Notice Regarding Changes  All information in this catalog pertains to the 2005–2006 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.ope.ed.gov/security/search.asp](http://www.ope.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](http://criminaljustice.state.ny.us/nsor/index.htm).
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Fall Term 2005
August 12
Fall tuition and fees due.

August 22
Residence halls and apartments open for upperclass and new graduate students.

August 26
Dining halls open with breakfast.

August 28
Class of 2009 Convocation.

August 29
Classes begin.

September 5
Labor Day. No classes. Staff Holiday.

September 12
Last day for graduate and undergraduate students to add courses or change sections without appeal or to put courses on audit. Last day for completion of "NE" grade requirements for spring 2005 courses.

September 23
Last day to file degree applications with Registrar’s Office for December 31, 2005 graduation.

October 7
Midterm break begins after last class.

October 10
No classes.

October 11
Classes resume. Follow Monday class schedule.

October 14
Honors Convocation.

October 14–16
Family Weekend.

October 15
Rensselaer Legacy Reception.

October 21
Last day for undergraduate and graduate students to drop a course without appeal.

October 24–28
Consultation Week. Advisement for spring registration. Students should consult their faculty advisers.

October 31–November 14
Registration for all currently enrolled students for the spring semester.

November 22
Last day for undergraduates to add or remove Pass/No Credit designation.

Thanksgiving recess begins after last class.

Dining halls close after dinner.

November 23
Master’s theses and engineering projects due to advisers. Doctoral theses due to thesis professors.

November 23–25
No classes.

November 24–25
Staff Holidays.

November 27
Dining halls open with dinner.

November 28
Classes resume.

December 9
Master’s theses and engineering project records of completion due in the Office of Graduate Education.

Last day for final examinations for doctoral theses. Classes end after last evening class.

December 12
Add/Drop reopens for spring 2006.

December 12–13
No classes. Study-Review Days.

December 14–16 and 19–20
Final examinations.

December 16
Doctoral dissertations due in the Office of Graduate Education.

December 20
Dining halls close after dinner.

December 21
Winter recess begins. All students, whether or not returning for spring term must vacate residence halls by noon.

December 25–26
Staff Holiday.

December 30
Official date of December graduation; diplomas mailed to students after final clearance is completed in January. Degree recipients may take part in the May 2006 Commencement ceremony.

January 2
Staff Holiday.

January 6
Spring tuition and fees due.

Spring Term 2006
January 11
Residence halls and apartments open for spring term at noon.

January 15
Dining halls open with dinner.

January 16
Martin Luther King Jr. Day. No classes. Staff Holiday.

January 17
Classes begin.

January 27
Last day to file degree applications with Registrar’s Office for May 2006 graduation. Last day for graduate and undergraduate students to add courses or change sections without appeal or to put courses on Audit.

February 20
No classes. Staff Holiday.

February 21
Classes resume. Follow Monday class schedule.

March 10
Last day for undergraduates to drop a course. Last day for graduate students to drop courses without appeal. Spring recess begins after last class. Contract dining halls close after dinner.
March 13–17
Spring Break.

March 19
Contract dining halls open with dinner.

March 20
Classes resume.

March 20–24
Consultation Week. Advisement for summer and fall registration. Students should consult their faculty advisers.

March 27–April 10
Registration for all currently enrolled students for summer and fall semesters.

April 5
No Classes.

April 21
Last day for Undergraduates to add or remove Pass/No Credit designation.

Master’s theses and engineering projects due to advisers.

Doctoral theses due to thesis professors.

April 28
Master’s theses and engineering projects records of completion due in Office of Graduate Education.

May 3
Classes end after last evening class.

May 4
Graduation status check and post-graduation career plans.

May 4–5
No classes. Study-Review Days.

May 5
Doctoral Dissertations due in Office of Graduate Education.

May 8
Add/Drop reopens for fall 2006.

May 8–12
Final examinations.

May 12
All contract dining halls close after dinner. Deadline for completion of “NE” grade requirements for fall 2005.

May 13
Residence halls and apartments close for all students not participating in Commencement at noon.

May 19
ROTC Commissioning Ceremony.

May 20
Commencement.

May 21
All residence halls close by 11 am.

Summer Session 2006
March 27–April 10
Currently enrolled Rensselaer students register for summer session.

May 21
Residence halls and apartments open for summer.

May 22
Final registration for summer term.

Classes begin. Courses will be scheduled for varying lengths of time during the summer session. See the class hour schedule for specific information.

May 29
No classes. Staff Holiday.

June 8–11
Reunion 2006.

June 9
Last day to file degree application with Registrar’s Office for August 31, 2006 graduation.

July 4
Staff Holiday. No classes.

July 14
Master’s theses and engineering projects due to advisers.

July 21
Doctoral theses due to thesis professors.

July 28
Master's theses and engineering project records of completion due in Office of Graduate Education.

Last day for final examinations for doctoral theses.

August 4
Doctoral dissertations due in Office of Graduate Education.

August 11
Final exams must be complete.

August 12
Residence halls and apartments close for summer.

August 31
Official date of August graduation; diplomas mailed to students after final clearance is completed in early September.

Fall Term 2006
August 11
Fall tuition and fees due.
## Information Directory

<table>
<thead>
<tr>
<th>Service</th>
<th>Contact Information</th>
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<tbody>
<tr>
<td><strong>Admissions</strong></td>
<td>Rensselaer Admissions</td>
</tr>
<tr>
<td>(Undergraduate/Graduate)</td>
<td>(518) 276-6216</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:admissions@rpi.edu">admissions@rpi.edu</a></td>
</tr>
<tr>
<td><strong>Alumni Relations</strong></td>
<td>Office of Alumni Relations</td>
</tr>
<tr>
<td></td>
<td>(518) 276-6205</td>
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<tr>
<td></td>
<td><a href="mailto:alumni@rpi.edu">alumni@rpi.edu</a></td>
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<tr>
<td><strong>Dining</strong></td>
<td>Rensselaer Dining Services</td>
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<tr>
<td></td>
<td>(518) 276-6277</td>
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<td></td>
<td><a href="mailto:fuscoj2@rpi.edu">fuscoj2@rpi.edu</a></td>
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<tr>
<td><strong>Disabled/Learning Disabled Information</strong></td>
<td>Disabled Student Services</td>
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<tr>
<td></td>
<td>(518) 276-2746</td>
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<td></td>
<td><a href="mailto:dss@rpi.edu">dss@rpi.edu</a></td>
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<tr>
<td><strong>Education for Working Professionals</strong></td>
<td>Hartford Campus and Groton Site Programs</td>
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<td>(860) 548-2400</td>
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<td>(800) 433-4723</td>
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<td><a href="mailto:info@rh.edu">info@rh.edu</a></td>
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<tr>
<td><strong>Troy Programs</strong></td>
<td>(518) 276-4795</td>
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<tr>
<td></td>
<td><a href="mailto:rsvp@rpi.edu">rsvp@rpi.edu</a></td>
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<tr>
<td><strong>General Student Advising</strong></td>
<td>Dean of Students Office</td>
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<tr>
<td></td>
<td>(518) 276-6266</td>
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<td></td>
<td><a href="mailto:vienj@rpi.edu">vienj@rpi.edu</a></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><a href="mailto:gradschool@rpi.edu">gradschool@rpi.edu</a></td>
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<tr>
<td><strong>Housing</strong></td>
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<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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<td>International Services for Students and Scholars</td>
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<td>(518) 276-6561</td>
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<td><a href="mailto:hospis@rpi.edu">hospis@rpi.edu</a></td>
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<tr>
<td><strong>Minority Student Information</strong></td>
<td>Office of Minority Student Affairs</td>
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<td>(518) 276-6272</td>
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<td><a href="mailto:smithm@rpi.edu">smithm@rpi.edu</a></td>
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<td><strong>Placement</strong></td>
<td>Career Development Center</td>
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<td>(518) 276-6234</td>
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<td><a href="mailto:tarant@rpi.edu">tarant@rpi.edu</a></td>
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<tr>
<td><strong>Rensselaer Union</strong></td>
<td>(518) 276-6505</td>
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<td><strong>Transcripts</strong></td>
<td>Office of Student Records and Financial Services</td>
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<td></td>
<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>(518) 276-6610</td>
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<td><a href="mailto:bursar@rpi.edu">bursar@rpi.edu</a></td>
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<td><strong>Undergraduate Academic Advising</strong></td>
<td>Advising and Learning Assistance Center</td>
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<td><a href="mailto:steig2@rpi.edu">steig2@rpi.edu</a></td>
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<td><strong>Undergraduate Financial Aid and Graduate Loans</strong></td>
<td>Student Records and Financial Services</td>
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<td>(518) 276-6913</td>
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<td><strong>Undergraduate Transfer, Part-Time, and Non-Matriculated Admissions</strong></td>
<td>Transfer Admissions/Special Programs</td>
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<td>(518) 276-6216</td>
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<td><a href="mailto:admissions@rpi.edu">admissions@rpi.edu</a></td>
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<td>Troy, NY 12180-3590</td>
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<td>275 Windsor Street</td>
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Rensselaer in Brief

Overview

Rensselaer Polytechnic Institute is the nation’s oldest technological research university. A nonsectarian, coeducational institution, the university offers degrees from five schools: Engineering, Science, Architecture, Humanities and Social Sciences, and the Lally School of Management and Technology, as well as an interdisciplinary degree in Information Technology. The Institute’s long-standing reputation for research and educational distinction draws students from every state and 72 foreign countries.

More than 140 degree programs in nearly 60 fields lead to bachelor’s, master’s, and doctoral degrees. Students are encouraged to work in inter- and cross-disciplinary programs that allow them to combine scholarly work from several departments or schools. The university provides rigorous, engaging, interactive learning environments and campuswide opportunities for leadership, communication, and creativity.

For almost two centuries, Rensselaer has maintained its reputation for providing an undergraduate education of undisputed intellectual rigor based on exceptional pedagogical innovation in the laboratory and classroom.

As a research university, Rensselaer has built an outstanding faculty whose research programs include such areas as biotechnology, nanotechnology, advanced materials, microelectronics, information technology, computational modeling and simulation, the social and political dimensions of technology, and electronic arts.

The Institute is especially well-known for its success 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.

Students

For the 2004–2005 academic year, Rensselaer enrolled 4,876 full-time undergraduates and 1,156 full-time graduate students in residence on the Troy, N.Y., campus, as well as approximately 1,300 in Hartford, Conn., and in distance learning opportunities around the world.

Self-identified underrepresented minorities account for 10 percent of the undergraduate student body. Twenty-five percent are women. It is an exceptionally bright and ambitious group: 63 percent of the members of the class of 2008 were in the top 10 percent of their high school classes.

Students operate the Rensselaer Union and control its $8.5 million annual budget. They belong to 23 NCAA intercollegiate teams, scores of intramural teams, and 160 clubs. About 30 percent of men are members of fraternities and 20 percent of women belong to sororities. Students publish a weekly newspaper and operate a 10,000-watt radio station.

Approximately 27 percent of Rensselaer graduates go on to graduate school. The average starting salary for Rensselaer bachelor’s recipients in 2004 was $48,577 and $62,172 for master’s degree recipients, higher than the national averages.

Rensselaer ranks annually among the top 50 national universities in U.S. News & World Report, and its graduate engineering program ranks among the top schools in the United States.
Faculty and Educational Innovations
Rensselaer’s more than 530 faculty members from both the Troy and Hartford campuses, include a Nobel laureate, 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. In coordination with the Anderson Center for Innovation in Undergraduate Education, Rensselaer’s faculty devotes much thought and time to designing more dynamic teaching methods, redesigning curricula, and transforming classrooms into interactive learning environments where students learn by doing.

Rensselaer is the recipient of the “triple crown” of higher education awards—the Hesburgh, Boeing, and Pew Charitable Trust awards for innovations in undergraduate education. Rensselaer is the only technological university to win all of these prestigious honors.

The Carnegie Foundation for the Advancement of Teaching report, Reinventing Undergraduate Education, has cited Rensselaer’s studio classes in “Ten Ways to Change Undergraduate Education.”

Research
One of the hallmarks of a Rensselaer education is the opportunity for intellectual partnerships between students and faculty. Particularly unique are the opportunities open to undergraduate students. During the 2004–2005 school year, nearly 300 students participated in the Undergraduate Research Program in which students in all four class years took part in formal research.

Graduate students are involved in myriad projects from the development of “smart” materials and manufacturing processes to exploring the social and humanistic effects of technology.

Rensselaer’s research ties are national and international with experiments conducted at the Saclay Laboratory in France, the Bates Accelerator, the National Radio Astronomical Observatories, Sandia, the U.S. Geological Survey, and the National Laboratories in Brookhaven, Los Alamos, and Oak Ridge. Rensselaer research awards total $72 million.

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

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 873,500) are home to many well-known colleges such as Albany Medical College, Russell Sage, Siena, Skidmore, Union, University at Albany (SUNY), and the nearby Williams College.

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 new downtown arts center. Nearby Saratoga Springs is the summer home to the New York City Ballet and the Philadelphia Orchestra. Albany’s Pepsi Arena hosts a wide array of top-name musical groups, sporting events, and other entertainment options.

Rensselaer at Hartford is housed in its own eight-story building on 15 landscaped acres in downtown
Hartford, Conn., readily accessible from both Interstates 84 and 91. Regional sites are in southeastern Connecticut and Malta, New York.

