical understanding of the relationships between design, culture, and society. “Design” is defined broadly, touching on product/industrial design, urban design, and so-called alternative design approaches such as ecological and feminist design. The focus is on the role of design in contemporary culture with the goal of training students’ emerging appreciation of design as cultural practice on their professional work as engineers, architects, or business managers. This is a communication-intensive course.
Offered: Spring term annually.
4 credit hours

STSS 2300
Environment and Society
Society and the natural environment are crucially linked in a number of ways. Environmental problems such as pollution and natural resource depletion are not only problems for society, affecting the way we live our lives; they are also problems of society — the result of patterns of social organization and social practices. In this course, we will explore these society/environment interactions at various levels, from the local to the global, using the concepts and insights of environmental sociology. Environmental sociologists aim to understand the social origins of environmental problems and propose workable solutions to them. By showing how social interaction, institutions, and beliefs shape human behavior, environmental sociology provides a useful complement to the natural sciences in the analysis of the environmental problems we face today.
Prerequisite: STSH 1110/STSS 1110 or permission of instructor.
Offered: Spring term annually.
4 credit hours

STSS 2310
A Century of Environmental Thought
This course examines the emergence of environmental consciousness in the United States throughout the 20th century. Students in this course will study the original writings of some of the most important thinkers and activists in the history of environmentalism, examine the social contexts in which their ideas formed, and consider their relevance to contemporary sustainability issues.
Prerequisites: STSS 1110 or IHSS 196x (Environment & Politics) or IHSS 196x (Politics of Global Environment) or IHSS 197x (Nature/Society) or permission of instructor.
Offered: Spring term annually.
Cross listed: STSH 2310. Students cannot obtain credit for both courses.
4 credit hours
STSS 2350
Law, Values, and Public Policy: Perspectives on Science and Technology
This course examines the interconnections between values and law, seeking to understand how these affect and are affected by science and technology by examining such topics as computers and privacy, medical malpractice, abortion, and other legal conflicts surrounding new reproductive technologies, problems of expert witnesses, sexual harassment, patent infringement, auto safety litigation, and siting of hazardous facilities, among others. This is a communication-intensive course.
Offered: Fall term annually.
4 credit hours

STSS 2400
Medicine and Society
The purpose is to explore the contributions of anthropology, sociology, and history to health and illness. By the end of the course, students will have an overall picture of health fields, problems faced by patients and caregivers, medicine and health in non-Western societies, and the social shaping of disease and therapeutic choices. This course introduces the Medicine and Society Minor Concentration.
Offered: Fall term annually.
4 credit hours

STSS 2460
Human Evolution
The systematic study of human origins has excited scientific and popular imaginations since Darwin. The course considers two overlapping frameworks, sociobiology and paleoanthropology, for explaining the evolution of behavior. Topics include “selfish gene” theories of biological altruism, adaptation, and organism-environment interaction. Also developed are critical perspectives on the exchange of ideas between science and society in determining the nature of human nature. This is a communication-intensive course.
Offered: Upon availability of instructor.
4 credit hours

STSS 2940
Readings in Science and Technology Studies, Anthropology/Archaeology, History, Political Science, or Sociology
With an individual faculty member on an agreed-upon topic.

STSS 2960
Topics in Science and Technology Studies

STSS 4230
Social Dimensions of Nanotechnology
Students will have a basic understanding of the current state of nanotechnology development and its future projections. They will understand the social and environmental issues at stake in nanotechnology and will have the conceptual tools to engage in analyzing these issues and creating an informed perspective on the choices that could lead to a more just and sustainable world.

Prerequisites: Any course with an STSH/STSS designation or permission of instructor.
Offered: Upon availability of instructor.
4 credit hours

STSS 4260
Food, Farms, and Famine
This course provides students with a wide-ranging understanding of the environmental and social context of food, agriculture, and hunger. Drawing primarily on sociological concepts and research, the class will take a “food systems” approach, analyzing food as it travels from farm to table as part of an interconnected process. Students will examine why we eat the way we do and how our food choices affect other people and the environment.
Prerequisites: Any 2000-level STSS course or permission of instructor.
Offered: Spring term annually.
4 credit hours

STSS 4270
Sustainability Problems
In this course students will map the matrix of problems that make sustainability difficult—problems with the U.S. political, legal, and educational system, with media, culture, and individual behavior. Students will also identify sustainability pathways in transportation, urban design, education, alternative energy, etc. Throughout, students will analyze and try to produce effective environmental communication.
Prerequisites: Any 2000-level STSS course or permission of instructor.
Offered: Fall term annually.
4 credit hours

STSS 4300
Social Entrepreneurs and Sustainable Communities
This course has three main goals: 1) to introduce students to community-level thinking about solutions to the twinned global problems of sustainability and injustice; 2) to introduce students to the literature on social innovation/social entrepreneurship and to provide a basis for additional research, work, and entrepreneurship in the field; and 3) to help students explore how they might integrate work in the social innovation/NGO sector into their careers or into voluntary activities so that their future lives and careers are more meaningful.
Prerequisites: Any course with an STSS, STSH, MGMT, or ECON designation.
Offered: Spring term annually.
4 credit hours
STSS 4330
21st Century Risks, Robotics, Nanotechnology, Cloning, and Other Technologies
This course covers two main types of technological risk: (1) innovating in ways that endanger health, quality of life, environment, or other goals; and (2) failing to pursue innovations that people need. Some understanding of the technical details is a prerequisite for making sense of emerging technologies, but the course focuses more on media, public opinion, political decision making, technologists' incentives, and other social issues. This is a communication-intensive course.
Prerequisite: STSH/STSS 1110 or permission of instructor.
Offered: Alternate years.
4 credit hours

STSS 4350
Politics of Design
A research seminar exploring the meaning of design in engineering, architecture, political theory, and other fields. How do social ideals and motives inspire design choices? To what extent does the design of human-made things shape the quality of public life? A variety of objects are studied: buildings, machines, artifacts in everyday use, computer programs, political constitutions, etc.
Prerequisite: Any 2000-level course in STS or permission of instructor.
Offered: Spring term odd-numbered years.
4 credit hours

STSS 4360
Contemporary Political Thought
This seminar focuses upon contemporary theoretical approaches to issues in political society. Writings in liberalism, conservatism, postmodernism, anarchism, and green politics are compared with special attention to their policy proposals.
Prerequisite: Any 2000-level STS course.
Offered: Upon availability of instructor.
4 credit hours

STSS 4370
Environmental Politics and Policy
A highly interactive introduction to environmental politics and policy in the United States. Major themes include the background and context of environmental politics and policy, the policy-making process, environmental issues selected and reported on by students, the varieties of environmentalism, and environmental ethics.
Prerequisite: Any 2000-level STS course or permission of instructor.
Offered: Fall term even-numbered years.
4 credit hours

STSS 4430
Drugs in History
This course teaches basic historical, anthropological, and sociological concepts that can be used to make sense of a wide variety of contemporary phenomena students encounter in everyday life. We focus on analyzing how licit and illicit drugs serve as "technologies" within specific social contexts or subcultures; what drug policy tells us about social, political, and economic organization; and the impacts of biomedical knowledge and practice on specific population groups. We focus on the representation of drug use and drug users in popular culture, science and medicine, and history and the social sciences. This is a communication-intensive course.
Prerequisite: 1000-level course (or higher) in STS.
Offered: Alternate years.
Cross listed: STSH 4430. Students cannot obtain credit for both this course and STSH 4430.
4 credit hours

STSS 4460
Body: Self, Symbol, and Politics
Using cross-cultural comparisons, this course highlights the distinctive ways we conceptualize the body and explore how these assumptions influence health care in Western societies. The body is examined from three perspectives: as experienced; as a natural symbol for thinking about the relationships between nature and society; and as an artifact of social and political control.
Prerequisite: A 1000-level social science course.
Offered: Upon availability of instructor.
4 credit hours

STSS 4500
Globalization and Development
This course surveys the actors, processes, and proposed solutions to the problems of environment and development. The theory and practice of three main themes are explored: the background and context of environment in North and South; politics and economic development in the south; and the problems and prospects for sustainable societies in North and South.
Prerequisite: STSS 2300 or permission of instructor.
Offered: Alternate years.
4 credit hours