**Facilities**

Rensselaer’s 260-acre Troy campus and its several off-site facilities provide diverse environments for learning and living. From the George M. Low Center for Industrial Innovation, with its manufacturing high bay laboratories and meeting rooms, to the Adirondack site of the Darrin Fresh Water Institute, Rensselaer’s facilities support the needs of researchers and students.

The 15 major interdisciplinary research centers and several smaller ones, the Incubator Center for start-up high-tech companies, and the nationally known Rensselaer Technology Park offer undergraduate and graduate students a wide range of opportunities for research and learning through interaction with business, government, and industry.

Rensselaer’s nearby Technology Park houses more than 50 companies and 2,200 employees. The Incubator Center, recently named Business Incubator of the Year, nurtures some 43 startup companies. Approximately two-thirds of participating companies have evolved from research at Rensselaer or have been started by Rensselaer alumni.

The Division of the Chief Information Officer provides information technology to support the academic, research, and administrative activities of Rensselaer. A Help Desk in the Voorhees Computing Center is open days and evenings (except Saturday). Supported teaching facilities include laptop classrooms which have a power and Internet connection for each student and classrooms where instructors can present multi-media materials.

Rensselaer’s Mobile Computing Program, requiring all undergraduate students to own laptop computers, has received resounding praise. This program ensures that all students have universal access to high-level tools to prepare them for real-world industry applications.

Students have anytime/anywhere mobile access across the campus via more than 8,000 data ports and wireless connections. Rensselaer Polytechnic Institute ranked first in a 2004 list of the “most connected campuses” in the country in a *Princeton Review* survey. The Institute takes an integrated approach to computing — across applications, systems, and networks—providing a seamless environment for students, staff, faculty and administrative users.

The Institute’s robust computing infrastructure supports new applications in diverse areas of research such as bioinformatics, multi-media, modeling, and simulation.

The Rensselaer Research Libraries digital library strategy is apparent in their electronic resource holdings of hundreds of digital databases including over 31,500 electronic and print journal titles, 24,000 electronic books, and 40 image databases. Rensselaer’s participation in the Connect NY consortium results in rapid availability of over 3,500,000 books and heightened focus on audio-visual media has increased those holdings to over 7,500.

Institute residence facilities house up to 2,900 single students and 93 student families in a variety of living environments. Indoor and outdoor athletic facilities include the Houston Field House, which is the home of the NCAA Division I Engineers ice hockey team. The Mueller Center, a $6 million, 32,000-square-foot fitness center, houses more than 40 pieces of aerobic exercise equipment.

The mission of Rensselaer at Hartford 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, Rensselaer at Hartford offers conference, training, and event facilities accommodating up to 100 guests. Our facilities are ideal for meetings, seminars, corporate
trainings, nonprofit, government organizations, and professional associations. We offer a trained and experienced staff, state-of-the-art technology, free parking, and a hospitality service.

Alumni
Rensselaer’s more than 85,000, including Hartford, living alumni 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, and the Institute. A full range of services are offered, including career assistance, regional and campus events, affiliate group programs, print and Internet communications, sports programs, and more. Student programs include the Red and White service organization, regional “fairs,” alumni speakers, and mentoring programs.

Accreditation
Rensselaer is accredited by the Middle States Association of Colleges and Schools 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 Association of Colleges and Schools, 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.

Why Not Change the World? The Rensselaer Plan
The Rensselaer Plan—the Institute’s new strategic plan—serves as the driving force to achieve new prominence for the Institute in the 21st century. This comprehensive plan defines Rensselaer’s core enterprises and sets forth the Institute’s goal to double its doctoral program and virtually triple its research initiative with special focus on biotechnology and information technology.

To fulfill The Rensselaer Plan, President Shirley Ann Jackson identified certain areas as the highest priorities of the Institute. The initiatives under way include the recruitment and hiring of faculty constellations in biotechnology and information technology; a first-year experience initiative to support the drive to attract and retain the very best students, faculty, and staff; construction of a 218,000-square-foot Center for Biotechnology and Interdisciplinary Studies, expected to house approximately 400 faculty members, staff, and graduate students; and a world-class Experimental Media and Performing Arts Center.
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 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. Rensselaer’s portfolio in Education for Working Professionals also offers a highly successful distributed delivery program that extends graduate courses, certificates, and degree programs to students at many leading global corporations. 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

Dean: Prabhat Hajela

Undergraduate programs leading to the Bachelor of Science degree are available in more than 30 fields listed on the inside of the front cover 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 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 on the next page.
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. This program offers students real-world, hands-on research experience. Students 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. Details on the program and titles of past projects are available at http://www.rpi.edu/dept/urp/ or in the Office of Undergraduate Education, Walker Lab, Room 4010.

Exchange and Study-Abroad Programs
Studying abroad can broaden students’ cultural horizons and offer a new and extended perspective on a technological education. Rensselaer, therefore, offers a wide variety of exchange and/or study-abroad programs to undergraduate students.

Most exchange programs are intended for students in their junior year. Students apply to participate in these programs during the second semester of their sophomore year. Serious consideration for these programs generally requires that students achieve and maintain a GPA of 3.0 or better.

Study-abroad programs with a number of established colleges and universities throughout Europe, as well as with a limited number of Asian and Australian institutions, are available. Participation in these programs is usually for one year. However, some one-semester arrangements are possible. Some programs give priority to specific majors, and some institutions require foreign language proficiency. Detailed information on study-abroad or exchange programs that individual Rensselaer schools administer can be found within the catalog section devoted to the associated school.

A comprehensive list of Rensselaer study-abroad and exchange programs and the associated contact person is provided below. Regardless of which Rensselaer Program is being considered or if studying abroad is being considered through another university, the student should first contact Bob Conway in the Office of Undergraduate Education.

- Undergraduate International Exchange Program
  Robert Conway, (518) 276-6822, conwar@rpi.edu

- International Management Exchange Program
  Beth Macey, (518) 276-2388, maceyb2@rpi.edu

- Architecture Exchange Program
  Lecia O'Dell, (518) 276-8478, odelll@rpi.edu

- Global Engineering Education Exchange (Global E3) Program
  Lester Gerhardt, (518) 276-6203, gerhal@rpi.edu

- Swiss Exchange Program
  William A. Wallace, (518) 276-6854, wallaw@rpi.edu

- French Exchange Program
  Lucien Gerber, (518) 276-8125, gerbel@rpi.edu

Preprofessional Programs
The baccalaureate program in a number of fields in the Schools of Science and Engineering will prepare Rensselaer students to receive secondary school (grades 7-12) teacher certification from New York State. These courses of study must be done in partnership with several local colleges which have New York State registered teacher education programs. If a decision is made early enough in a Rensselaer student’s
undergraduate career, then courses can be taken at several local universities leading, upon graduation, to a Rensselaer degree in the student’s chosen major, together with preliminary teacher certification. Students who are too far along in their Rensselaer education may obtain certification through a fifth year at other institutions. For further information, students should contact Lester Rubenfeld, the director of the Center for Initiatives in Pre-College Education, at rubenl@rpi.edu.

**Prehealth Programs** Rensselaer successfully prepares students to enter medical and other health professional schools. These students major in such fields as biology, chemistry, biomedical engineering and other engineering programs, mathematics, physics, or psychology. 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 refer to the Prehealth Web site: http://bio.bio.rpi.edu/MED/ or contact members of the Prehealth Professions Committee located in 1W14 Science Center, (518) 276-8427.

Accelerated programs that permit students to complete undergraduate and professional studies within an abbreviated period of time are also available. For detailed information, see the School of Science section of this catalog.

**Prelaw 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 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 student’s 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.rpi.edu/%7Einterns/ or contact Sharra Vostral, Department of Science and Technology Studies at (518) 276 6381.

**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: vacant

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 the Office of Graduate Education homepage at http://www.rpi.edu/dept/grad/gradschool.html

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 Scientific Computation Research Center (SCOREC), the Center for Integrated Electronics (CIE), the New York State Center for Polymer Synthesis, the New York State Center for Automation Technologies, the Rensselaer Nanotechnology Center, and the Severino Center for Technological Entrepreneurship. 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, more than 2,000 working professionals seek degrees on a part-time basis through Rensselaer at Hartford and distributed sites.

Education for Working Professionals

Vice President and Dean, Rensselaer at Hartford: John A. Minasian

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. The EWP organization supports the Rensselaer vision by forging strategic partnerships with businesses, governments, universities, and innovative professionals who impact society and technology around the nation and the world.

Rensselaer’s educational enterprise for working professionals is dedicated to providing an interactive learning environment for students who are seeking high-level knowledge while they hone their analytical capabilities and leadership skills and enhance their innovative thinking. The intent is to have Rensselaer graduates—executives, senior professionals, managers, and individuals with high potential—become architects of their futures. 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.

Rensselaer at Hartford

Rensselaer at Hartford, a branch campus of Rensselaer Polytechnic Institute, provides a challenging educational environment and a dynamic learning experience for students who need to balance their professional, academic, and personal lives. More than 800 students attend classes at Rensselaer’s Hartford campus and southeastern Connecticut regional site.

Rensselaer at Hartford offers graduate programs in Business Administration, Management, Computer
Science, Computer and Systems Engineering, Electrical Engineering, Engineering Science, Mechanical Engineering, and Information Technology. Specialized programs include Dual Master’s Degrees, the Weekend MBA, the Executive Master’s Program, and the one-year professional M.S. in Computer Science, 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 on a global basis. 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?”

Distance Delivery
For the past 18 years Rensselaer has pioneered the application of state-of-the-art technologies to deliver high-quality, interactive learning experiences in distributed environments. Rensselaer is a leading provider of graduate-level, distributed education programs for working professionals at leading corporations and government agencies all over the world. Students participate in Rensselaer courses, certificates, and degree programs from their workplace, at home, or on the road using a range of distributed delivery technologies, including videoconferencing, videostreaming, CD-ROM, and online conferencing tools, together with face-to-face interaction during faculty visits. Distance courses originate from Rensselaer’s Troy, Hartford, and Groton site campuses and are supported by course Web sites and other means that provide communication and collaboration tools to facilitate interaction between students and faculty and among students. Rensselaer is known for excellence in content, delivery, and services, and has received considerable national recognition and numerous awards. Degree and Certificate programs in Engineering, Science, Information Technology, Management, and Technical Communication are available via distance.

Regional Site in Southeastern Connecticut
Rensselaer operates a regional site in southeastern Connecticut. Many faculty from Rensselaer’s Hartford campus travel to the southeastern Connecticut site to teach courses. On-site courses are supplemented with distributed delivery of courses from Rensselaer’s Troy and Hartford campuses via videoconference delivery. Online courses are also available to students. Many of the degree and certificate programs available on the Hartford campus are also available at the southeastern Connecticut site.

Navy Nuclear Program
Rensselaer operates a regional site in Malta, N.Y. for graduates of the Navy Nuclear Power Training School who are stationed at the Kesselring site in West Milton, N.Y. Navy personnel enter the program with one year’s worth of undergraduate coursework and Rensselaer provides the remaining course work for students to complete a B.S. in Nuclear Engineering or Engineering Physics within two to three years. Rensselaer courses are primarily taught onsite in Malta by faculty from the Troy campus. Onsite courses are supplemented by one or two online courses each semester.

Professional Development Programs
Lifelong learning is essential to continued professional growth. The Centers for Professional Development support this pursuit by providing a series of training programs, ranging from one to five days in length, that take advantage of the research and teaching strengths of the institution. Content includes Information Technology, Technical and Professional Development, and Management and Technology. Rensselaer at Hartford is also part of an internationally acclaimed network of the Center for Creative Leadership offering the finest, most effective leadership and executive development courses available. In addition to programs offered for open enrollment, the Center also offers services to companies and organizations for dedicated training and development. This includes organization needs assessment, development of custom
content to meet those needs, and consistent delivery of this content across multiple locations and times. Quality/Continuous Improvement programs and events are offered through a unique arrangement with the Connecticut Quality Council (CQC), a non-profit, member-driven organization founded in 1990 and operating as a non-degree entity of Rensselaer at Hartford.

**Professional Engineering**

Professional Engineering seminar topics and preparatory programs for the Professional Engineering Exams are provided in our Engineering course schedules and Web site. The exam review courses for Part I (EIT) and II (PE) and Land Surveyor are held evenings for 10 to 12 weeks prior to the April and October state exams. Rensselaer at Hartford works closely with the State of Connecticut to provide testing schedule information as well as application requirements.

- Fundamentals of Engineering (EIT) Review Course
- Professional Engineering Review Courses (Mechanical, Electrical, and Civil)
- Land Surveyor Review Course

**Division of the Chief Information Officer**

**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 Research Libraries. Therefore, these two departments are described below.

**Academic and Research Computing**

**Director:** Sharon Roy

**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 5 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 short courses. At the Help Desk in the Voorhees Computing Center (VCC), services can be requested from any Division of the Chief Information Officer department, and consulting help is available from the ARC staff.
As part of the Mobile Computing Program (http://www.rpi.edu/laptops), all undergraduates are required to have a laptop computer. There are network ports in public buildings across campus and in every residence hall room. The wireless network is expanding and includes large portions of core campus buildings.

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, and library services.

Campus computing facilities offer students several platforms including PCs running Windows and UNIX. Several hundred public PCs in classrooms and labs are connected to the network. From a single workstation, personal computer, or laptop, a student can connect to several different 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 (SolidWorks), graphics packages, and electronic mail programs. Specialized software for course work is also installed in some locations.