STSS 4540
Inequality in America
Modern societies are characterized by varying degrees of social inequality or differences in education, income, wealth, status, and power. How large are these differences in the U.S.? What are their consequences? How are they created, and why do they persist? The course examines such issues using social statistics, ethnographic accounts of people's lives, international comparative data, and theoretical writings on social class.
Prerequisite: STSS 1110.
Offered: Upon availability of instructor.
4 credit hours
STSS 4560  
**Gender, Science, and Technology**  
“Sex” is the biological distinction between being male and female. “Gender” is the social construction of masculinity and femininity. The purpose of this course is to explore if, and if so, how, science and technology reciprocally contribute to and are shaped by gender ideals and images. Gender is used as a tool for critical thinking about such topics as studies of sex differences, women in science and engineering, the environment, and war and peace.  
**Prerequisites:** STSS 1110/STSS 1110 or permission of instructor.  
**Offered:** Upon availability of instructor.  
4 credit hours

STSS 4580  
**Self-Organization in Science and Society**  
Self-organization has become increasingly important in science and engineering. Self-assembly of molecular structures are critical to nanotechnology; self-organizing swarms of insects are modeled in biology and robotics, and so on. But recursive loops in which things govern themselves are also foundational to society. Indigenous societies are renowned for their ecological self-stabilization. Wikipedia, Open Sources Software, and other means of “crowdsourcing” offer new visions for a more democratic civil society.  
**Prerequisites:** Any course with an STSH/STSS designation or permission of instructor.  
**Offered:** Spring term even-numbered years.  
4 credit hours

STSS 4720  
**Consumer Culture**  
What is consumer culture? What are its roots, its consequences, and alternatives? Documentaries and the research of anthropologists, historians, and religious scholars examine consumer culture in the US and UK including recognition of the global locations in which our consumer goods are made. Topics include buying and selling, shopping, retail, manufacture, material culture, pricing, consumer goods, disposal, kinship, identity, exchange, and advertising, with attention paid to differences in race, class, and gender.  
**Prerequisites:** Any 1000- OR 2000-level STS course or permission of instructor.  
**Offered:** Annually.  
**Cross listed:** STSS 4720. Students cannot obtain credit for both courses.  
4 credit hours

STSS 4800  
**Public Service/Professional Careers Internships**  
This course offers an insight into the public policy process from the vantage point of a part-time internship in the public or private sector as well as an opportunity to explore a career option before actually embarking upon it. The following is a partial list of the large number of possible internships: airport planning, architecture, banking, biological research, clinical psychology, computer science, consumer protection, corporate management, engineering, environmental planning, geology, local government, materials and mechanical engineering, noise pollution abatement, personnel management review, premedical, public finance and taxation, public health management, public relations, social work, state legislature, stock market, transportation planning, and urban planning.  
**Prerequisites:** STSH 1110/STSS 1110; IHSS 1960; first year studies course or permission of instructor.  
**Offered:** Fall and spring terms annually.  
**Cross listed:** STSH 4800. Students cannot obtain credit for both this course and STSS 4800.  
4 credit hours

STSS 4840  
**Professional Development II**  
This course explores technological contexts for leadership roles. Assignments develop a variety of communication skills. A team-based project gives students the opportunity to demonstrate leadership initiative by proposing solutions to social problems that combine technical expertise with social analysis and communication skills.  
**Prerequisite:** ENGR 1010. The course is limited to junior and senior engineering majors. A similar course is offered in Cognitive Science, and students cannot take both courses for credit.  
**Offered:** Fall and spring terms annually.  
2 credit hours

STSS 4850  
**The Phelan Seminar on Technology and Society**  
An undergraduate honors-style seminar examining interactions between technology and modern society. Particular attention will be given to the historical origins and contemporary contexts of technological change in America, especially the Hudson/Mohawk region of New York. The specific topic of the seminar will change each year, coordinated with visiting lecturers and other scholarly events, publicized during the fall term.  
**Prerequisite:** Any 2000-level STS course and permission of instructor.  
**Offered:** Spring term annually.  
4 credit hours

STSS 4940  
**Readings in Science and Technology Studies, Anthropology/Archaeology, History, Political Science, or Sociology**  
With an individual faculty member on an agreed-upon topic.

STSS 4960  
**Topics in Science and Technology Studies**
STSS 6010  
Concepts/Research Seminar in Science and Technology Studies  
A two-semester graduate seminar designed primarily for matriculants in the department’s M.S. program in Science and Technology Studies. Introduces students to the literature and the current issues in the constituent disciplines of Science and Technology Studies. Considers applications of this scholarship to current practical problems involving the human dimensions of science and technology. The first semester culminates in a bibliographic essay. In the second semester, students conduct research under the supervision of individual faculty members on topics of mutual interest.  
Prerequisite: Graduate status or permission of instructor.  
Offered: Upon availability of instructor.  
3 credit hours

STSS 6020  
Concepts/Research Seminar in Science and Technology Studies  
A two-semester graduate seminar designed primarily for matriculants in the department’s M.S. program in Science and Technology Studies. Introduces students to the literature and the current issues in the constituent disciplines of Science and Technology Studies. Considers applications of this scholarship to current practical problems involving the human dimensions of science and technology. The first semester culminates in a bibliographic essay. In the second semester, students conduct research under the supervision of individual faculty members on topics of mutual interest.  
Prerequisite: Graduate status or permission of instructor.  
Offered: Fall and spring terms annually.  
3 credit hours

STSS 6040  
Technology Studies  
The seminar examines interactions between technology and society from the vantage point of the various disciplinary and interdisciplinary perspectives that have contributed to technology studies. The texts, theories, and arguments that were important for the historical development of the field are covered, as well as contemporary issues. The seminar provides the resources and develops the skill needed for understanding, criticizing, constructing, and developing research in the field. Restricted to STS graduate students or by permission.  
Offered: Annually.  
3 credit hours

STSS 6100  
Policy Studies  
An overview of the field of science and technology policy studies from various disciplinary perspectives and a survey of various policy types or arenas. The texts, theories, and arguments that were important for the historical development of the field are covered, as well as contemporary issues. The seminar provides the resources and develops the skill needed for understanding, criticizing, constructing, and developing research in the field. Restricted to STS graduate students or by permission of instructor.  
Offered: Annually.  
3 credit hours

STSS 6110  
Research Methods in STS  
This course offers an overview of social science techniques and research design and logistics and approaches widely used in STS.  
Offered: Fall term annually.  
3 credit hours

STSS 6120  
Advanced Research Methods  
This course provides a foundation for professional-level research in science and technology studies. Through group research exercises, students explore the intersection between research issues (ethics, reliability, validity, quantification) and types of observation. Restricted to STS doctoral students or by permission.  
Offered: Spring term even-numbered years.  
3 credit hours

STSS 6200  
Science Studies  
A broad survey of the field of science studies from the vantage point of various disciplinary and interdisciplinary perspectives that have contributed to the development of science studies. The texts, theories, and arguments that were important for the historical development of the field are covered, as well as contemporary issues. The seminar provides the resources and develops the skill needed for understanding, criticizing, constructing, and developing research in the field. Restricted to STS graduate students or by permission of instructor.  
Offered: Annually.  
3 credit hours

STSS 6300  
Environment and Social Theory  
This course focuses on contemporary social theory to understand the historical origins, institutional structures, and dominant trajectories of environmental-social change. Three main questions structure our inquiry into the links among science, technology, environment, and social theory: 1) why do modern societies degrade their environments? 2) why do environmental movements arise, or what are the social structural, cultural, and political origins of environmentalism? and 3) can some particular politics curtail environmental degradation?  
Offered: Alternate years.  
3 credit hours

STSS 6360  
Advanced Contemporary Political Thought  
Conducted in conjunction with STSS 4360, with additional graduate-level readings. Graduate students must write a research paper along with all other requirements for the course.  
Offered: Upon the availability of instructor.  
3 credit hours
STSS 6400
Environment and Health
This course explores how the health impacts of environmental problems are understood and responded to through medical, legal, and regulatory intervention. Case studies are used to highlight different strategies for dealing with environmental illness, comparing the perspectives of affected people, medical professionals, lawyers, government officials, industry representatives, and media. A core component of the course is devoted to problems related to exposure to toxic chemicals, including readings on popular epidemiology, mass torts, transboundary victimization, and medical rehabilitation models.
Offered: Upon availability of instructor.
3 credit hours

STSS 6540
Advanced Environment, Law, and Culture
Conducted in conjunction with STSS 4540, with additional graduate-level readings and assignments.
Offered: Upon availability of instructor.
3 credit hours

STSS 6560
Advanced Gender, Science, and Technology
Conducted in conjunction with STSS 4560. Additional graduate-level readings will focus on the impact of feminist theory on science and technology studies, and students are required to write a research paper.
Offered: Upon availability of instructor.
3 credit hours

STSS 6600
Seminar in Ecological Economics, Values, and Policy
This introductory seminar in the Ecological Economics, Values, and Policy Professional Master’s Program surveys the theories, methods, and world views of the approaches of ecological economics and science and technology studies to social scientific and humanistic environmental inquiry. Topics include: valuation, social construction, market failure, cultural studies, externalities, environmental policy and politics, Pareto optimality, and environmental ethics and philosophy.
Offered: Fall term annually.
3 credit hours

STSS 6650
Professional Project in Ecological Economics, Values, and Policy
The course focuses on the development of practical proposals for responding to environmental problems and opportunities. Research projects will include both primary data collection and the formulation of policy recommendations. Course readings will focus on case studies that involve disputes over environmental and economic issues, providing the basis for class discussion about how such disputes can be documented, analyzed and resolved through various scientific, legal, managerial, and policy initiatives.
Prerequisites: EEVP Professional Master’s students or permission of instructor.
Offered: Fall term annually.
3 credit hours

STSS 6940
Readings in Science and Technology Studies
With an individual faculty member on an agreed-upon topic.
1 to 3 credit hours

STSS 6960
Topics in Science and Technology Studies
Selected topics.