Some of the larger public workstation areas are located in the Voorhees Computing Center (VCC), Troy Building, Folsom Library, and Russell Sage Laboratory. The VCC is open 24 hours a day.

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.

**The Rensselaer Research Libraries**

**Director:** Loretta Ebert

The Rensselaer Research 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 both teaching and research missions. Researchers can access over 290,000 print book titles, 31,500 electronic and print journals, 23,000 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 one of the Research 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 3,500,000 titles. They may borrow books in person from more than 50 regional libraries. The Libraries also offer Rensselaer faculty, research staff, and graduate students fully subsidized access to Ingenta, a document delivery vendor for more than 20,000 journals.

Reference & Instructional Services’ librarians with subject expertise 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.” A “Virtual Reference” service places patrons, wherever they are, just a mouse click away from consulting a reference librarian.

RensSearch, the Rensselaer Research 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 Research Libraries continue to be an important “place” on campus for intellectual and social nourishment. Transponders have recently been installed throughout Folsom Library to provide wireless network access.

Patrons may socialize and have lunch in Folsom’s Library Café, peruse the latest best-selling fiction and non-fiction books in Folsom’s Class of ’96 Reading Room, browse music CDs or film DVDs, 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:** Jeannie Steigler (Interim)

The mission of the Advising and Learning Assistant Center is to provide a unified approach to supporting students and faculty in the learning and advising processes. The Center provides academic support in the form of services and programs designed for students to become more effective and efficient learners.

The center coordinates academic advising events, counsels individual students, offers workshops, advises undecided students, trains learning assistants (la), and teaching and learning assistants (tla) who work with students in the residence halls, and provides help to students for whom English is their second language. The center strives to improve the quality of faculty, staff, and student interaction. In addition to fostering a strong mentoring atmosphere, the center carries out functions to enhance the basic principles of performance by minimizing exam anxiety and improving time management, note-taking, textbook reading, and general learning skills.

The center also provides information and makes referrals, interprets, administers and makes exceptions to Institute policies and procedures; serves as a support service for students experiencing academic difficulty; and processes all academic standing issues regarding academic awards, dismissals, suspensions, and probation.

Additionally, the center’s staff serves on a number of campus committees that are involved in program adjustments, curriculum changes, and general advising issues. The center is a resource for departments to help train faculty and professional staff in academic advising.

The center also takes part in a strong collaboration effort with other support services on campus (Office of the First-Year Experience, The Dean of Students Office, Counseling Center, Career Development Center, 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.

**The Anderson Center for Innovation in Undergraduate Education**

**Director:** Bradford C. Lister

Since its inception in 1990, the Anderson Center has served as an incubator for curriculum reform and a driving force for change and innovation in higher education. In brief, the Center’s mission has been to develop, research, and support new teaching methods and technologies with the aim of improving education, both on and off campus. The Center is dedicated to extending Rensselaer’s leadership position as one of the premiere learning environments in higher education. It supports faculty involvement in educational computing, develops new techniques and facilities for interactive learning, and conducts research on cognition, learning, and the assessment of learning outcomes. Current projects encompass research on student learning styles, interaction and peer-based learning in student teams,
constructivist approaches to teaching complex systems, and the use of asynchronous learning networks for on-campus instruction.

The Anderson Center facilitates faculty involvement in the renewal of undergraduate education through a series of hands-on workshops on interactive learning and an annual Colloquium on Teaching and Learning. Center staff are available for consulting on all aspects of studio teaching and educational technology. Externally, the Center hosts hundreds of visitors each year from all over the world who come to Rensselaer to learn about our teaching practices. In addition to the director, associate director, and administrative assistant, the Anderson Center employs Web developers, assessment specialists, video production personnel, and a cadre of undergraduate and graduate research assistants. Center staff have expertise in experimental design, statistical analysis, course redesign, protocol analysis, assessment of learning styles, instructional design, and Web-based multimedia development.

Institute Diversity

Vice-Provost for Institute Diversity: Kenneth Durgans

The Office of Institute Diversity serves as a campuswide 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 on the fourth floor of the Walker Laboratory.

Center for Initiatives in Pre-College Education

Director: Lester A. Rubenfeld, Professor of Mathematical Sciences

Program Home Page: http://cipce.rpi.edu

Realizing that for too long now the nation’s best research universities have often sat idle while our system of public school education has not met expectations, Rensselaer is taking the lead in forging new relationships which will become models for others to follow. Educators at all levels and leaders in government, business, and the philanthropic community, are unanimous in their deep concern that students in kindergarten through twelfth grades are not being properly educated and are not ready to enter the technological workplace that awaits them. Therefore Rensselaer believes that it shares with the nation’s schools an obligation to develop and deliver a first-class education to students at all levels. It also believes that the work of this Center in pursuit of that goal can enrich its own intellectual environment, tap new sources of funding for these outreach efforts, deliver substantial long-term benefits to its admission efforts, and improve its public and community relations. To achieve its vision, CIPCE seeks to foster innovations in pre-college education that build upon Rensselaer’s strengths and traditions in pedagogy, interactive learning, educational technologies and teacher education. Its activities include:

- A graduate M.S. in Natural Sciences program over three consecutive summers for secondary school mathematics and science teachers.
- Professional development projects for teachers including on-site classroom support; after school workshops; and summer institutes.
- The development of interactive multimedia instructional materials.
The development and integration of robotics activities into classroom curriculum, including distance experimentation.

The use of online and other distance learning technologies to facilitate its professional development activities.

Cognitive research focused on how technology affects student learning.

**M.S. in Natural Science**

The challenges presenting themselves today in the realm of mathematics and science education are vast and complex. Never in our time has education in these areas been more vital and important. Never has it been more difficult to teach. Students in these times present much greater demands, and also potential, than their predecessors.

Getting young people excited about mathematics and science is a task that has added to the challenge of teachers. And yet, if a teacher can learn to inspire observant inquiry by infusing the curriculum with the kind of immediacy and relevance that makes it compelling to students, the job itself will be much more fulfilling for the educator as well.

Excellent teaching of mathematics and science occurs when the teacher has a broad-based, in-depth view of content, knowledge of how to integrate it with other disciplines, and the ability to use modern instructional technologies to vitalize classroom activities.

Rensselaer's program provides teachers with an opportunity to upgrade their qualifications and examine how their curricula can make the best use of advancing technologies. Our goal is to help secondary school science and mathematics teachers enhance their skills with new techniques, tools, and a rich body of scientific and mathematics content.
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. Our research programs reach across the campus, linking together departments, schools, and interdisciplinary centers, and creating opportunities for integration of research and education. Undergraduates work one-on-one with faculty members in real-world, hands-on research as part of Rensselaer’s Undergraduate Research Program (URP). In addition, research drives technological entrepreneurship and commercialization, interfacing closely with the Rensselaer Technology Park and Incubator Center.

The Office of the Vice President for Research provides infrastructure and resource support for the development of research programs and projects. Support services are offered for faculty seeking research opportunities, research proposal and budget preparation, and guidance on research management and intellectual property policies. The Office coordinates major research themes and programs through interdisciplinary research centers. Links from this Web site offer overviews of these centers, reviews of major research projects and recent accomplishments, as well as information on research policies, guidelines, and infrastructure.

**NY State Center for Advanced Technologies on Future Energy Systems (Energy CAT)**

**Director:** Omkaram (Om) Nalamasu

Future Energy Systems is a newly designated Center for Advanced Technologies by NYSTAR (New York State Office of Science, Technology and Academic Research) with Rensselaer as the lead university, Cornell and Brookhaven National Laboratories as partnering institutions. Future Energy Systems CAT brings together Rensselaer and Cornell’s world-class scientists, programs, infrastructure, and Energy research under a CAT umbrella to focus on energy conservation and renewable energy systems through the design, development, and implementation of advanced materials, devices and systems, and the transfer of the associated technologies to New York (NY) state-based industries. The vision of “Future Energy Systems” is to make New York state a world leader in energy research, and an industrial power house in the energy business, by focusing on the core research strengths of Rensselaer and Cornell in materials, devices, systems, nanotechnology, light emitting diodes (LEDs), organic light emitting diodes (OLEDs), fuel cells and photovoltaics, and by further nurturing a tradition of industrial collaboration and technology transfer. The Center’s key initial thrust areas are: Smart Lighting, Fuel Cells, and Renewable Energy Sources.

**Center for Automation Technologies**

**Acting Director:** Raymond H. Puffer, Jr.

**CAT Home Page:** [http://www.cat.rpi.edu/](http://www.cat.rpi.edu/)

The CAT has been designated since 1988 as a Center for Advanced Technology by the New York State Office for Science, Technology and Academic Research (NYSTAR).

Interdisciplinary teams of faculty, staff, and students work closely with the Center’s industrial partners to
conduct basic and applied research aimed at radical industrial innovations.

Research programs in the CAT are focused on automation and systems technology and include topics such as precision motion control, distributed microrobotic systems, and their applications to microphotonic and microfluidic systems. The CAT also specializes in outreach and applied research in technologies associated with industrial automation, focused on enhancing the competitiveness of industrial partners. Areas of expertise include: manufacturing process development; automaton systems design and development; precision mechanical assembly; and material handling.

**Faculty and Staff**  S. Akella, K. Anderson, T. Borca-Tasciuc, Partha Dattu, W. Huang, J. Lu, H. Merrill, G. Nagy, Y. Peles, R. Puffer, A. Sanderson, G. Saunders, D. Walczyk, J. Wen, M. Wozny

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**Center for Integrated Electronics**

**Director:** Omkaram (Om) Nalamasu

**Associate Director:** Toh-Ming Lu

**Associate Director:** Morris Washington

**CIE Home Page:** [http://www.rpi.edu/dept/cie/](http://www.rpi.edu/dept/cie/)

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. A complement of about 50 faculty, 100 students, and 15 full-time research post doctoral fellows, staff, and 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 microelectromechanical systems (MEM).

State-of-the-art facilities enhance research opportunities and include a Class 100 nanofabrication clean room with processing capabilities both for Si and III-V 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 nationally recognized faculty from Rensselaer’s Schools of Engineering, Management, Science, and Humanities and Social Sciences. In addition, over 100 undergraduate and graduate students, post doctoral fellows, and visiting scholars are supported annually through the CIE’s programs.

**Major Programs**

**Center for Advanced Interconnect Systems Technologies** The research plan in CIE’s Center for Advanced Interconnect Systems Technologies (CAIST) focuses on finding innovative, creative, and competitive ways to maximize interconnection performance. The research involves the development of new materials, processes, simulation, modeling, and fabrication techniques for high-performance and reliable interconnections. The goal of CAIST is to investigate, test, and prototype new concepts, from the
device-to-system approach, that provide attractive options for significantly upgrading the performance of interconnections into the 21st century.

**Center for Microcontamination Control** The Center for Microcontamination Control is an NSF Industry/University Cooperative Research Center with Research sites at the Northeastern University, the University of Arizona, and Rensselaer. The UA site was established in 1989 and has research in high-K dielectric contamination, bacterial contamination, and ultrapure water (UPW) research. The RPI site was established in 1998 and has research in CMP and electrochemical planarization. Northeastern University established a site in 2002 with research in nano and microscale particle removal.

**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 members are Rensselaer, SUNY-Albany, Georgia Tech, MIT, and Stanford. Rensselaer’s efforts focus on 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://nina.esce.rpi.edu/shur/broadband](http://nina.esce.rpi.edu/shur/broadband)).


**Technical Staff and Support** J. Barthel, D. Chichester, L. Couvillon, D. King, R. Kraft, J. McMahon, K. Orava, J. Tedesco, A. Tyson


**Visiting Scholar** Y. S. Kim
Rensselaer Nanotechnology Center

**Director:** Richard W. Siegel

**Home Page:** [http://www.rpi.edu/dept/nsec](http://www.rpi.edu/dept/nsec)

The Rensselaer Nanotechnology Center provides a major resource to advance the scientific promise represented by the nanotechnology chair and provides interdisciplinary research programs to educate new generations of students. Research areas of the Center include advanced materials and coatings, biosciences and biotechnology, nanoelectronics, and nanosystems. Nanotechnology uses clusters of molecules and atoms to make nanometer (billionth of a meter) size building blocks for new materials. These blocks have different properties than larger sizes of the same materials, such as electrical conductivity, optical properties, and mechanical strength. These materials can therefore be used for many new applications. The Center focuses on creating novel materials and devices that could create more effective drug delivery systems in the human body, result in stronger and more durable plastics, enable high capacity energy and information storage devices, and produce flame-retardant plastics for planes and automobiles, as well as other important applications.


**Visiting Scholars:** S. Chao, M. Frederick, S. Herth, A. Kumar, A. Purkayastha, S. Sen, W. Shang, S. Shenogin

**Administrative Staff:** D. Belser, D. Huising, N. Rysedorph


**Research Staff:** R. Vajai, A. Vertegel, H. Yang

Scientific Computation Research Center

**Director:** Mark S. Shephard

**Associate Director:** Kenneth E. Jansen

**Home Page:** [http://www.scorec.rpi.edu](http://www.scorec.rpi.edu)

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 employ, 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 multiscale systems engineering. Multiscale systems engineering will introduce a new paradigm in which all interacting scales important to the behavior of materials, devices, and systems will be accurately modeled and accounted for in the design of optimized products and processes. To enable the implementation of this new paradigm, advanced modeling, simulation, optimization, and control technologies must be developed to provide the basis for design environments in which systematic exploration of alternative designs is supported by (1) a hierarchy of models that provides a consistent description of multiscale
phenomena, (2) adaptive simulation methods that account for the scale interactions, (3) efficient computational analysis, optimization and control methods, and (4) the representation of uncertainty and its propagation.