STSS 6970
Master’s Internship
3 to 6 credit hours

STSS 6990
Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of S or U are assigned by the adviser each term to reflect the student’s research progress for the given semester. Once the thesis has been presented, approved by the adviser, and accepted by the Office of Graduate Education, it will be archived in a standard format in the library.
1 to 9 credit hours

STSS 9990
Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.
Up to 3 credit hours
USAF Aerospace Studies (ROTC)

USAF 10
Air Force Leadership Laboratory
The leadership laboratory courses (LLABs) include a study of Air Force customs and courtesies, drill and ceremonies, and military commands. The LLAB also includes studying the environment of an Air Force officer and learning about areas of opportunity available to commissioned officers. The AS 300 and AS 400 LLABs consist of activities classified as leadership and management experiences. They involve the planning and controlling of military activities of the cadet wing, and the preparation and presentation of briefings and other oral and written communications. LLABs also include interviews, guidance, and information which will increase the understanding, motivation, and performance of other cadets. **Offered:** An eight-semester (fall and spring) sequence, beginning each fall. **0 credit hours, 2 contact hours**

USAF 80
Air Force Leadership Laboratory
The leadership laboratory courses (LLABs) include a study of Air Force customs and courtesies, drill and ceremonies, and military commands. The LLAB also includes studying the environment of an Air Force officer and learning about areas of opportunity available to commissioned officers. The AS 300 and AS 400 LLABs consist of activities classified as leadership and management experiences. They involve the planning and controlling of military activities of the cadet wing, and the preparation and presentation of briefings and other oral and written communications. LLABs also include interviews, guidance, and information which will increase the understanding, motivation, and performance of other cadets. **Offered:** An eight-semester (fall and spring) sequence, beginning each fall. **0 credit hours, 2 contact hours**

USAF 1010
Air and Space Studies 100A (Foundations of the U.S. Air Force)
AS 100 is a survey course designed to introduce cadets to the United States Air Force and Air Force Reserve Officer Training Corps. Featured topics include: mission and organization of the Air Force, officership and professionalism, military customs and courtesies, Air Force officer opportunities, and an introduction to communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences. **Offered:** 100 A (fall term) 100 B (spring term). **1 credit hour**

USAF 1020
Air and Space Studies 100B (Foundations of the U.S. Air Force)
AS 100 is a survey course designed to introduce cadets to the United States Air Force and Air Force Reserve Officer Training Corps. Featured topics include: mission and organization of the Air Force, officership and professionalism, military customs and courtesies, Air Force officer opportunities, and an introduction to communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences. **Offered:** 100 A (fall term) 100 B (spring term). **1 credit hour**

USAF 2030
Air and Space Studies 200A (The Evolution of USAF Air and Space Power)
The AS200 course designed to examine the general aspects of air and space power through a historical perspective. Utilizing this perspective, the course covers a time period from the first balloons and dirigibles to the space-age global positioning systems of the modern day. Historical examples are provided to extrapolate the development of Air Force capabilities (competencies), and missions (functions) to demonstrate the evolution of what has become today’s USAF air and space power. Furthermore, the course examines several fundamental truths associated with war in the third dimension: e.g., Principles of War and Tenets of Air and Space Power. As a whole, this course provides the cadets with a knowledge level understanding for the general element and employment of air and space power, from an institutional, doctrinal, and historical perspective. In addition, the students will continue to discuss the importance of the Air Force Core Values, through the use of operational examples and historical Air Force leaders, and will continue to develop their communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences. **Offered:** 200 A (fall term) 200 B (spring term). **1 credit hour**
USAF 2040  
Air and Space Studies 200A (The Evolution of USAF Air and Space Power)  
The AS200 course designed to examine the general aspects of air and space power through a historical perspective. Utilizing this perspective, the course covers a time period from the first balloons and dirigibles to the space-age global positioning systems of the modern day. Historical examples are provided to extrapolate the development of Air Force capabilities (competencies), and missions (functions) to demonstrate the evolution of what has become today's USAF air and space power. Furthermore, the course examines several fundamental truths associated with war in the third dimension: e.g., Principles of War and Tenets of Air and Space Power. As a whole, this course provides the cadets with a knowledge level understanding for the general element and employment of air and space power, from an institutional, doctrinal, and historical perspective. In addition, the students will continue to discuss the importance of the Air Force Core Values, through the use of operational examples and historical Air Force leaders, and will continue to develop their communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences.  
Offered: 200 A (fall term) 200 B (spring term).  
1 credit hour

USAF 2050  
Air and Space Studies 300A (Air Force Leadership Studies)  
AS300 is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and the communication skills required of an Air Force junior officer. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts being studied. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences in officer-type activities, giving students the opportunity to apply the leadership and management principles of this course.  
Offered: 300 A (fall term) 300 B (spring term).  
3 credit hours

USAF 2060  
Air and Space Studies 300B (Air Force Leadership Studies)  
AS300 is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and the communication skills required of an Air Force junior officer. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts being studied. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences in officer-type activities, giving students the opportunity to apply the leadership and management principles of this course.  
Offered: 300 A (fall term) 300 B (spring term).  
3 credit hours

USAF 2070  
Air and Space Studies 400A (National Security Affairs and Preparation for Active Duty)  
AS400 examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. Special topics of interest focus on the military as a profession, officership, military justice, civilian control of the military, preparation for active duty, and current issues affecting military professionalism. Within this structure, continued emphasis is given to refining communication skills. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences, giving students the opportunity to apply the leadership and management principles of this course.  
Offered: 400 A (fall term) 400 B (spring term).  
3 credit hours

USAF 2080  
Air and Space Studies 400B (National Security Affairs and Preparation for Active Duty)  
AS400 examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. Special topics of interest focus on the military as a profession, officership, military justice, civilian control of the military, preparation for active duty, and current issues affecting military professionalism. Within this structure, continued emphasis is given to refining communication skills. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences, giving students the opportunity to apply the leadership and management principles of this course.  
Offered: 400 A (fall term) 400 B (spring term).  
3 credit hours

USAR Military Science (ROTC)  

USAR 10  
Fundamentals of Military Science Lab I  
This course is an overview of leadership fundamentals such as setting direction, problem-solving, listening, presenting briefs, providing feedback, and using effective writing skills. Students explore dimensions of leadership values, attributes, skills, and actions in the context of practical, hands-on, and interactive exercises. Contents of the course are linked to USAR 1010.  
0 credit hours

USAR 20  
Fundamentals of Military Science Lab II  
This course is an overview of leadership fundamentals such as setting direction, problem-solving, listening, presenting briefs, providing feedback, and using effective writing skills. Students continue to explore dimensions of leadership values, attributes, skills, and actions in the context of practical, hands-on, and interactive exercises. Contents of the course are linked to USAR 1020.  
0 credit hours
USAR 30  
**Applied Leadership Lab I**  
This course explores the dimensions of creative and innovative tactical leadership strategies and styles by examining team dynamics and two historical leadership theories that form the basis of the army leadership framework. Aspects of personal motivation and team building are practice planning, executing, and assessing team exercises. Contents of the course are linked to USAR 2010.  
0 credit hours

USAR 40  
**Applied Leadership Lab II**  
This course continues to explore the dimensions of creative and innovative tactical leadership strategies and styles by examining team dynamics and two historical leadership theories that form the basis of the army leadership framework. Aspects of personal motivation and team building are practice planning, executing, and assessing team exercises. Contents of the course are linked to USAR 2020.  
0 credit hours

USAR 50  
**Applied Military Leadership Lab I**  
The purpose of this course is to develop basic leadership skills. The course has three objectives: teach cadets those aspects of the art of leadership and the science of warfare they will use as junior officers in the U.S. Army; prepare cadets for the Leadership Development and Assessment Course (LDAC); instill in cadets the values and ethos required to become leaders of character. Contents of the course are linked to USAR 2060.  
0 credit hours

USAR 60  
**Applied Military Leadership Lab II**  
The purpose of this course is to continue development of the basic leadership skills. The course has three objectives: teach cadets those aspects of the art of leadership and the science of warfare they will use as junior officers in the U.S. Army; prepare cadets for the Leadership Development and Assessment Course (LDAC); instill in cadets the values and ethos required to become leaders of character. Contents of the course are linked to USAR 2070.  
0 credit hours

USAR 70  
**Advanced Military Management and Leadership Lab I**  
This course explores the dynamics of leading in the complex situations of current military operations in the Contemporary Operating Environment (COE). Students will examine differences in customs and courtesies, military law, principles of war, and rules of engagement in the face of international terrorism. Also explored are aspects of interacting with non-government organizations, civilians on the battlefield, and host nation support. The course places significant emphasis on preparing students for Basic Officer Leadership Course II and III, and for the first unit of assignment. It uses case studies, scenarios, and “What Now, Lieutenant?” exercises to prepare students to face the complex ethical and practical demands of leading as a commissioned officer in the United States Army. Cadets are responsible for planning, rehearsing, and executing all ROTC events by performing duties similar to that of officers assigned to a battalion staff. Contents of the course are linked to USAR 4010.  
0 credit hours

USAR 80  
**Advanced Military Management and Leadership Lab II**  
This course concentrates on leadership, management, and ethics. The course begins with a series of lessons designed to enable cadets/students to make informed decisions as they prepare for accessions into the Army. The remainder of the course concentrates on Army Operations, training management, communications, and leadership skills. Cadets are responsible for planning, rehearsing, and executing all ROTC events by performing duties similar to that of officers assigned to a battalion staff. Contents of the course are linked to USAR 4020.  
0 credit hours

USAR 1010  
**Fundamentals of Military Science**  
The course introduces students to fundamental components of service as an officer in the United States Army. These initial lessons are the building blocks of progressive lessons in values, fitness, leadership, and officership. Additionally, the course addresses “life skills” including fitness, communications theory and practice (written and oral), and interpersonal relationships. Upon completion, students should be prepared to receive more complex leadership instruction. Actual schedule will be posted in syllabus. Leadership Laboratories are held every other week for two hours, and attendance is voluntary.  
1 credit hour

USAR 1020  
**Fundamentals of Military Science II**  
The course builds upon the fundamentals introduced in USAR 1010 by focusing on leadership theory and decision making. “Life skills” lessons in the semester include: problem solving, critical thinking, leadership theory, followership, group interaction, goal setting, and feedback mechanisms. Upon completion, students should be prepared to advance to more complex leadership instruction concerning the dynamics of organization. Actual schedule will be posted in syllabus. Leadership Laboratories are held every other week for two hours, and attendance is voluntary.  
1 credit hour
USAR 2010
Applied Leadership I
The course contains the principal leadership instruction of the Basic Course. The instruction delves into several aspects of communication and leadership theory. The use of practical exercises is emphasized, as students are increasingly required to apply communications and leadership concepts. Virtually the entire course teaches critical “life skills.” The relevance of these life skills to future success in the Army is emphasized throughout the course. The course concludes with a major leadership and problem-solving case study which draws on all of the classroom instruction received in the Basic Course. Upon completion of this semester, students should be well grounded in the fundamentals of leadership, and be prepared to intensify the practical application of their studies during the Advanced Course. Leadership Laboratories are held every other week for two hours, and attendance is voluntary. Actual schedule will be posted in syllabus.

1 credit hour

USAR 2020
Applied Leadership II
The course focuses principally on officership, providing an extensive examination of the unique purpose, roles, and obligations of commissioned officers. It includes a detailed look at the origin of the Army’s institutional values and their practical application in decision making and leadership. At the core is the Basic Course’s Capstone Case Study in Officership. This five-lesson exercise traces the Army’s successes and failures as it evolved from the Vietnam War to the present, placing previous lessons on leadership and officership in a real-world context that directly affects the future of the students who plan on attending the Advanced Course. This course, more than any before it, draws the various components of values, communications, decision making, and leadership together to focus on a career as a commissioned officer. Upon completion of this course, students should possess a fundamental understanding of both leadership and officership, and demonstrate the ability to apply this understanding in real-world situations.

1 credit hour

USAR 2060
Applied Military Leadership I
The course begins with instruction in the Leadership Development Program (LDP), used throughout the academic year to assess and develop leadership. Instruction in principles of war and purposes, fundamentals, and characteristics of the defense provides the necessary knowledge base for meaningful contextual treatment of Troop leading procedures (TLP). Instruction in decision-making, planning, and execution processes of the TLP are followed by a refocus on the critical leadership task of communicating the plan using the standard military format. The course addresses motivational theory and techniques, the role and actions of leaders, and risk assessment. The course closes with instruction in small unit battle drills to facilitate practice application and further leader development during labs and situational training exercises (STX).

2 credit hours

USAR 2070
Applied Military Leadership II
The course continues to focus on doctrinal leadership and tactical operations at the small unit level. It includes opportunities to plan and conduct individual and collective skill training for military operations to gain leadership and tactical experience. The course synthesizes the various components of training, leadership, and team building. Students are required to incorporate previous military science instruction for their practical application in a performance-oriented environment. Upon completion of the course, students will possess the fundamental confidence and competence of leadership in a small unit setting.

2 credit hours

USAR 4010
Advanced Military Management and Leadership I
The course concentrates on leadership, management, and ethics. The course focuses students, early in the year, on attaining knowledge and proficiency in several critical areas they will need to operate effectively as Army officers. These areas include: coordination of activities with staffs, counseling theory and practice within the “army context” training management, and ethics. While proficiency attained in each of these areas will initially be at the apprentice level, students will continue to sharpen these skills as they perform their roles as cadet officers within the ROTC program and after commissioning. At the end of the course, students should possess the fundamental skills, attributes, and abilities to operate as competent leaders.

2 credit hours

USAR 4020
Advanced Military Management and Leadership II
The course focuses on completing the transition from cadet to lieutenant. As a follow-up to the ethics instruction in USAR 4010, the course starts with a foundation in the legal aspects of decision making and leadership. The curriculum reinforces previous instruction on the organization of the Army and introduces how the Army organizes for operations from the tactical to the strategic level. This is followed by instruction on administrative and logistical management that will focus on the fundamentals of soldier and unit level support. At the core of the semester is the Advanced Course Capstone Exercise. This 12-lesson exercise incorporates learning objectives from the entire military science curriculum. The capstone exercise will require students, both individually and collectively, to apply their knowledge to solve problems and confront situations commonly faced by junior officers. Upon completion of the course, students will be prepared for the responsibility of being a commissioned officer in the United States Army.

2 credit hours
USNA Naval Science (ROTC)

USNA 10
Drill/Laboratory
Consists of one period each week lasting approximately two hours. The periods are spent conducting various activities, including military drill, athletics, lectures, and discussions on various topics of naval interest. Operating within a battalion organizational structure, students are given additional opportunities for leadership training and hands-on experience.
**Prerequisite:** An eight-semester (fall and spring) sequence, beginning each fall.

0 credit hours

USNA 80
Drill/Laboratory
Consists of one period each week lasting approximately two hours. The periods are spent conducting various activities, including military drill, athletics, lectures, and discussions on various topics of naval interest. Operating within a battalion organizational structure, students are given additional opportunities for leadership training and hands-on experience.
**Prerequisite:** An eight-semester (fall and spring) sequence, beginning each fall.

0 credit hours

USNA 1010
Introduction to Naval Science
The organization of the Department of Defense with emphasis on the Department of the Navy. This course provides a broad overview of all aspects of the operation and administration of today’s Navy and Marine Corps. Additionally, the course will introduce naval topics such as rank structure, naval etiquette, naval history, naval warfare platforms and missions as well as basic naval leadership principles. The course will also cover basic military conduct and NROTC rules and regulations. Finally, the course will look at the role of the U.S. military in today’s ever changing geopolitical climates and global conflicts.