The interdisciplinary team of faculty, research staff, and students working with SCOREC are involved in funded research to address key research areas that must be addressed in terms of the overall methods involved as well as their application to specific critical application areas such as nano-composites design and vascular disease modeling. SCOREC research programs include the active transition of the methods and simulation technologies developed to industrial practice and commercialization by software companies.


**Research Associates:** A.C. Bauer

**Research Scientists/Engineers:** C. Dupre, D. Godavarty

**Post Doctoral Research Associates:** S. Amanuel, W. Chen, S. De, D. Littlewood, J. Mueller, M.L. Shofner, L. Yin

**Administrative Staff:** M. Verville

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**The Academy of Electronic Media**

**Home Page:** [http://www.academy.rpi.edu](http://www.academy.rpi.edu)

Electronic media is an integral part of all aspects of society, yet with all the potential offered by today's electronics and computing we have only begun to scratch the surface of how we may use technology to improve our lives. The Academy's vision is to produce and facilitate the use of interactive environments that explore a creative application of electronic media and computing. We strive to empower individuals by developing innovative electronic media and technologies that engage users and remove the restrictions imposed by static toolsets, passive entertainment, conventional media, structure boundaries, or physical proximity. The web has provided a means for access to information at anytime, from anywhere. Today's limit to what knowledge can be learned and applied by an individual is a shortage of time.

The mission of the Academy is to fundamentally challenge and expand the way electronic media impacts people, and the way people relate to electronic media and technology. The Academy combines multiple award-winning (2003 PREMIER AWARD for Excellence in Engineering Education Courseware) artistic and technological expertise to investigate basic IT research in the areas of dynamic data access/utilization (e.g. animation, video, multimedia, etc.), collaborative computing environments, 2-D/3-D visualization & modeling, user I/O interactivity programming, and electronic media scalability/ platform adaptation. At the Academy, developing interactive electronic media that stimulates multiple senses to better understand, visualize, and express ideas is part of the daily work.

New interactive user interfaces and visualization technologies hold the promise for many to now grasp and utilize information and concepts that once was the domain of a select few. The Academy offers those competing in increasingly technical and global markets a greater potential for achieving new success in shorter periods - through the use of innovative technologies, multi-user web-based environments, and interactivity. The Academy is a magnet for scholarly students, faculty/staff, and corporate partners to work together on projects in education and arts & entertainment. Some of the Academy's recent projects involve the development of a multimedia tool to teach Greek as a second language (in collaboration with the
Hellenic American Union), educational materials to support engineering and computer science (through a number of NSF supported efforts), a visual language that explores an evolutionary writing system (the Glide project), nanotube-based sensor R&D modeling (an NUE project), and interactive musical visualizations. The Academy offers a home where community members can exercise both the technical and artistic sides of their creativity, while serving as a Rensselaer resource to facilitate the utilization of electronic media and offer the guidance necessary to allow content providers to produce innovative material and technology.

**Academy Staff:** D. Millard, Director; W. Brubaker, Programming Director; K. Carlson, Production Coordinator; D. Slattery, Associate Director; A. Yu, Systems Administrator
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.

Details on student life and services are offered in *The Rensselaer Planner and Guide to Student Life*, a publication of the Office of the First Year Experience.

**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; the approval and processing of excused absences, leaves of absence, and withdrawals and readmission for undergraduate students; and overseeing the Institute judicial system.

**Greek Life**

Greek Life provides counseling, advising, and program development for individual social fraternities and sororities, as well as advising the Interfraternity and Panhellenic Councils. In addition, this 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.

**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 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.

First-Year Experience

Dean: Lisa Trahan

The Office of the First-Year Experience

The Office of the First-Year Experience offers a comprehensive array of programs and initiatives for new and continuing students, as well as for parents and families that begin before students arrive on campus and continue well beyond their first year. Specifically, the Office of the First-Year Experience sponsors the new student orientation program, Family Weekend, Campus Community Service Day(s), the Information and Personal Assistance Center (IPAC), and the Community Advocate Program, along with many other community actions initiatives, programs, and publications designed to help students and families navigate Rensselaer. Additional services include walk-in, email, and phone support for students and parents as well as a strong electronic presence via email and the web.

Student Orientation (SO) and Navigating Rensselaer & Beyond (NRB)

Student Orientation and Navigating Rensselaer & Beyond are programs in place to facilitate a smooth transition to college life at Rensselaer for all incoming students. Student Orientation is designed to aid new students in their transition, integrate them into the life of the Rensselaer community, and introduce these students to the broad opportunities available at Rensselaer. Essential components of the program include an introduction to academic and student life at the Institute; opportunities for new students to interact with faculty, staff, and continuing students; and the opportunity to meet with an academic adviser and register for classes. The orientation process also includes a component that is designed to provide information to the immediate support group (e.g. parents/guardians, spouse, etc.) who play an important role in the life of each new student. Navigating Rensselaer & Beyond is a five-day program held before classes begin that is full of skill-building opportunities, interest-specific activities, and interactive ways to connect with others both on campus and throughout the community. When students arrive on campus in the fall, it is our hope that they are relatively comfortable with the campus and ready to get involved, connect with classmates, and explore the surrounding community.

Community Service

The Office of the First-Year Experience offers a wide variety of programming for the entire campus to become citizens in the larger community. Community service, through a number of volunteer and service-learning projects, offers participants the opportunity for civic engagement as well as intellectual, emotional, and spiritual growth. FYE-sponsored programming includes the America Reads and America Counts tutoring programs in local schools, Tutor Time, the Community Service Fair, monthly blood drives, Community Service Day projects and Communiversity Events, and the Student Appreciation Dinner for Clothe-A-Child.

Information and Personal Assistance Center (IPAC)

IPAC is a resource to the campus community, providing directory and general information. In addition IPAC offers several campus service programs each year designed to enhance the student experience at Rensselaer.
Parent and Family Programs
Parents and families play an integral role in the lives of Rensselaer students. Therefore, the Office of the First-Year Experience continues to offer programs and initiatives including Family Weekend, Parent Orientation, and other activities that allow families to stay involved and connected to Rensselaer. The Parents of Rensselaer, a parents association open to all parents and family members of undergraduate students, also facilitates the connection of parents with the campus community. Family Weekend, occurring in the fall semester, is a wonderful opportunity for students and their families to spend time together participating in various activities and events on and around campus.

Preparing the Global Citizen (PGC)
The PGC initiative is designed to increase cultural and community awareness among members of the Rensselaer community and to prepare our students to be facilitators of inclusivity in diverse environments. The program oversees the student leadership group Community Advocates and various diversity programming throughout the year.

Communiversity Events
Communiversity Events provide opportunities for all of us to celebrate common interests, purposes, and goals. These special events are opportunities for members of the larger Rensselaer Community of students, faculty, staff, and residents of Troy, to come together and enjoy entertainment and learn more about the community on common-ground - in festive and cultural settings. They are free to all and strategically scheduled so that members of the campus community have the opportunity to learn early about what is available outside the campus walls, and residents of Troy have an opportunity to meet the campus community. Events include: Welcome Fest; Fall Fest; Communiversity Concerts; and events surrounding the Martin Luther King Day holiday.

Career Development Center
Director: Thomas L. Tarantelli
Career Development Center Home Page: http://www.cdc.rpi.edu
The Career Development Center (CDC) helps students take charge of and manage their career development. The CDC offers a comprehensive program of career development, co-op, internship, and job placement activities to both undergraduate and graduate students. Rensselaer students have 24-hour access to many career services and resources via the World Wide Web.

Graduating Student Services In 2003–2004, 2278 students registered with the CDC for on-campus recruiting, resume drops, and open jobs. Top employers of May 2004 graduates include: Boeing, CGI-AMS, GE, General Dynamics, IBM, JP Morgan Chase, Lockheed Martin, Northrop Grumman, Raytheon, and United Technologies, Corp.

Co-op 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 550 students were enrolled in the Co-op Program in 2003-2004, working for leading employers in 20 states such as GE, IBM, NASA, Stryker Orthopaedics, Sandia National Labs, and General Motors, in addition to small, entrepreneurial companies. The vast majority of students locate their co-op positions through the Career Development Center. Undergraduate students normally work during a January to August or June to December rotation; graduate students may work during one of the same rotations or for only one academic term.
Athletics

Director: Ken Ralph

Athletics are an integral part of Rensselaer life. Varsity sports, intramurals, and athletic clubs provide students with an opportunity for instruction in sports for physical fitness, recreation, and development of leadership/followership skills.

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  Colin Tory, head coach
- Field Hockey  Bridget LaNoir, head coach
- Football  Joe King, head coach
- Golf  Miles Nolan, head coach
- Men's Ice Hockey  Dan Fridgen, head coach
- Women's Ice Hockey  John Burke, head coach
- Men's Lacrosse  Tom Korrie, head coach
- Women's Lacrosse  Leslie Khachadourian, head coach
- Men's Soccer  Adam Clinton, head coach
- Softball  Erica Lewis, head coach
- Men's and Women's Swimming  Shannon O'Brien, head coach
- Men's and Women's Tennis  Carol Pillsworth, 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  Leslie Khachadourian, head coach

The men's hockey team competes at the Division I level and in the Eastern College Athletic Conference (ECAC) hockey league. The remaining teams play in Division III. In three sports, Rensselaer also fields junior varsity teams. Rensselaer is a member of the National Collegiate Athletic Association, the ECAC, NYSWCAA, 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  Club sports sponsored by the Rensselaer Union include offerings such as Aikido Karate, Archery, Badminton, Ballroom Dance, Bowling, Cheerleading, Chung Do Kwan, Crew, Cricket, Cycling, Equestrian, Fencing, Gymnastics, Isshinryu Karate, Judo, Juggling and Unicycling, Outing Club, Racquetball, Rugby, Sailing, Scuba, Ski Club and Team, Squash, Table Tennis, Tae Kwon Do, Tennis, Ultimate Frisbee, Volleyball, Water Polo, Weightlifting, and Wrestling.

Intramural and Recreational Program  An extensive intramural athletic program offers competition in 20 sports: basketball, billiards, bowling, golf, gym hockey, ice hockey, indoor soccer, soccer, softball, swimming, tennis, touch football, track, badminton, aerobics, water polo, baseball, wallyball, wiffleball, 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  Rensselaer's athletic fields include five illuminated for practice after dark and the Ned Harkness Field and Track, a synthetic turf field and track, was opened in 1994.

The '87 Gymnasium contains two general-purpose gymnasiums, a swimming pool, seven four-wall combination handball and squash courts, a weight room, an indoor track, and a wrestling room. The
The Rensselaer Alumni Sports and Recreation Center houses the Robison Gymnasium, which has an indoor track; a physiotherapy room; basketball, volleyball, and tennis courts on a resilient surface; and locker facilities. The Robison Pool has eight lanes for competitive swimming as well as three-meter and one-meter diving boards. The Houston Field House has an ice rink, locker and team rooms, and permanent seating for 5,300 spectators. The Mueller Center, housing cardiovascular, weights, aerobics, and other fitness activities, opened in 2000.

The Rensselaer Union

Director: Richard M. Hartt

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 130 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. 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 bank, and a number of other retail operations. The Union also works with student organizations to identify and carry out projects that benefit the greater Troy community.

Student leaders at Rensselaer are elected in an all-campus student election each spring. 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

The Archer Center for Student Leadership Development provides leadership education for the Rensselaer students and community both in and outside of the classroom. The Center enhances students’ leadership skills through a variety of cutting-edge, interactive learning experiences that include adventure-based initiatives, corporate training techniques, and other methods. Archer Center programs provide every student with the opportunity to gain key leadership skills in areas such as team development, visioning, effective communication, ethical decisionmaking, and multiculturalism.

The Archer Center offers custom-designed workshops for student organizations, manages the Professional Leadership Program for juniors, the Professional Leadership Series for graduate students, and facilitates other co-curricular programs. It also works with faculty across campus to develop interactive formats for classes and laboratories, and coordinates many other special events. Additionally, the Archer Center teaches a required course sequence in the Lally School of Management and Technology and a required Professional Development course sequence in the School of Engineering. Student groups, faculty, staff, administrators, and local communities benefit from Archer Center programs. Corporate representatives work with the Archer Center by funding some of its programs and/or speaking in leadership classes, at workshops, conferences, and at the recognition banquet.

The Archer Center for Student Leadership Development, with help from its colleagues and corporate partners, is dedicated to promoting practices that foster teamwork and integrity in the professional and personal lives of tomorrow’s leaders.
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

Director: Peter G. Snyder

Approximately 55 percent of the undergraduate student body lives in campus housing. Options vary from apartments to traditional double and triple rooms in residence halls.

Institute policy requires that all non-commuting single first year students live on campus and participate in a Platinum, Diamond, or Gold dining plan. Single upper-class and graduate students may choose to live either on or off campus, to join a dining plan, or to cook for themselves. Students selecting Burdett Avenue Residence Hall housing are required to enroll in either the Platinum or Diamond dining plan.

Rensselaer’s Family Student Housing community is home to 93 families who reside in two individually styled apartment complexes. A closely knit and culturally diverse community, the family housing area offers ample green space and play areas, a community center, and access to campus and community resources.