3 credit hours

USNA 2020
Sea Power and Maritime Affairs
A study in the development of the United States Navy and Marine Corps throughout the history of the United States. This course treats the broad principles, concepts, and elements of seapower with historical and modern applications to the United States and other world powers.
**Offered:** Spring term annually.

3 credit hours

USNA 2030
Naval Leadership and Management I
Comprehensive study of organization, leadership, and management with emphasis on the naval organization. Survey of the management process. Introduction to individual and small group behavior, decision making, responsibility, authority, and accountability. Extensive study of motivation, leadership, and communication. Application explored by case study and seminar discussions.
**Offered:** Fall term annually.

3 credit hours

USNA 2040
Naval Ships Systems I
A familiarization course in naval engineering. Study of types, structure, and purpose of naval ships. Elements of ship design to achieve safe operations and ship stability characteristics are examined. Ship compartmentation, propulsion systems, auxiliary power systems, ship control systems, and elements of damage control are included.
**Offered:** Spring term annually.

3 credit hours

USNA 2050
Navigation
The principles and procedures of ship navigation, movements, and employment. Course includes piloting, mathematical analysis, spherical triangulation, navigational aids, tides and currents, electronic navigation, and rules of the nautical road.
**Offered:** Fall term annually.

3 credit hours

USNA 2060
Naval Operations
An introduction to the complexities of modern naval operations. Course emphasis includes fleet communications and communication security, naval tactics, relative motion, maneuvering board, and ship operations and control.
**Offered:** Spring term annually.

3 credit hours

USNA 2070
Naval Ships Systems II
The study of weapons systems and the theoretical concepts underlying the design and operation of those systems. Includes sensor and detection subsystems, tracking systems, propulsion and guidance systems, launching systems, fire control problem solutions, and systems integration. In-depth analysis of representative, state-of-the-art weapons systems in use today.
**Offered:** Fall term annually.

3 credit hours

USNA 2150
Evolution of Warfare
A study of the forms of warfare practiced throughout history with the emphasis on those of the Middle East and Western Europe. Selected battles, strategy, formations, and commanders are studied from the times of the pharaohs to the present. The moral, ethical, and cultural attitudes of the times are brought into the course so that the student may understand how they influenced warfare and in turn were influenced by warfare.
**Offered:** Spring term odd-numbered years.

3 credit hours

3** credit hours
USNA 2170
Amphibious Warfare
The science of amphibious operations, emphasizing tactical and logistical planning and the coordination required of joint forces. The case study approach is used, with each operation being analyzed as to its strengths and weaknesses and the lessons learned, which were applied to subsequent operations.
Offered: Spring term even-numbered years.
3** credit hours

USNA 2940
Readings in Naval Science
An individually arranged independent study course under supervision of a member of the Naval Science Department.
1 to 3 credit hours

USNA 4190
Naval Leadership and Ethics
The capstone course of the NROTC academic syllabus, providing a study of personal and professional military ethics and Navy/Marine Corps junior officer leadership and administration. Presents leadership and ethical dilemmas in case study and small group discussion format. The course also exposes the student to a study of counseling methods, military justice administration, human resources management, directives and correspondence, personnel management, and career development.
Prerequisites: USNA 1010, USNA 2020, USNA 2030, USNA 2040, USNA 2050, USNA 2060, USNA 2070.
Offered: Spring term annually.
3 credit hours

WRIT Writing (HSSH)

WRIT 1110
Writing for Classroom and Career
This course emphasizes written, visual, and oral communication strategies that will help students succeed in both academic and professional contexts. Principal assignments are based on types of writing required in school and on the job: reporting, evaluating, taking a position, and making a proposal (orally and in writing). Written assignments will include visual elements such as headings, charts/graphs, and page or screen design. This is a communication-intensive course.
Offered: Fall and spring terms annually.
4 credit hours

WRIT 1960
Topics in Writing
4 credit hours

WRIT 2110
Rhetoric and Writing
This course aims to increase students’ ability to develop ideas and to express them effectively. It gives special attention to expository and persuasive writing. Study of rhetorical theory and critical reading of speeches and/or essays help the students to understand the rhetorical process, to analyze the audience, and to foresee its response. A substantial amount of writing is required. This is a communication-intensive course.
Offered: Fall and spring terms annually.
4 credit hours

WRIT 2310
Creative Writing: Poetry
This course is for students with little or no previous creative writing experience. Readings introduce traditional, modern, and post-modern poetic practice emphasizing imagery, figurative language, voice, line, and other formal aspects of poetry. Notebooks track development of student writing from reading exemplary texts to drafting revision of original poems. Writing workshop format includes analysis of published poems and peer discussion and critique of student work. For final projects, students create chapbooks, thematically sequenced poetry collections. This is a communication-intensive course.
Offered: Spring term annually.
4 credit hours

WRIT 2320
Creative Non-fiction
This is a workshop course in which novice and more experienced student writers produce creative nonfiction-prose that aims to be both factually accurate and compelling literature. Focus may vary by semester among memoir, lyric and personal essays, plotted narrative, oral history, and nature writing. For models students study classic and contemporary accomplished writers who connect the self to the larger world. Class work centers on drafting and revising essays, with regular peer workshops. This is a communication-intensive course.
Offered: Upon availability of instructor.
4 credit hours

WRIT 2330
Creative Writing: The Short Story
A workshop course in reading and writing varied forms of short narrative and non-narrative prose fiction. This course will focus on reading and analyzing exemplary short fiction and writing and revising original work. Students learn to develop plot, character, setting, point of view, style, and theme, and use description effectively to invent and shape narrative strategies. Peer reading and writing groups offer opportunities for shared response and critique. This is a communication-intensive course.
Offered: Upon availability of instructor.
4 credit hours
WRIT 2340
Speech Communication
This course focuses on developing public speaking skills and critical listening abilities. Guided by rhetorical theory, theories of persuasion, and argumentation theory, students prepare several oral presentations, engage in extemporaneous speaking exercises, and criticize other performances. This is a communication-intensive course.
Offered: Fall term annually.
4 credit hours

WRIT 2960
Topics in Writing
4 credit hours

WRIT 4160
Writing about Science
This course introduces students to a set of principles that can guide their print and multimedia communication with readers who are not specialists in a particular scientific or technical field but who are affected by developments in those fields. Students will learn to use these principles in analyzing exemplary texts as well as in creating their own work. This is a communication-intensive course.
Prerequisites: Successful completion of any 1000- or 2000-level WRIT course or junior or senior status.
Offered: Spring term annually.
Cross listed: WRIT 6160. Students cannot receive credit for both courses.
4 credit hours

WRIT 4170
Writing for Promotion and Marketing
This course engages students in persuasive and information writing designed to promote skills, products, services, or concepts. Writers craft such texts and materials as: application essays, news releases, advertising copy, newsletters, oral presentations, marketing plans, and Web sites and other e-materials. Coursework will emphasize the fundamentals of good writing based on audience and context analysis, and on basic understanding of branding and marketing communication options. Restricted to EMAC and COMM majors. This is a communication-intensive course.
Prerequisites: WRIT 1110, WRIT 2110, or permission of instructor.
Offered: Spring term annually.
4 credit hours

WRIT 4410
Research Writing
In this class, students will write on topics from their major discipline and investigate the kinds of texts that professionals in their field produce. They will identify and explore research questions, use discipline-specific library databases, and write research reports. In addition, they will develop effective note-taking and research skills and learn strategies for effective prose style. This is a communication-intensive course.
Prerequisite: One other WRIT or COMM course or one other communication-intensive course.