Residence Life is the focus for student housing programs related to living and dining at Rensselaer. In addition to providing clean, comfortable, and well-maintained residence halls and apartments, 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. A student staff of resident assistants, resident directors, apartment managers, teaching learning assistants, and learning assistants complements the professionals in the Residence Life office.

Rensselaer Dining Services

General Manager: John Fusco

Rensselaer Dining Services, managed by the Sodexho Campus Services, offers an innovative dining program designed to meet the diverse dining needs of the Rensselaer community. Meal plans range from unlimited meals anytime, in any resident dining hall, to those with unlimited meals within specified hours or days. Students may also use Mealplan Advantage Dollars (MAD) at all resident dining halls and other Sodexho Campus...
Services managed facilities on campus as well as Rensselaer Advantage Dollars (RAD), which can also be used at nondining services food outlets such as Father’s, Ben and Jerry’s Ice Cream, and on-campus laundry machines.

Students with special dietary concerns for religious, health, or personal reasons may make arrangements to meet with the dining services to see how their needs can be met. Rensselaer does not operate a kosher kitchen but can offer frozen kosher dinners to any resident student who requests them. Dining services also offers packaged kosher foods daily. Bag lunches are available for any meal plan participant who cannot attend a regularly scheduled meal due to class schedule conflicts by bringing his or her class schedule to the general manager or dining hall manager.

For more information, refer to our web site at www.rpi.edu/dept/dining.

**Student Health Center**

**Director:** Leslie Lawrence, MD

The Student Health Center is a comprehensive, nationally accredited, physician-directed program providing outpatient ambulatory health care. Services include medical, gynecology, and allergy clinics, a counseling center, and health education and wellness programs. Specialty consultation referral and a prescription delivery program are also available.

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.

The Counseling Center offers 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.

Located on the Troy campus, the Gallagher Student Health Center is open Monday through Friday from 8 a.m. to 6 p.m. and from 1 p.m. to 5 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 is not waivable. Coverage for summer sessions is included in the spring semester fee.

Rensselaer students are required to have adequate health insurance. The Rensselaer Student Accident and Sickness 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 PPO plan.

All students, including part-time students, must submit a medical history and record of physical examination on a form provided by Rensselaer. No other form can be accepted. Students must show adequate evidence of meeting Rensselaer and New York prematriculation immunization and tuberculosis screening requirements.
Student Records and Financial Services

**Director:** Sharon L. Kunkel

This office combines the activities of the registrar and the financial aid office to provide seamless services to students, families, alumni, and Institute faculty and staff.

Student Records and Financial Services registers, provides advising support, awards and administers financial aid resources, and manages accounts for all Rensselaer students. This office maintains accurate student academic and financial records and preserves the confidentiality, security, and ethical handling of these records. It implements academic policy guidelines developed by the faculty as well as financial policies set forth by federal, state, and Institute guidelines.
Undergraduate Admissions

Acting Dean of Enrollment Management: Karen S. Long

Contacting Rensselaer Admissions
Information and application forms are available by contacting:
Office of Undergraduate Admissions
Rensselaer Polytechnic Institute
110 8th Street
Troy, New York 12180-3590
Phone: (518) 276-6216
Western regional office: (760) 730-3132
E-mail: admissions@rpi.edu
World Wide Web: http://admissions.rpi.edu

Undergraduate admission to Rensselaer is outlined briefly below. Detailed information is provided with freshman or transfer application forms available from the Office of Undergraduate Admissions.

Rensselaer accepts the Common Application in lieu of its own form and gives equal consideration to both. Students may also apply electronically via The Princeton Review or via the Common Application. Both websites can be accessed on the Rensselaer Admissions website noted above. If you apply via the Common Application, Rensselaer also requires you to submit the Common Application Supplemental Form.

Rensselaer admits qualified students without regard to gender, sexual orientation, 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 undecided candidates. Electronic Arts applicants are required to submit a creative portfolio. Architecture candidates are asked to submit a creative portfolio by January 1. Architecture applicants with unusually strong academic profiles may be reviewed without the portfolio.

Applications for freshman admission should be addressed to the Dean of Enrollment Management and filed by January 1 of the year in which the applicant expects to begin his or her college program. The non-refundable application processing fee for electronically submitted applications is $50. The nonrefundable application processing fee for paper-based applications submitted via mail is $70.

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

Early Decision Rensselaer offers an early decision opportunity to students who have decided definitely that Rensselaer is their first choice. An Early Decision application must be received by November 15 of the candidate’s senior year in secondary school. Students can expect to receive notification of the admissions decision by the end of December. 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.

Midyear 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. Students interested in January admission should file applications by November 1 of the preceding year. Midyear admission is not possible for the accelerated programs in medicine, law, or for the School of Architecture. Midyear admission does have some special challenges, and we cannot guarantee class availability if the fall class is a large one.

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 precalculus, three years of science, 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 Rensselaer community.

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

Standardized Test Requirements

n SAT or ACT
n SAT Subject Tests in Math (level 1C or 2C) and Science (biology, chemistry, or physics) for accelerated program applicants only (or ACT in lieu of SAT and SAT Subject Tests).

n 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) or a minimum score of 230 on the computer-based test (CBT).

Portfolio Requirements

n Electronic Arts applicants are required to submit a creative portfolio.

n Architecture candidates are asked to submit a creative portfolio by January 1. Students with unusually strong academic profiles may be reviewed without the portfolio.

Entrance Tests  Candidates for freshman entrance are expected to take the College Entrance Examination Board’s SAT or the ACT.

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 December 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.

For students applying for Fall 2005, Rensselaer will accept the current SAT. For students applying for Fall 2006, we will accept the highest verbal and highest math scores from either the current SAT, the new SAT, or across the two exams. For those applying for Fall 2007 and beyond, we will accept only the new SAT scores.

SAT Subject Tests in Level 1C or Level 2C and a Science will continue to be required only for applicants to our accelerated programs in medicine or law.
We will continue to accept ACT scores. We will, however, request that applicants submit the ACT with the optional writing test according to the same schedule outlined above for the new SAT.

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 new SAT and SAT Subject Tests or the ACT 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 nonrefundable fee ($50 for applications submitted electronically and $70 for paper applications submitted via U.S. mail) 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 $300 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 from department to department and school to school.

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 nonrefundable $50 application fee, official transcripts from all previously attended colleges, and a faculty letter of recommendation from your major department. Applicants to the School of Architecture and the Electronic Arts program 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 a plan of study, which outlines the course work the student must complete at Rensselaer to earn the desired degree.

In order to earn a Rensselaer undergraduate degree, a 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 48 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 48 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 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 who wish to be considered for federal financial aid should complete and submit the Free Application for Federal Student Aid (FAFSA). Rensselaer’s FAFSA code is 002803.

For further information on our financial aid programs, please contact the Financial Aid office at (518) 276-6813, or e-mail them at financial_aid@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), Humanities and Social Sciences (H&SS), and Building Sciences (BLSC).)

- Adirondack Community 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.
- Corning Community College, N.Y. (SCI, MGT, H&SS)
- 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, H&SS, BLSC)
- Jamestown Community College, N.Y.
- Jefferson Community College, N.Y.
- Miami-Dade Community College, Fla.
- Mohawk Valley Community College, N.Y. (SCI, MGT, H&SS)
- Monroe Community College, N.Y.
- Montgomery Community College, Md. (SCI)
- Morrisville Agricultural and Technical College, N.Y.
- Nassau Community College, N.Y.
- Niagara Community College, N.Y.
- North Shore Community College, Mass.
- Norwalk 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 Agricultural and Technical College at Alfred, N.Y.
- SUNY Agricultural and Technical College at Delhi, 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. Applications are available from Rensselaer’s Office of Admissions. 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, Morris Brown 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 at Fredonia, N.Y.
State University of New York 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 nonmatriculated 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 Nondegree Students
Rensselaer welcomes students who wish to take one or more courses on a nonmatriculated 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 admissions 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). Nonmatriculated 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 coursework receives full credit, which may be applied toward degrees at Rensselaer or other universities. Students and guidance counselors should contact the Office of Admissions for further information.

**International Students**
More than 1000 international students representing 72 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, if English is not your native language. 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, if English is not the student’s native language; 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 and Electronic Arts applicants are required to submit a portfolio.

**English Language Requirement**  There are two options for international students to demonstrate their English language proficiency. These options include achieving minimum scores on one of the following testing options: 570 (TOEFL); 580 (SAT Verbal).

**Financial aid**  Rensselaer does not offer need-based financial assistance to international students.

**Graduate Admissions**

**Acting Dean of Enrollment Management:** Karen S. Long

**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: admissions@rpi.edu
http://gradadmissions.rpi.edu

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 bachelor’s degree or the equivalent prior to enrollment. Degree-seeking applicants may sometimes be admitted with conditions. Admission and/or continued enrollment depends on 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.

**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.

**Nonmatriculated 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 nonmatriculated 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 nonmatriculated student that can ever be credited toward a degree varies by department, usually from a low of six to a universitywide maximum of 12 credit hours. Time limit to completion of degree begins with the first course taken as a nonmatriculated student. The Rensselaer Admissions Office provides additional information and applications.

**Admission Procedures**

For application forms and program information, visit [http://gradadmissions.rpi.edu](http://gradadmissions.rpi.edu) 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 nonmatriculated status when they inquire about admission. Applicants must submit a completed official application form and a nonrefundable application fee. $60 for applications submitted electronically; $75 for paper applications submitted via U.S. mail; $40 for reapplication. An applicant holding a bachelor’s degree and wishing to register for university courses as a part-time or nonmatriculated 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 [http://gradadmissions.rpi.edu](http://gradadmissions.rpi.edu).

The Graduate Management Admission Test (GMAT) is required of all applicants to the Master of Business Administration. Applicants for the Ph.D. degree in Management may take either the GMAT or the GRE General Test.

Applicants whose native language is not English must have scores from the Test of English as a Foreign Language (TOEFL) submitted directly by the Educational Testing Service, Princeton, N.J. A minimum score of 230 CBT 570 PBT is required. An IELTS score of 7 or higher may be substituted for the TOEFL requirement. Some departments require a higher TOEFL score and evidence of spoken proficiency. Please see the department-specific requirements in the graduate admissions application.
Reapplication for Graduate Admission
Reapplication for graduate admission is available only to those applicants who applied to Rensselaer for graduate school within the past two years. Applicants to a fall term may reapply only to the subsequent fall term and beyond. Applicants to a spring term may reapply for any subsequent term.

A student whose previous application to Rensselaer occurred more than two years ago must complete a new graduate application and submit all new documentation.

Early Admission to Graduate Studies
Rensselaer undergraduates with strong academic records may apply to the Admissions Office for graduate studies as early as the junior year. If they are considered academically qualified by the department and the Admissions Office, Rensselaer students may be admitted and pursue both the undergraduate and graduate degrees simultaneously. The bachelor’s degree must be completed concurrently with, or prior to, the master’s degree.

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, one for each department, each 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.

Eighteen-Hour Rule
A Rensselaer undergraduate who is within 18 credit hours of the bachelor’s degree and is considered academically qualified by the department and the Rensselaer Admissions Office may be admitted to the Graduate School and begin work toward a graduate degree under the supervision of a graduate adviser. Such work will be undertaken simultaneously with the work required for the bachelor’s degree. The bachelor’s degree must be completed concurrently with or prior to the master’s degree. Students admitted under the 18-Hour Rule who wish to be billed as graduate students should contact the Rensselaer Admissions Office. If the billing change is approved, any undergraduate financial aid is discontinued.

Deferment of Graduate Enrollment
An admitted student may request a deferment of his/her entry to Rensselaer due to unique and extenuating circumstances. Upon a written review of the request, Rensselaer may approve an admitted student’s request for deferment; however, a deferment will be granted only once and for up to one year. A $100 nonrefundable tuition deposit is required within four weeks of the deferment approval in order to secure the admitted student’s seat in an upcoming class.
Undergraduate Financial Aid

Director: James H. Stevenson

Education for leadership in the technological professions requires substantial resources. As a private university, Rensselaer meets the costs of education, laboratories and facilities, student services, and administrative support by 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 not able to meet the cost with their own resources. Financial aid is important for most undergraduate and graduate students.

Rensselaer is committed to making a quality education financially possible for undergraduates and their families. The Institute is equally committed to making a complex process as simple and straightforward as possible.

Current and prospective students are invited to contact the Financial Aid Office, which at Rensselaer is part of the Office of Student Records and Financial Services, at (518) 276-6813.

Applying for Financial Aid

Prospective first-year students apply for financial aid by submitting only the Free Application for Federal Student Aid (FAFSA)* to the Federal Processing Center. This simple form entitles the applicant to consideration for all financial aid administered by Rensselaer, including industrial, foundation, and endowed scholarships. Transfer students must complete both the FAFSA and the RPI transfer financial aid application.

Upper-class students requesting aid, whether or not they have received aid before, must submit the FAFSA and, if their application has been selected for verification, copies of their federal tax returns, their parents' federal tax returns, and the federal verification worksheet.

Financial Aid

Most assistance from Rensselaer is based on financial need: the difference between college costs and what student and family can be expected to pay.