WRIT 4550
Proposing and Persuading
Make things happen: start a business, raise funds, solicit work, support research, win a place on a conference program, take initiative, change the way things are done around here. This course will teach students how to write proposals that persuade. Students will learn to turn situations into occasions for proposing, write a variety of proposals, locate Request for Proposals, develop a workplan for feasible projects that come in on-time and on-budget, use networks to strengthen proposals, detail a budget, and edit for clarity and grace. This is a communication-intensive course.
Prerequisite: Graduate standing or successful completion of a WRIT 1110, WRIT 2110, or permission of instructor.
Offered: Fall term annually.
Cross listed: WRIT 6550. Students may not receive credit for both courses.
4 credit hours

WRIT 4960
Topics in Writing
4 credit hours

WRIT 6160
Writing about Science
This course introduces students to a set of principles that can guide their print and multimedia communication with readers who are not specialists in a particular scientific or technical field but who are affected by developments in those fields. Students will learn to use these principles in analyzing exemplary texts as well as in creating their own work.
Offered: Spring term annually.
Cross listed: WRIT 4160. Students cannot obtain credit for both courses.
3 credit hours

WRIT 6170
Writing for Promotion & Marketing
This course engages students in persuasive and information writing designed to promote skills, products, services or concepts. Writers craft such texts and materials as: application essays, news releases, advertising copy, newsletters, oral presentations, marketing plans, and Web sites and other e-materials. Coursework will emphasize the fundamentals of good writing based on audience and context analysis, and on a basic understanding of branding and marketing communication options. Restricted to EMAC and COMM majors. This is a communication-intensive course.
Prerequisites: Permission of instructor.
Offered: Spring term annually.
3 credit hours
WRIT 6410
Research Writing
In this class, students will write on topics from their major discipline and investigate the kinds of texts that professionals in the field produce. They will identify and explore research questions, use discipline-specific library databases, and write research reports. In addition, students will develop effective note-taking and research skills and learn strategies for effective prose style.
Offered: Fall term annually.
Cross listed: WRIT 4410. Students cannot obtain credit for both this course and WRIT 4410.
3 credit hours

WRIT 6550
Proposing and Persuading
Make things happen: start a business, raise funds, solicit work, support research, win a place on a conference program, take initiative, change the way things are done around here. This course will teach students how to write proposals that persuade. They will learn to turn situations into occasions for proposing, write a variety of proposals, locate Request for Proposals, develop a work-plan for feasible projects that come in on time and on budget, use networks to strengthen proposals, detail a budget, and edit for clarity and grace.
Prerequisite: Graduate standing or successful completion of a writing course.
Offered: Fall term annually.
Cross listed: WRIT 4550. Students may not receive credit for both courses.
3 credit hours
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Commanding Officer, Military Science ROTC ...................................................................................... Lt. Col. Samantha Ross
Commanding Officer, Naval Science ROTC .......................................................................................... Capt. Daniel D. Arensmeyer

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Vice Provost for Institute Diversity ................................................................. (vacant)

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Assistant Vice President for Capital Projects ......................................... Oleh Turczak

Auxiliary, Parking, and Transportation Services
Director ............................................................................................ Alexandre da Silva
Manager, Operations/Houston Field House .......................................... Elizabeth Preston
Operations Manager, Parking and Transportation .................................... Jason M. Jones

Campus Planning and Facilities Design
Director ............................................................................................ J. Bruce Kunkel
Manager, Engineering .......................................................................... (vacant)
Manager, Design and Construction ........................................................ Edward M. Staats

Emergency Management
Director .......................................................................................... Stephen Abrams

Environmental and Site Services
Director ............................................................................................ Jerry Faiola
Manager, Environmental Services ....................................................... (vacant)
Manager, Site Services ......................................................................... John Holstein

Physical Plant
Director ............................................................................................ Ernest Katzwinkel
Associate Director ............................................................................. David Ira
Facilities Engineer (BioTech/CII) ............................................................ Swaran Rataul
Facilities Engineer (EMPAC) ................................................................. John Gall
Senior Project Coordinator .................................................................... Richard Hornberger
Project Coordinator ................................................................. Duane DeWeerdt
Manager, Customer Service Center .................................................. Paul Galbraith

**Procurement and Administrative Services**

Director, Procurement Services ......................................................... (vacant)
Associate Director, Material Management ................................................ (vacant)
Manager, Purchasing Systems ........................................................... (vacant)
Manager, Administrative Services ...................................................... Cathleen A. DiDio
Senior Business Manager ................................................................. Steven Schwan
Manager, Stockroom ........................................................................ Donald Ammerman

**Public Safety**

Director ...................................................................................... Roger Johnson
Associate Director ........................................................................... (vacant)

**Rensselaer Dining Services (Sodexo)**

Resident District Manager ............................................................... Timothy MacTurk
General Manager ........................................................................... Matthew Muller
Dining Director, Rensselaer Union ...................................................... (vacant)
Resident Dining Director ................................................................. Joyce Schoenig
Marketing Director .......................................................................... Elaine Reynolds
Catering Manager ............................................................................ Ron Knoth

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Assistant Vice President for Information Services ................................ Jeffrey G. Miner
Director, Academic & Research Computing ...................................... Jeffrey G. Mine (Acting)
Director, Communications and Middleware Technologies .................. Gary Schwartz
Director, Information Technologies and Infrastructure ....................... Graham Doig
Director, Integrated Administrative Computing Services .................... Mary Alice O’Brien
Director, Rensselaer Libraries ........................................................... Robert Mayo
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Senior Business Manager ............................................................... Sandra R. Redemann Butcher

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Director, Operations ........................................................................ Sharon M. Beaudoin
Director, Graduate Admissions ........................................................ George B. Robbins
Director, Undergraduate Admissions ................................................ Karen S. Long
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Vice President for Finance and Chief Financial Officer .......................................................... Virginia C. Gregg

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Assistant Vice President for Finance and Controller .......................................................... Kelli A. Hudson
Director, Accounting .......................................................................................................... John Kalbacher
Director, Disbursement Operations and Payroll ............................................................... Pamela A. Rochminski

Financial Planning and Budget
Assistant Vice President for Finance and Budgeting .......................................................... Eileen McLoughlin
Director, Budget .............................................................................................................. Helen Grzymala

Treasury
Assistant Treasurer for Investments ..................................................................................... David J. Guame
Assistant Treasurer ......................................................................................................... Susan L. Proskine
Bursar ............................................................................................................................... Jacquelyn Ellsworth

Research Administration and Finance
Assistant Vice President for Research and Finance ............................................................. (vacant)
Director, Research Finance ............................................................................................... Jennifer Fisher
Director, Research Administration ..................................................................................... Richard Scammel

Institute Advancement
Vice President for Institute Advancement ........................................................................... (vacant)
Assistant Vice President, Alumni Relations .......................................................................... Jeffrey Schanz
Assistant Vice President, Advancement Strategy, Services, and Infrastructure ......................... Joseph Medina

Advancement Strategy Services and Infrastructure
Director, Prospect Research, Management & Analytics ....................................................... Patricia Ayers-Miller
Manager, Advancement Systems ......................................................................................... Marie K. Carroll
Manager, Donor Relations and Communications .................................................................. Kristi Jongeling

Development and Alumni Relations
Director, Advancement Events ............................................................................................ Lulleen Lamar
Director, Annual Giving ..................................................................................................... Dawn Stever
Director, Corporate and Foundation Relations ................................................................... Maria Mike-Mayer
Director, Gift Planning ....................................................................................................... Art Tracy
Director, Major Gifts ........................................................................................................... (vacant)
Director, Principal Gifts ..................................................................................................... Kathy Durivage
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Associate Vice President for Research .................................................. Wolf von Malltzahn
Associate Vice President for Research, Physical Sciences and Engineering ................................................. Jon Morse
Assistant Vice President for Research .................................................... Nick Viggiani
Grant Director .................................................................................. Jack Huang

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Associate Vice President, External Relations and Administration .................................................. Allison Newman
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Director, Federal Relations ................................................................. Deborah Altenburg
Director, Creative Services ................................................................. Diane Piester
Director, News & Editorial Services ...................................................... Mark Marchand
Director, University Events ............................................................... Peter Grimm
Managing Editor, Rensselaer Magazine ................................................................ Tracey Leibach
Manager, Web Communications .......................................................... Steven Morris

Student Life

Vice President for Student Life ............................................................. Dr. Timothy E. Sams
Executive Assistant ........................................................................ Analusette Shaello-Johnson
Business Manager ............................................................................ Gina Ricci

Athletics

Director of Athletics ........................................................................... Jim Knowlton
Associate Director, Business and Finance, SWA .................................... Karen Hansen
Associate Director, Communication and Compliance ............................... Kevin Beattie
Director of Intramurals ...................................................................... Karl Steffen
Assistant Director ............................................................................. Mike Steffen

Center for Career and Professional Development

Acting Director, Center for Career and Professional Development ............... Dr. Timothy E. Sams
Senior Associate Director and Director, Cooperative Education ............... (vacant)
Associate Director ............................................................................ Dawn Weaver
Career Counselor .............................................................................. Meaghan Johnson
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Dean of Students .................................................... Mark Smith
Assistant Dean, International Services for Students & Scholars ................................................. Jane Havis
Assistant Dean, Disability Service for Students ................................................................. (vacant)
Assistant Dean of Students/Director, Pipeline Initiatives and Partnership ................................... Cynthia Smith

Student Experience Office

Assistant Vice President, Student Experience ................................................................. Lisa T rahan
Associate Dean, Success and Retention ................................................................. J. Louis T rzepacz
Class Dean, Student Experience .................................................................... Jennifer Forbesl
Class Dean, Student Experience ................................................................... Darren Jones
Class Dean, Student Experience ..................................................................... Amy Pettengill
Dean, First-Year Experience ........................................................................... Janelle Fayette
Assistant Dean, Student Experience ................................................................. Shanté Brown

Student Health Center

Director ...................................................................................... Leslie Lawrence, M.D.
Associate Director ........................................................................ Kevin Readdean
Director, Counseling Services ................................................................ Benjamin Marte, M.D.
Health Educator .................................................................................... Tara Schuster
Health Educator ..................................................................................... Alexandra Blais

Religious Affairs

Coordinator, Religious Affairs and Resident Catholic Chaplain ........................................ Rev. Edward S. Kacerguis
Associate Protestant Chaplain ........................................................................ Beth Illingworth, Troy Area United Ministries
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Director ............................................................................................ Joseph Cassidy
Director, Mueller Center, Programs, and Club Sports .................................................. Steve Allard
Assistant Coordinator, Fitness Center, Programs, and Intramurals .............................. Joseph Campo
Assistant Coordinator ............................................................................... Lauren Chemotti
Assistant Coordinator, Strength and Weight Training ................................................ John Hudak
Mueller Center Program Coordinator .................................................................... John Nehrich
Director, Student Activities ........................................................................ Cameron Reid McLean
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Associate Dean of Greek Commons ................................. Matthew Hunt
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Assistant Dean ....................................................... Christina Lowery
Assistant Dean ......................................................... Renata Williams
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Registrar and Director .................................................... Sharon L. Kunkel
Senior Associate Registrar ........................................... Maria Zanotta
Associate Registrar .................................................. Peggy Conroy-Martín
Assistant Registrar ...................................................... Kim Herkert
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*As of April 2013
Named Professorships

Rensselaer has several professorships honoring individuals or institutions for whom they are named, as well as honoring those who occupy them. These named professorships are listed below with their incumbents. Dates in parentheses indicate the year the professorship was established.

Ray Palmer Baker Distinguished Professorship .............................................................. Toh-Ming Lu
Richard Baruch M.D. Career Development Professor ......................................................... vacant
Clay P. Bedford, Sr. ’24 Endowed Chair Professorship ........................................................ Michael Stein
Howard N. Blitman ’50 P.E. Career Development Professor in Engineering ......................... Yuri Gorby
Irene and Robert Bozzone ’55 Assistant Professor of Management and Technology ................ (vacant)
Ann and John H. Broadbent Jr. ’59 Senior Constellation Professor, Biocatalysis and Metabolic Engineering ........ Robert J. Linhardt
Warren H. Bruggeman ’46 and Pauline Urban Bruggeman Distinguished Associate Professor ........ Bill Francis
Henry Burlage Chaired Professor in Engineering .......................................................... Robert Hull
Priti and Mukesh Chatter ’82 Center for Global Energy Research ........................................ (vacant)
Dorothy and Fred Chau ’71 Career Development Constellation Professor in Biocatalysis and Metabolic Engineering ........ (vacant)
Constellation Professor, Biocomputation and Bioinformatics ........................................... Angel E. Garcia
Constellation Professor, Biocomputation and Bioinformatics ........................................... George Makhatadze
Constellation Professor, Biocomputation and Bioinformatics ........................................... Catherine Royer
Constellation Professor, Biocatalysis and Metabolic Engineering ....................................... Richard Gross
Career Development Constellation Professor, Biocatalysis and Metabolic Engineering ........ Mattheos Koffas
Constellation Professor, Future Chips ............................................................................ Shawn-Yu Lin
Constellation Professor, Tetherless World ......................................................................... James A. Hendler
Constellation Professor, Tetherless World ......................................................................... Deborah L. McGuinness
Constellation Professor, Tetherless World ......................................................................... Peter Fox
John A. Clark and Edward T. Crossan Professor of Engineering ......................................... Nikhil Koratkar
John A. Clark and Edward T. Crossan Professor of Engineering ......................................... Ge Wang
Thomas and Constance D’Ambra Professor in Synthetic Organic Chemistry ..................... (vacant)
David M. Darrin ’40 Senior Endowed Chair at the Darrin Fresh Water Institute ................... (vacant)
Margaret A. Darrin Distinguished Professor in Applied Mathematics ...................................... (vacant)
James L. Decker ’45 Endowed Chair in Aerospace Engineering ......................................... Michael Amitay
Amos Eaton Professor of Computer Science ........................................................................ (vacant)
Nancy and Roland Fitzroy Professor of Engineering .......................................................... (vacant)
Ford Foundation Professor of Mathematics ......................................................................... Joyce R. McLaughlin
Frank and Lillian Gilbreth Professor in the Technologies of Management ............................ Albert S. Paulson
Alma and H. Erwin Hale ’30 Teaching Professorship of Humanities and Social Sciences ........ Linda L. Layne
Edward P. Hamilton Distinguished Educator ....................................................................... Francine Berman
Edward P. Hamilton Distinguished Professor of Science Education............................................ Frank Spear
William Howard Hart Professor of Rational and Technical Mechanics........................................ Jose Holguin-Veras
Edward E. Hood Jr. Professorship......................................................................................... (vacant)
John Tod Horton ’52 Professor of Materials Engineering.................................................... David Duquette
John Tod Horton ’52 Professor of Materials Engineering.................................................... (vacant)
Robert W. Hunt Professor of Materials Science and Engineering........................................ Richard W. Siegel
Institute Professor ................................................................. Georges Belfort
Institute Professor of Engineering.................................................................................. Ricardo Dobry
Institute Professor of Nuclear Engineering................................................................. (vacant)
Institute Professor of Science..................................................................................... E. Bruce Watson
Institute Professor of Science..................................................................................... (vacant)
Institute Professor of Science and Technology................................................................. (vacant)
Judith and Thomas Iovino ’73 Career Development Professor in Civil Engineering.............. Tarek Abdoun
Howard P. Isermann ’42 Professor of Chemical and Biological Engineering....................... Jonathan Dordick
Samuel A. Johnson ’37 and Elisabeth C. Johnson Professor in Engineering......................... Mark S. Shephard
J. Erik Jonsson ’22 Distinguished Professor ........................................................................ (vacant)
Kodak Chair in Environmental Engineering................................................................. Philippe Baveye
Gail and Jeffrey L. Kodosky ’70 Chair in Physics, Information Technology, and Entrepreneurship......................... Shengbai Zhang
Gail and Jeffrey L. Kodosky ’70 Career Development Chair........................................ Vincent Meunier
Frederic R. Kolleck ’52 Career Development Professor in Chemistry................................. (vacant)
Louis Ellsworth Laflin Professor of English........................................................................ Merrill D. Whitburn
P.K. Lashmet Career Development Chair............................................................................. Ravi Kane
Ruth and Augustine Marusi ’36 Professorship in Global Business Management ................. (vacant)
Elaine S. and Jack S. Parker Chair in Engineering.............................................................. Shekhar Garde
Thomas Phelan Chair in Humanities and Social Sciences................................................ Langdon Winner
Rayleigh Chair for Theoretical Physics................................................................................. (vacant)
Rosalind and John J. Redfern Jr. ’33 Professor of Engineering............................................. Farhan Gandhi
Eliza Ricketts Foundation Professor of Mathematics................................................................. (vacant)
Eliza Ricketts Foundation Professor of Mathematics................................................................. (vacant)
Virginia and Lloyd W. Rittenhouse ’35 Teaching Professor of Humanities and Social Sciences.................................................................................................................. (vacant)
Patricia W. and C. Sheldon Roberts ’48 Chaired Professor in Solid State Electronics................. Michael S. Shur
Russell Sage Professor of Engineering.............................................................................. Linda Schadler
Claire and Roland Schmitt Distinguished Professorship....................................................... Boleslaw Szymanski
Alan Paul Schulz Career Development Professor of Chemistry............................................ (vacant)
Marty Silverman (Noble Enterprise) Functional Tissue and Regenerative Medicine Constellation Chair.................................................................................................................. (vacant)
Marty Silverman (Noble Enterprise) Functional Tissue and Regenerative Medicine Constellation Chair.................................................................................................................. (vacant)
Marty Silverman (Noble Enterprise) Functional Tissue and Regenerative Medicine Constellation Chair (vacant)
Marty Silverman (Noble Enterprise) Functional Tissue and Regenerative Medicine Constellation Chair (vacant)
Kay and Jackson Tai ’72 Senior Professor (vacant)
Travelstead Institute Chair Gwo-Ching Wang
William Weightman Walker Professor of Chemistry Linda McGown
William Weightman Walker Professor of Polymer Engineering Steven Cramer
Wellfleet Constellation Professor, Future Chips Christian M. Wetzell
Wellfleet Senior Constellation Professor, Future Chips E. Fred Schubert
Cary L. Wellington Professor of Management of Technology (vacant)
Dean R. Wellington ’83 Teaching Professorship in Management (vacant)
Yamada Corporation Professor William A. Wallace
The Faculty

Faculty Roster

An asterisk (*) indicates recipients of the William H. Wiley Distinguished Faculty Award; a dagger † indicates recipients of the David M. Darrin Counseling Award; a double dagger †† indicates recipients of the James M. Tien ’66 Early Career Award for Faculty.