College Cost The total estimated expenditure for a Rensselaer undergraduate for the nine-month 2005–2006 academic year is as follows:

<table>
<thead>
<tr>
<th></th>
<th>Resident Students</th>
<th>Commuter Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition</td>
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</tr>
<tr>
<td>Fees</td>
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<td>857</td>
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<td>Room and board</td>
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<tr>
<td>Books and personal expenses</td>
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<tr>
<td><strong>Total</strong></td>
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<td>$37,285</td>
</tr>
</tbody>
</table>

Family Contribution To determine the expected family contribution, the Financial Aid Office looks at both parent and student resources. Parent contribution is determined by income and asset information provided on the FAFSA, along with the previous year's federal tax return. Allowances are made for such factors as siblings in college, age of parents (for estimating retirement needs), and family size.

* FAFSAs can also be filed over the Internet at http://www.fafsa.ed.gov
**Aid Award** In making aid awards, Rensselaer's usual approach is to award scholarship funds first and because these funds are necessarily limited, add self-help awards (loans and work-study jobs) to help meet need. Most awards are a combination of scholarship, loan, and/or job. Students receiving combination scholarship and loan and/or job awards are not required to accept the loan or job in order to retain the scholarship.

**Adjustments** Rensselaer evaluates parent and student tax returns and verifies the enrollment status of other family members in college. Awards may be adjusted when there are differences between FAFSA estimates and actual figures. If you receive scholarship aid from outside industrial, community, or other sources, you must notify the Financial Aid Office of these awards. If your federal need has not been fully met or you are receiving only merit awards, you may be able to keep the outside award in addition to our financial aid offer. However, if your need is fully met and your aid award includes federal aid, we will reduce the loan or work portion of your package first. If you should have any questions regarding how an outside award may affect your financial aid offer from Rensselaer, please contact our office.

**Annual Renewals**
Because family circumstances may change from year to year, need is re-evaluated annually. Students reapply for financial aid each April, and awards are returned during the summer.

**Continued Commitment** If your need persists, you will continue to receive financial assistance. Moreover, Rensselaer will maintain, but not increase, the amount of Rensselaer scholarship you are receiving, provided that your need is also at the same level.

**Academic Progress** Rensselaer does not tie renewal of financial aid, including the size of Rensselaer scholarships, to grades. Students with federal or New York state awards, however, must meet their satisfactory progress guidelines.

**Eligibility** Undergraduate aid is continued through eight semesters (10 for students in the School of Architecture), including semesters spent at institutions other than Rensselaer. Students who require additional semesters to complete their degree because of reduced course loads, change of major, double major, failure in courses that must be made up, or other unusual circumstances are not eligible for any type of aid administered by Rensselaer.

**Dependence/Independence** Under standard financial aid procedures, the student’s personal and family situation, as described in the initial application for admission, continues to be the basis for Rensselaer financial assistance for the duration of the undergraduate program. A student enrolling at Rensselaer as a dependent family member must continue to submit parental financial information as the basis for aid until the bachelor’s degree has been received. Marriage, leaves of absence, declarations of “emancipation,” or other circumstances do not alter this requirement.

**Financial Aid Refund and Repayment**
If, for some reason, a student cannot complete a semester, the following financial aid refund and repayment policies apply.

**Refund** Rensselaer’s refund policy for a student withdrawing on or after the first day of class of a payment period is outlined in the Tuition and Fees section of this catalog. If the student received any federal Title IV funds, a portion of the refund will be returned to the programs from which the student was funded. Refunds are distributed to Title IV programs in the order prescribed by law. The non-Title IV share of the refund is distributed in the following order: state grant, institutional grant, institutional loan, private grants or scholarships, private loans, student/parent.

**Repayment** When a student withdraws, drops out, or is expelled on or after the first day of class of a payment period, the Institute will determine whether the student received an overpayment of financial
aid funds for noninstitutional expenses. If the student received a cash disbursement of Title IV funds and owes a repayment, a portion will be returned to the Title IV programs from which the student was funded. The Title IV portion of the repayment will be distributed among the Title IV programs in the order prescribed by law. A student who owes a repayment on a Pell Grant or SEOG is ineligible for further Title IV assistance until the repayment is made. Full details on policy and procedures are available in the Financial Aid Office.

Financial Aid Awards

Rensselaer Scholarship Programs
To provide access to a quality education for high-quality students, Rensselaer offers substantial financial aid from its own funds. Scholarship grants are awarded after full consideration 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.

Industrial, Foundation, 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. A list of these scholarships is provided at the end of the undergraduate financial aid section of this catalog.

Rensselaer Medal
This medal has been awarded by 3,000 high schools worldwide to their most promising juniors in math and science since 1916. Medalists who enroll at Rensselaer receive a substantial scholarship throughout their four years.

Federal Grants, Loans, and Work/Study Assistance
The federal government offers a number of grant, loan, and work-study programs:

Federal Pell Grant
These grants, varying from $400 to $4,050, are awarded to the neediest students (based on a federal calculation).

Federal Supplemental Education Opportunity Grant (SEOG)
These additional grants are made to Pell Grant recipients.

Federal Perkins Loan
A need-based loan program, 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.

Federal Stafford Loan (Subsidized)
A need-based student loan with a variable interest rate and maximum amounts of $2,625 (freshmen), $3,500 (sophomores), and $5,500 (juniors and seniors) 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 deducts a 3% processing fee from the amount borrowed.

Federal Stafford Loan (Unsubsidized)
Students who do not qualify for all or part of the subsidized Stafford Loan program may qualify for an unsubsidized Stafford 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 federal government deducts a 3% processing fee from the amount borrowed.

Federal Work-Study Program
This is a need-based program for students with very high needs. Jobs earn $7.00 per hour up to $2,000 per year.

Other Programs
In addition to these general forms of student assistance, the federal government has aid programs directed to specific groups of students. Examples include the U.S. Bureau of Indian Affairs, Aid
to Native Americans Higher Education Assistance Program, and Veterans Administration (VA) educational benefits. Students who may be candidates for these programs are urged to contact the Financial Aid Office.

**Application** Based on the FAFSA, the Financial Aid Office 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, distribution of funds, cancellation, and specific rights and responsibilities of recipients is available from the Financial Aid Office.

**Academic Progress** To remain eligible for these Title IV federal student assistance programs, students must earn a specified number of credit hours and maintain a required grade point average each year. These requirements are published annually and are distributed to recipients with their awards. Students who fail to maintain the minimum credit hours or achieve the required grade point average are placed on federal financial aid probation and have one academic year in which to earn sufficient credits or achieve the required grade point average before losing federal aid eligibility. Students denied federal financial aid for failure to make satisfactory academic progress may appeal through the Office of Financial Aid.

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

The former receive scholarships for periods varying from two to four years. These provide tuition ranging from approximately $4,000 to full tuition, a variable allowance for books, some fees, plus a monthly stipend. Students entering Rensselaer with certain 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 and resides in on-campus housing and participates in a meal plan.

Nonscholarship 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) 276-6251

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

- Regents Awards for Children of Deceased or Disabled Veterans
- Regents Awards for Children of Deceased Police Officers or Firefighters
- Regents Professional Opportunity Scholarships
- Robert C. Byrd Honor Scholarships
- Vietnam Veterans Tuition Awards
- State Aid to Native Americans
- Scholarship for Academic Excellence

**Tuition Assistance Program (TAP)** TAP awards are available to New York residents attending Rensselaer full time during the academic year (half time during the summer). They are based on New York state taxable income and vary from $500 to $5,000.
Financial aid awards to New York residents include a TAP award at a level estimated based on information provided on the FAFSA. Students, however, must complete an Express TAP application and send it to the New York State Higher Education Services Corporation, 99 Washington Avenue, Albany, NY 12255. Notification of the actual grant amount is received from this agency approximately four weeks after receiving the application.

Undergraduate students may generally receive TAP awards for four years of study. Students enrolled in approved five-year programs or in state-sponsored opportunity programs may receive undergraduate awards for five years.

To remain eligible to receive New York state financial assistance, students must earn a certain number of credit hours each semester, maintain a minimum grade point average, and achieve what is referred to as “satisfactory program pursuit.” These requirements are published annually and are distributed to recipients with their awards.

Higher Education Opportunity Program (HEOP) This program is open to New York state residents who matriculate at an independent college or university in New York state, and who are academically and economically disadvantaged according to guidelines approved by the Board of Regents and the director of the budget.

Application is made to Rensselaer, and Rensselaer’s HEOP program selects the students eligible for participation. The amount of assistance depends on need as determined by Rensselaer within state and federal guidelines. For more information contact the director, HEOP Program, Office of Minority Student Affairs, at (518) 276-6272.

Other 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, Champlain Mill, PO. Box 2000, Winooski, VT 05404-2000.

Rhode Island State Scholarship applications are made to the Office of Scholarships, Rhode Island Department of Education, 199 Promenade Street, Providence, RI 02908.

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. It should be noted, however, that Rensselaer’s academic programs are demanding of both energy and time, and students should not expect to earn a large part of their college expenses through part-time employment. Information on part-time employment is available from the Career Development Center, (518) 276-6234.

Alternative Loans There are several alternative loan programs available for students attending Rensselaer. Additional information is available in the Financial Aid Office.

Federal Parent Loan for Undergraduate Students (PLUS) If creditworthy, parents of undergraduates may be eligible to borrow up to the cost of attending Rensselaer (minus other financial aid accepted). The PLUS interest rate varies annually with a cap of 9%, and repayment begins 60 days after the funds are fully disbursed. A one-page application form is available from the Financial Aid Office. The various lenders approve these loans based on a credit check, and loan proceeds are credited directly to the student’s account. The federal government deducts a 3% processing fee from the amount borrowed.
Student Rights and Responsibilities
As a student, you have the right to know and understand all aspects of the financial aid process at Rensselaer. Specifically, you have the right to ask the Financial Aid Office staff:

- What financial assistance is available, including information on all federal, state, and Rensselaer aid programs.
- What the deadlines are for submitting applications for each of the financial aid programs available.
- What our costs are, and what our policy is for making refunds to students who leave.
- What criteria we use to select students who receive financial aid.
- How we determine financial need, including how costs for tuition and fees, room and board, travel, books and supplies, and miscellaneous expenses are considered in the budget.
- What resources (such as parental contribution, other financial aid, assets, etc.) are considered in the calculation of need.
- How much of your financial need, as determined by the Institute, has been met.
- What the various programs included in your financial aid package mean.
- What portion of the financial aid you receive must be repaid and what portion is grant aid. If the aid is a loan, you have the right to know the interest rate, the total amount that must be repaid, the payback procedures, the total time you have to repay the loan, and when repayment is to begin.

If you feel you have been treated unfairly, you may request reconsideration of your award.

Along with these rights, students have responsibilities. Yours include:

- Review and consider all information about a school's financial aid program before you enroll.
- Complete your application for aid accurately. Errors may delay your aid award. Intentional misreporting of information on application forms for federal financial aid is a violation of law and is subject to penalties under the U.S. Criminal Code.
- Return all additional documentation, verification, corrections, and/or new information requested by the Financial Aid Office or by other agencies to which you have submitted applications.
- Read and understand all forms you are asked to sign and keep copies of them.
- Accept responsibility for all agreements you sign.
- Notify a lender (someone who has made you a loan) of any change in name, address, or school status.
- Perform in a satisfactory manner the work that is agreed upon in accepting a Federal Work-Study award.
- Know and comply with all deadlines for application or reapplication for aid.

List of Undergraduate Scholarships
Industrial and foundation scholarships are financed by annual grants from their sponsors. Restricted endowed scholarships are awarded from annual endowment earnings; the date in parentheses indicates the year in which the scholarship was established.

Industrial and Foundation Scholarships and Annual Grants
Sal Alfiero '64 Scholarship First preference given to students from Buffalo, N.Y., New Bedford, Mass., and Rhode Island.

General Electric Foundation Scholarship For a minority student entering sophomore year. Student must be majoring in mechanical, electrical, or management engineering, or computer science and must rank in the top quartile of his or her class. Renewable for junior and senior years.

General Motors Minority Engineering Scholarship For a freshman enrolled in an engineering program of interest to General Motors. Renewable for sophomore, junior, and senior year.

IBM Minority Scholarship For students majoring in a field designated by IBM each year.
A. Lindsay and Olive B. O’Connor Foundation Scholarship Preferably for students from Delaware County, N.Y., or for students from counties surrounding Delaware County.

David T. Ryan Scholarship Established by family, friends, and colleagues in memory of David T. Ryan. Preference given to academically exceptional students who are involved in athletics.

Herman J. Schafer Scholarship For electrical and civil engineering students.

Restricted Endowed Scholarships

Marion and Glen Abplanalp ’36 X-Dimension Scholarship (1994) Preference to participants in Rensselaer Christian Association.


Roger Osborn Ackerman Scholarship (1989) Founded by bequest of Annie C. Ackerman as a memorial to her late husband. For a male engineering student.

George I. Alden Scholarship (1984)

Charles S. Aldrich Scholarship (1952) First preference given to a graduate of Vermont Academy at Saxtons River, Vt.


Kenneth G. Anderson ’50 Scholarship (2000) First preference given to students enrolled in the Lally School of Management and Technology.

Rose O. and Arthur J. Anderson Memorial Scholarship (1984) For students from the New York state Capital District and the area of Concord, N.H., who have demonstrated leadership qualities and devotion to the Institute through participation in and contribution to its extracurricular activities.

Dr. Victor A. Babits Memorial Scholarship (1983) Established through gifts from family and friends in memory of Dr. Babits. For students majoring in electrical engineering who have completed their sophomore year.


William T. Bahr ’49 Memorial Scholarship (2001) Established by Mary F. Bahr. For students enrolled in the School of Engineering with first preference for mechanical engineering majors.