†† Abdoun, Tarek  Associate Dean for Research and Graduate Programs; Professor of Civil and Environmental Engineering; Judith and Thomas Iovino ’73 Career Development Professor in Civil Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Abetti, Pier A.  Professor of Practice, Lally School of Management and Technology; Ph.D. (Illinois Institute of Technology).

Aboul-Seoud, Mohamed  Lecturer, Department of Industrial and Systems Engineering; Ph.D. (University of Technology).

Abouzeid, Alhussein  Associate Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Washington, Seattle).

Abali, Sibel  Associate Professor of Computer Science; Member, Faculty of Information Technology and Web Science; Ph.D. (University of Maryland).

Ahn, Woojin  Research Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Korea Advanced Institute of Science and Technology).

Akera, Atsushi  Associate Professor of Science and Technology Studies; Member, Faculty of Information Technology and Web Science; Ph.D. (University of Pennsylvania).

Allen, Brian  Research Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (University of California, Los Angeles).

Amitay, Michael  James L. Decker ’45 endowed Chair in Aerospace Engineering; Director, Center for Flow Physics and Control; Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Technion, Israel Institute of Technology).

Anderson, Kurt  Associate Dean for Undergraduate Studies; Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Stanford University).

Anshelevich, Elliot  Associate Professor of Computer Science; Ph.D. (Cornell University).

Antal, Steven P.  Research Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Arensmeier, Captain Daniel  Professor of Practice, Naval Science.

Bae, Chulsung  Associate Professor of Chemistry and Chemical Biology; Ph.D. (University of Southern California, Los Angeles).

Bahn, Curtis  Associate Professor, Department of the Arts; Ph.D. (Princeton University).

Bailey, Ronald A.  Associate Head and Professor of Chemistry and Chemical Biology; Member, Faculty of Information Technology and Web Science; Ph.D. (McGill University).

Ban, Xuegang (Jeff)  Assistant Professor of Civil and Environmental Engineering; Ph.D. (University of Wisconsin, Madison).

Barquera, Blanca  Associate Professor of Biology; Ph.D. (Institute de Fisiologre, Mexico).

Bauner, Christoph  Lecturer, Department of Economics; Ph.D. (Duke University).

Baveye, Philippe  Kodak Chair in Environmental Engineering; Professor of Civil and Environmental Engineering; Ph.D. (University of California, Berkeley).

Bedard, Donna  Research Professor of Biology; Ph.D. (University of Chicago).

Begley, Thomas  Dean and Professor, Lally School of Management and Technology; Ph.D. (Cornell University).

* Belfort, Georges  Institute Professor; Professor of Chemical and Biological Engineering; Ph.D. (University of California, Irvine).
Bell, David H. Associate Professor of Architecture; M.Arch. (University of Virginia).

Bennett, Audrey Associate Professor of Communication and Media; M.F.A. (Yale University).

†† Bennett, Kristin P. Professor of Mathematical Sciences; Professor of Computer Science; Ph.D. (University of Wisconsin).

Bennett, Victoria Assistant Professor of Civil and Environmental Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Bequette, B. Wayne Professor of Chemical Engineering; Ph.D. (University of Texas, Austin).

Berman, Francine Edward P. Hamilton Distinguished Professor of Science Education and Professor of Computer Science; Ph.D. (University of Washington).

Bevilacqua, Riccardo Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (University of Rome).

Bhat, Ishwara B. Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Blackmon, Master Sergeant Heath Lecturer, Military Science.

Bjornsson, Christopher S. Research Assistant Professor of Biology; Ph.D. (University of Manitoba).

Blanchard, Lieutenant Patrick Lecturer, Naval Science.

†† Blanchet, Thierry A. Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Dartmouth College).

Bopp, Richard E. Associate Professor of Earth and Environmental Sciences; Ph.D. (Columbia University).

Borca-Tasciuc, Diana Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (University of California, Los Angeles).

Borca-Tasciuc, Theodorian Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (University of California, Los Angeles).

Boudjelkha, Mohamed T. Lecturer, Department of Computer Science; Ph.D. (Rensselaer Polytechnic Institute).

Boyer, Kim Department Head and Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Purdue University).

† Boylen, Charles W. Professor of Biology; Ph.D. (University of Wisconsin).

Braasch, Jonas Director, Center for Cognition, Communication, and Culture (CCC); Associate Professor of Architecture; Ph.D. (University of Bodsam, Germany).

Braunstein, Jeffrey Lecturer, Department of Electrical, Computer, and Systems Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Breneman, Curtis M. Department Head; Professor of Chemistry and Chemical Biology; Director, Rensselaer Exploratory Center for Cheminformatics Research; Member, Faculty of Information Technology and Web Science; Ph.D. (University of California, Santa Barbara).

Breyman, Steven J. Associate Professor of Science and Technology Studies; Member, Faculty of Information Technology and Web Science; Ph.D. (University of California, Santa Barbara).

† Bringsjord, Selmer Department Head and Professor of Cognitive Science; Professor of Computer Science; Member, Faculty of Information Technology and Web Science; Ph.D. (Brown University).

Bustamante, Nao Associate Professor of Arts; Member, Faculty of Information Technology and Web Science; M.F.A., (San Francisco Art Institute).

Bystroff, Christopher Associate Professor of Biology; Member, Faculty of Information Technology and Web Science; Ph.D. (University of California, San Diego).

Campbell, Nancy Associate Dean for Research and Graduate Studies, School of Humanities, Arts, and Social Sciences; Professor of Science and Technology Studies; Ph.D. (University of California, Santa Cruz).

Canier, Caren Professor of Art; M.F.A. (Boston University).

Caporael, Linnda R. Professor of Psychology; Professor of Science and Technology Studies; Ph.D. (University of California, Santa Barbara).
Caracappa, Peter  Lecturer, Department of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Carothers, Christopher D.  Director, Computational Center for Nanotechnology Innovations (CCNI); Professor of Computer Science; Member, Faculty of Information Technology and Web Science; Ph.D. (Georgia Institute of Technology).

Cassimatis, Nicholas  Associate Professor of Cognitive Science; Ph.D. (Massachusetts Institute of Technology).

Century, Michael L.  Professor of Music; Ph.D. (University of Sussex, U.K).

Chakrapani, Vidhya  Assistant Professor of Chemical and Biological Engineering; Ph.D. (Case Western Reserve).

Chan, Wai Kin (Victor)  Associate Professor of Industrial and Systems Engineering; Ph.D. (University of California, Berkeley).

Chang, Benjamin  Associate Professor, Arts Department; M.F.A. (School of the Art Institute of Chicago).

Chari, Murali  Associate Professor of Cognitive Science; Ph.D. (Massachusetts Institute of Technology).

Chen, Ying  Assistant Professor of Materials Science and Engineering; Ph.D. (Massachusetts Institute of Technology).

Cherniak, Daniele J.  Research Professor of Earth and Environmental Sciences; Ph.D. (University at Albany, SUNY).

Chow, Joe H.  Director, CURENT Engineering Research Center; Professor of Electrical, Computer, and Systems Engineering; P.E., Ph.D. (University of Illinois).

Chow, T. Paul  Director, Center for Power Electronic Systems (CPES); Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Chung, Aram  Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Cornell University).

Collins, Cynthia  Assistant Professor of Chemical and Biological Engineering; Ph.D. (California Institute of Technology).

†† Colón, Wilfredo  Professor of Chemistry and Chemical Biology; Ph.D. (Texas A&M University).

Combs, Lonn  Assistant Professor of Architecture; M.S. AAD (Columbia University).

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