Delwyn K. Barnes ’36 Scholarship (1991) Established by Delwyn K. Barnes ’36 and his grateful friends and colleagues in appreciation for his many years of active community service. Preferably for a student from Northbridge High School, Whittinsville, Mass.

Burt A. Baron ’59 Memorial Scholarship (2002) Established by Lynne L. and Victor B. Murray in memory of their close friend. First preference given to students enrolled in civil engineering.

Carolyn and Neal Barton ’58 Booster Scholarship (1989) For upper-class students who have encountered academic difficulty or because of extenuating financial limitations demonstrate a need for additional support to continue their studies.


Myrtle Isabel Bedell Scholarship (1985) Established by Captain Floyd C. Bedell in memory of his wife. For juniors and seniors majoring in civil engineering.

Dr. Arthur E. Bergles Scholarships (1996) For students in the Department of Mechanical, Aerospace, and Nuclear Engineering.
Alfonzo Bills Scholarship (1914) Founded by Mrs. Charles H. Knight of Troy. For a student from Troy High School.

Graham and Emmeline H. Blandy Scholarship (1916) Founded by Isaac C. Blandy, Class of 1887, in memory of his parents. For a student from Washington County, N.Y.


Charles H. Blitman Scholarship (1969) Founded by Mrs. Bernice M. Blitman in honor of her husband, of the Class of 1914.

Bornefeld Memorial Scholarship (1989) Established by Helen B. Bornefeld. For students enrolled in the School of Engineering, first preference for civil engineering majors.

BRAE Scholarship (2000) For students majoring in chemical engineering.

Christopher and Maria Brennan Scholarship (1941) Founded by Mary A. Brennan of Pittsfield, Mass., in honor of her father and mother. Preference given to students from western Massachusetts.


William and Gertrude Brotman Scholarship (1987) Founded by Stephen L. Brotman ’66 in honor of his parents. For students enrolled within the School of Science or Engineering.

William A. Browne Memorial Scholarship (2000) Founded by bequest of Florence T. Browne. For students enrolled in civil engineering.

Pauline Urban and Warren H. Bruggeman ’46 Scholarship (1989) For a student enrolled in the School of Engineering or Science, with first preference given to a student of Ukrainian heritage.


Harvey M. Bryans Scholarship (1974)

Julia Buchman Scholarship (1922) Founded by Edwin Buchman of Troy in honor of his mother. For a student from Lansingburgh (North Troy) High School.

Jane I. Burgess Memorial Scholarship (1983) Established by Richard M. Burgess ’27. For students who have completed the freshman year, preferably for civil engineering majors.

John F. Cahill Scholarship (1936) For a student from Troy.

Keith M. Callanan ’25 Memorial Scholarship (1982) Founded by a gift from Mrs. Gertrude DeYoung Callanan, widow of Keith Callanan. For students recruited as aspirants for varsity hockey.

Dale V. Carlson Scholarship (1980) Established through gifts from family and friends in memory of Dale V. Carlson. First preference given to two or more students from the same family attending RPI simultaneously. Second preference given to students from Minnesota.

Simon Peter Carman ’22 Memorial Scholarship (1999) For juniors or seniors majoring in civil engineering who rank in the top 10 percent (10%) of their class.

The Carr Scholarship for African American Students (2002)


Howard and Carol Cavanaugh Scholarship (1980) For students from the greater Buffalo, N.Y., area. Preference given to graduates of Canisius High School.
Leon C. Chamberlin ’28 Scholarship (1983) For undergraduate students in engineering. Selection based on academic excellence and financial need with preference for graduates of Salem Central School, Salem, N.Y.

Janice and Richard Chen ’71 Scholarship (1987) For a freshman international student from Hong Kong majoring in engineering or science.

Anthony A., Mary G., and Agnes B. Ciresi Scholarship (1981) Founded by Anthony D. Ciresi, Class of 1929, and his wife, Astrid B. Ciresi, as a memorial to honor Mr. Ciresi’s parents and sister. Preferably for a student from the state of Connecticut.


Class of ’31 Scholarship (1986)

Class of ’32 Scholarship (1983)

Class of ’37 Scholarship (1966) Preferably for sons and daughters of members of the Class.

Class of 1951 Transfer Student Scholarship (2000) For students transferring to Rensselaer in their junior year.

Class of ’71 Chinese Student Scholarship (1987) For a freshman international student from Hong Kong.

Class of ’81 Scholarship (2004)

Arnold and Jessie Cogswell Another Chance Scholarship (1989) For students who have encountered academic difficulty and require additional support to continue their studies.

John D. and Mary J. Colby Scholarship (1977)

Ann M. and Frank J. Conte ’34 Scholarship (2000) Established by Frank J. Conte ’34. For students enrolled in the school of engineering.

Joseph Brandly Converse Scholarship (1964) Founded by Laura Keith Jones Converse in honor of her husband, of the Class of 1910. For a student in civil engineering, preferably from a southern state.

H. H. Cook Scholarship (1964) Founded by John Walter Gummo, Class of 1908. For a young man of American-born parents and a resident of Albany, N.Y.

Isabel L. and Dane H. Corey ’36 Scholarship (1990) For students enrolled in the School of Engineering or the School of Science, preferably residents of Vermont. Also, preference will be given to descendants of Isabel and Dane Corey.


Pamela L. and James Q. Crowe ’72 Scholarship (2004)

Roman Cygan ’45 Scholarship (1994) First preference for students of Polish heritage from Easthampton, Mass., who have an interest in classical music.

Philomena C. and Walter C. Daniels ’50 Scholarship (2000) Established by Walter C. Daniels ’50. For students enrolled in the School of Architecture.

David M. Darrin ’40 Scholarship (1981) Originally established by David M. Darrin and later added to by his widow Margaret Darrin. For outstanding freshmen.

Delta Chapter Theta Chi Fraternity Scholarship (1996) For students who are members of Theta Chi Fraternity.


Rodney Derbyshire Scholarship (1981)

Derrick Family Scholarship (1999) Established by Margaret and George Derrick ’67. First preference given to students majoring in civil engineering.

E. Jane Devereaux Memorial Scholarship (1998) Established by Robert J. Devereaux ’53 in memory of his mother. Preference given to students from single parent background who are “average” students.

Ronald P. Diaz Scholarship (2001) First preference given to students enrolled in computer science.

David M. Diltz Scholarship (1981)

Joel Dolven Scholarship (1987) Established by family and friends in memory of Joel Dolven. For engineering students who are active participants in musical activities at Rensselaer.

John and Clara Doty Scholarship (1962) For a student in science or engineering.

Clarence W. Dunham ’20 Scholarship (1981) For students who have completed their freshman year and are majoring in civil engineering.


Ruth E. and Kenneth S. Eff ’33 Scholarship (1990)

Judith and Laurence Eiseman ’51 Scholarship (1992) For students enrolled in the School of Humanities and Social Sciences.

Beatrice W. Ellis Scholarship (1991) Established by William C. Ellis. For students majoring in science or engineering.

Catherine H. Ellis Memorial Scholarship (1990) Established by William C. Ellis. For students majoring in science or engineering.

Lila A. and Gerald S. Ellsworth ’50 Scholarship (2000) Established by Gerald S. Ellsworth ’50. First preference given to students enrolled in the Lally School of Management and Technology.


Rene F. Erkins Scholarships (1970) Established by Mrs. Eleanor Erkins in memory of her husband, for students in engineering.


Helaine Miriam Falkson Scholarship (1982) Established by Ralph E. Gorin in memory of his mother. For a student enrolled in an area of electrical engineering or computer science that, broadly construed, includes any of computer systems architecture, operating systems design, or the design of computer communications networks.

Alton Farrel Jr. Scholarship (1967) For a student from Connecticut, with preference given to residents of the city of Ansonia and vicinity.

The First Albany Scholarship (1993) Established by George McNamee and The First Albany Corporation. For students enrolled in the Lally School of Management and Technology, with first preference given to women and minorities.
Beatrice E. Fischbach Scholarship (1956) Founded by Jerome Fischbach, Class of 1938, in memory of his mother. For an upper-class student in architecture.


Mary and George Flitcher Scholarship (1999) Founded by a bequest from Helen M. Flitcher in honor and memory of her late husband’s parents.

Charles E. Frey ’59 Memorial Scholarship (1991) Established by Daniel O’Connell’s Sons, Inc., in conjunction with the O’Connell Companies and their subsidiary corporations. First preference given to a freshman majoring in civil engineering who is a child of an employee of Daniel O’Connell’s Sons, Inc.

Anna S. and Albert L. Gaetano Scholarship (1989) First preference given to a student who attended one of the following schools: Utica Senior Academy (Utica, N.Y.), The Gunnery (Washington, Conn.), or The Taft School (Watertown, Conn.).

Virginia and Ralph H. Gallinger ’30 Scholarship (1993) Established by Virginia Gallinger in memory of her husband, Ralph H. Gallinger ’30. For students majoring in civil engineering.

James W. Gaynor ’30/31 Memorial Scholarship (1991) Established by the family of James W. Gaynor. For students in Schools of Engineering and/or Science, with first preference given to female students.


Mary and Angelo Giardini ’32 Scholarship (1987)

Raymond A. Gibson ’23 Scholarship (1995) For students enrolled in the School of Engineering with first preference given to electrical engineering.

Joan and Francis Gicca ’54 Scholarship (2004) First preference given to students enrolled in electrical engineering.


Elisabeth Smith Golden and Arthur Golden ’66 Scholarship (2002) First preference given to graduates of Westover School in Middlebury, Conn.

Philip Gowdey Scholarship (1998)

Richard Pope Graham ’42 Memorial Scholarship (1994) Preference for students enrolled in the Department of Mechanical, Aerospace, and Nuclear Engineering.

Wayne Green Scholarship (1985)


Kermit Gulden Memorial Scholarship (1997)

Thomas J. Guy Scholarship (1959) Founded by Thomas H. Guy in memory of his father. For a student from Troy High School or LaSalle Institute who is a resident of Troy.

Martin Hapeman ’58 Steinmetz Scholarship (1994) For students who are citizens of the United States and enrolled in the School of Engineering or the School of Science.
Oscar Hasbrouck Scholarship (1986) Founded by bequest of Catherine Hasbrouck Calhoun in memory of her father. For a student majoring in civil engineering.


Earl Hendry ’15 Memorial Scholarship (1996) Founded by bequest of Evelyn Hendry as a memorial to her husband.

Jacob E. Heyl Scholarships (1960)


Leon D. Holden Scholarship (1980) Founded by the will of Mr. Holden, a graduate of the Class of 1921.

Normond S. Holroyd ’29 Memorial Scholarship (1986) Founded by bequest of Isabell S. Gillett in memory of her first husband.


Jessie M. and Arthur J. Horan Scholarship (1977)


George T. Horton Scholarships (1963) Founded by a graduate in the Class of 1893. For students nominated by CBI Industries, Inc.

L. W. Houston ’13 Memorial Scholarship (1977) Established through gifts from friends in memory of Livingston W. Houston, a former president of Rensselaer. For a student in engineering.

Shih-Tze Hsiao ’76 Memorial Scholarship (1994) Established by the estate of Alice Wang, in memory of her son.

Helen and Robert Hughes Scholarship (2000) First preference given to students from the New Hartford and/or the East Ramapo Central School District in New York state.

Alan T. Hundert Memorial Scholarship (1978) Founded by Mr. and Mrs. Leo D. Hundert in memory of their son, a member of the Class of 1960. For a student in the School of Management.

Leonard W. Hyman Scholarship (1963) Founded by Lena Hyman in memory of her brother. For a student in chemistry who is a graduate of the public high schools in the city of Albany.


Harry C. and Dalys Oxnam Jaecker Jr. ’34 Scholarship in Management and Technology (1994) For students enrolled in the Lally School of Management and Technology.


Neil Howard Jagoda Scholarship (1981) Founded by his family and friends in his memory. Preference given to two or more students from the same family attending Rensselaer simultaneously.


Mary Low Kee Memorial Scholarship (1997) Established by Dr. Herbert Kee ’50 in memory of his grandmother. First preference given to Asian-American students.


Edward J. Kilcawley Memorial Scholarship (1994) For students majoring in environmental engineering.

Elwin F. Lackman ’41 Memorial Scholarship (2001) For students enrolled in the School of Engineering.

Joseph V. Landau Scholarship (1992) Established to honor Joseph V. Landau upon his retirement from active teaching at Rensselaer. For students enrolled in the premedical program in the School of Science.

Barbara and Stanley Landgraf ’46 Scholarship (1988) For students who are athletes on the varsity hockey team.

John and Marguerite La Pan Memorial Scholarship (1997) Founded by bequest of Marguerite La Pan. For a sophomore majoring in civil engineering.


Phyllis S. and C. Erik Larson ’55 Scholarship (1996)


Robert L. Levy ’62 Memorial Scholarship (1990) Established by Kenneth L. Foster. For students enrolled in the School of Engineering with first preference for students majoring in electrical engineering.

Alfred Li ’73 Scholarship (1993) For a freshman international student from Hong Kong.

Linear Technology Corporation-Glenn Mueller ’64 Memorial Scholarship (1994) For students in the Department of Electrical, Computer, and Systems Engineering interested in semiconductors and analog circuit designs.

Eric Lopez Scholarship (1992) Established by Nancy J. and Henry J. Lopez ’53. For students enrolled in the School of Engineering, with first preference given to Hispanic students.

Archibald Longworth Love III ’42 Scholarship (1993) For students enrolled in the School of Engineering with first preference to students pursuing study in the Department of Electrical, Computer, and Systems Engineering.

Wilfred T. Lowery Scholarship (1960) Founded by Miss Eva C. Lowery in memory of her brother, of the Class of 1916. For a student in electrical engineering.


Richard C. McCurdy Scholarship (1984)


James W. McEwan Memorial Scholarship (1973)  Founded by Ethel J. McEwan in memory of her husband, James W. McEwan.

Hugh T. McKee '30 Memorial Scholarship (1998)  For students from Cohoes, N.Y.

Frank McKone '63 Family Scholarship (2003)

Brian E. '61 and Dorothy W. McManus Scholarship (1997)  For a freshman with first preference given to a student from Texas.

Philip Henry Mead Memorial Scholarship (1993)  For students enrolled in the School of Science or Engineering, with first preference given to U.S. students raised on a farm.


Arthur Hanfeld Miller Jr. Scholarship (1968)  Founded by Mrs. Marie Alison Miller in memory of her son, of the Class of 1944. For a student in the School of Engineering.


Samuel J. Miller II Memorial Scholarship (1941)  Founded by Mr. and Mrs. D. Henry Miller in memory of their son, of the Class of 1937. Preferably for a student from Connecticut in mechanical engineering.

W. Webb Moffett '30 Scholarship (2000)  First preference given to students who are members of Delta Tau Delta Fraternity.

Preston L. Moody Scholarship (1980)  Founded by family and friends to honor Preston L. Moody, Class of 1922, on his 80th birthday. Preference given to graduates of public schools from the island of Oahu, Hawaii, majoring in civil engineering.

Thomas H. Moorehead '56 Scholarship (1992)  Established by Mrs. Patricia Moorehead in honor of her late husband, Thomas H. Moorehead '56. For students enrolled in the School of Engineering, with preference toward mechanical engineering.

James F. Morrill ’52 Scholarship (1987)  For students who are enrolled in the Schools of Engineering or Science, with first preference given to high school graduates in the St. Lawrence (N.Y.) County area.

John F. and Lewis R. C. Morse Scholarship (1977)  Founded by Mrs. John F. Morse in memory of her husband, a former vice president of Rensselaer, and their son. Selection based on academic excellence, leadership, character, and financial need.

Mow Family Scholarship (1986)  For a foreign-born student, preferably from Taiwan.

Glenn M. Mueller '64 Memorial Scholarship (1994)  Established by family and friends.

James C. Mullen '80 Scholarship (2000)
Edward Theobald Murphy Memorial Scholarship (1980) Founded by Helen S. Murphy in memory of her husband. Preference given to a male graduate of an Albany, N.Y., high school, majoring in civil engineering.

Reta G. Murphy Scholarship (1981) Founded by Arthur G. Murphy ’32 in memory of his wife. For students recruited as aspirants for the varsity hockey team.

Edward F. Murray Scholarship (1929) Founded by Mrs. Edward F. Murray of Troy in memory of her husband. For a student from St. Joseph's Parish in Troy or, in case there is no applicant from St. Joseph's Parish, a Catholic student from Troy.


Theodore Newcomb Scholarship (1987) Founded by bequest of Theodore Newcomb. For students who are residents of the state of Connecticut.


Ronald D. Pacchiana ’54 Memorial Scholarship (1990) Established by the family, friends, and associates of Ronald D. Pacchiana ’54. For students enrolled in the School of Engineering with first preference to those in civil engineering.


Neill S. Perri ’93 Memorial Scholarship (1997) Established by Neill’s family. First preference for students enrolled in the Department of Mechanical, Aerospace, and Nuclear Engineering.

Henry F. Peters ’49 Scholarship (1982) Established by Ruth Peters in memory of her husband. For students in materials engineering. Selection based on academic excellence and financial need with preference to applicants whose parent(s) are employed by Oregon Metallurgical Corporation.

Marvin L. Peterson ’21 Scholarship (1983) Established in his memory by his wife and his children, Eleanor Splinter, Marilyn Kerwin, and Donald M. Peterson ’55. For students in the Schools of Engineering or Science.

Simone C. Peterson ’84 Scholarship (1999)

Joel H. Port ’70 Scholarship (1974)

John Woodward Prosser Scholarship (1955) Founded by Mrs. Mary C. Prosser in memory of her son, of the Class of 1946. For an upper-class student.

Essie and Harriet Rader Scholarship (1979) Founded by Lawrence A. Rader, Class of 1958, in honor of his mother and his wife.

Barbara W. and William J. Raymond ’60 Scholarship (2002) First preference given to students enrolled in the School of Engineering. Second preference given to students who come from any state west of the Mississippi.


Rensselaer Endowed Scholarship (1960) Established through miscellaneous gifts given for scholarship assistance.
Rensselaer Faculty-Staff New Century Scholarship (1994) Established by members of the faculty and staff during the Campus Campaign.


Lynn S. Richards Scholarship (1957) Founded by Dr. and Mrs. Clifford S. Richards in memory of their son, of the Class of 1956. For a student enrolled in the School of Architecture.

William G. Riviello ’33 Scholarship (1997)

C. Sheldon Roberts Scholarship (1981) For graduates of secondary schools of the state of California, entering either the School of Engineering or School of Science.

Patricia W. Roberts Scholarship (1981) For graduates of secondary schools of the state of Oregon, entering either the School of Engineering or School of Science.

RSE Foundation Scholarship (2004) First preference given to students who are members of the Rensselaer Society of Engineers Junior Membership, Inc. Second preference to first or second year undergraduates not affiliated with a “Greek” organization.

Edward I. Rudd, Jr. Scholarship (1997)

Gerald E. Sabian ’57 Memorial Scholarship (1991) Established by Ruth A. Sabian in loving memory of her husband. First preference given to students recruited as aspirants for the varsity hockey team who will major in chemical engineering or nuclear engineering.


Alan Keith Schaluck ’70 Memorial Scholarship (1995) Established by the estate of Annie B. Schaluck.

Harvey O. Schermerhorn Scholarship (1960) Preferably for a student of the Protestant faith from Albany or Troy.

Edward P. Schinman Scholarship (1945) Founded by the Bogue Electric Co. of Paterson, N.J., under the presidency of Edward Paul Schinman, Class of 1930. For a graduate of Wayne Township High School, Wayne, N.J., or if there is not an eligible candidate, for a graduate of one of the public high schools of Passaic County, N.J.

Claire and Roland Schmitt Scholarship (1988) For students who demonstrate leadership qualities.


Scofield Memorial Scholarship (2003) Established in memory of Mr. and Mrs. James M. Scofield ’38.

Peter Bailey Seaman '73 Memorial Scholarship (1999) Established by Jacqueline and Robert L. Seaman '50 in memory of their son. For students enrolled in the Lally School of Management and Technology.

William F. Seber Scholarship (1972) For a graduate of Troy High School.

Harry E. Seifert Scholarship (2004)

Irving Shapiro ’34 Scholarship (1974)

Professor Stephen R. Shatynski Memorial Scholarship (1983) Established by his family and friends. For students in the Schools of Engineering or Science. Preference given to two or more students from the same family attending RPI simultaneously.

Aaron Wiley Sherwood Memorial Scholarship (1971)

Edward B. Showell Scholarship (1973) Founded by Gertrude C. Showell, in memory of her husband, Edward B. Showell, Class of 1912.


Isabel and Frederick B. Silliman ’37 Scholarship (1988) Established by Isabel Silliman in honor of her husband. For students in the School of Engineering with preference for those in civil or electrical engineering.

Paula Loring Simon ’68 Scholarship (1994) For female students enrolled in the Information Technology Program and pursuing a secondary discipline in the School of Engineering.

Walter E. Smalley Scholarship (1979) For electrical engineering students from Dutchess County, N.Y.

Joel C. Spaeth ’59 Memorial Scholarship (1999) Established by Susan Spaeth in memory of her husband. For students enrolled in the School of Architecture.

Robert A. Spinnicchia ’77 Memorial Scholarship (1995) For students majoring in mechanical engineering.


William P. (Willie) Stanton Scholarship (1954) For an orphan, preferably from Rensselaer County, N.Y.


Carol and Joseph Stern ’61 Scholarship (1999) First preference given to students enrolled in the Department of Electrical, Computer, and Systems Engineering.

Anna C. and Frank J. Stevens Scholarship (1971)

George A. Strichman Scholarship (1985)

Robert O. Swanson ’58 Scholarship (2003) First preference given to top level candidates for admission who are underrepresented minorities, intending to major in engineering or science.

John and Eva Sweeney Memorial Scholarship (1976)

Texas Alumni Scholarship (1979) Established by alumni from Texas. For a student from Texas.

Martha and Clinton Thornton ’33 Scholarship (1989) For students in the School of Engineering.

The TISCO Scholarship (1988) For a student from Thailand or of Thai heritage.

Doris and Frank Tocher ’41 Scholarship (1993) First preference for a student in civil engineering.

Edward N. Toste ’79 Scholarship (1989) For members of Gamma Epsilon chapter of Tau Kappa Epsilon Fraternity who have exhibited leadership qualities. Recommendations by the board of trustees of the fraternity.

J. Philip Ulrich ’79 Scholarship (1989) For students in engineering and science with preference given as follows: 1) ex-Navy in nuclear engineering, 2) ex-military, 3) student holding a senior position of responsibility in student government or Union Club activity.

Angelo and Rosina DeStefano Valente Scholarship (1985) Founded by bequest of Professor Frank A. Valente in memory of his parents. For students from Padula, Italy.

Anthony Valente Scholarship (1985) Founded by bequest of Professor Frank A. Valente in memory of his brother. Preferably for students in nuclear engineering and science.

Laura Neske Valente Scholarship (1985) Founded by bequest of Professor Frank A. Valente in memory of his wife. Preferably for students in the physical sciences.


Madeline and Chester T. Vogel ’58 Scholarship (1990) in Memory of Bernard H. Vogel (1906-1999) For students enrolled in the school of engineering. First preference to students majoring in mechanical or electrical engineering for buildings, who demonstrate a commitment to becoming a professional engineer.

William J. Vonk ’49 / Karen Sievert Memorial Scholarship (1994) For an engineering student who is active in musical activities on campus.


Norman Wainer Memorial Scholarship (1964) Founded in memory of Norman Albert Wainer, Class of 1964. For an upper-class student, preferably in civil engineering.

Gladys Watson Scholarship (1981) Preferably for students from Newburgh Free Academy, Newburgh, N.Y.

Henry George Webb Sr. Scholarship (1967) Founded by Mrs. Henry George Webb Sr. in memory of her husband.

Jay J. Webb ’61 Family Scholarship (1990) Established by Mrs. Ruth Helen Wolf in honor of the Jay Webb Family. First preference to students from the Chicago, Ill., or Newington, Conn., areas.

Todd M. Weber Memorial Scholarship (1979) Founded by Mr. and Mrs. Marvin Weber in memory of their son, of the Class of 1975. For students in geology.

Donald E. Weimer ’74 “2%” Scholarship (1996) For upper-class students enrolled in the School of Engineering or Science.


Caroline and Charles Williams Scholarship (1983) Established by Harry K. Williams ’22. Preferably for students who graduated from Sand Creek High School, Sand Creek, N.Y.

H. Arthur Williams Scholarship (1982)

Richard J. Williams ’23 Scholarship (2000) First preference given to students enrolled in the Department of Civil Engineering.

Helen G. Williamson Scholarships (1925) For students from Troy.

Mary K. and Elliot H. Woodhull ’43 Scholarship (1992)

Harold F. Wrede Family Scholarship (1995) For students enrolled in the School of Engineering or Science.

Conrad Victor Yunker Scholarship (1937) Founded by Erma B. Yunker of Troy. For a student who has attended the public schools of Troy.

Graduate Financial Aid

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 graduate Institute fellowships and the schools and departments award fellowships and research and teaching assistantships. In the awarding of aid, the Office of Graduate Education and the departments consider such factors as the candidate’s academic record and background, and, in some cases, financial need. Fellowships are awarded for the full academic year, and are typically allocated in March or April for the following academic year. All fellowships consist of a calendar year stipend of at least $16,000. Assistantships consist of a stipend of at least $12,000 for the academic year and $16,000 for the calendar year and financial support equal to the full tuition charge. The Financial Aid Office 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. A graduate student may be supported on a Rensselaer fellowship or assistantship for a maximum of five years, given continued availability of funds.

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 both a stipend and tuition scholarship, and is responsible for no more than 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 by the Institute will receive a minimum stipend of at least $16,000. 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 Stafford loan program to graduate students.

Federal Stafford Loan Program (Subsidized)  Graduate students may borrow up to $8,500 per academic year for a cumulative total of $65,500, including any loans for undergraduate study. Repayment begins six months after the student ceases to be enrolled at least half time. New borrowers have a variable interest rate capped at 8.25%. The federal government deducts a 3% processing fee from the amount borrowed.

Federal Stafford Loans (Unsubsidized)  Interest rate, loan limits, and processing fees are the same as for the subsidized Federal Stafford Loan, with interest payments beginning 60 days after the loan is disbursed. Interest payments can be paid monthly, quarterly, or can be capitalized and added to the loan principal. Borrowers can receive both subsidized and unsubsidized loans for the same loan period. The combined total borrowed for both programs cannot exceed the maximum annual limit of $18,500 for graduate students. Stafford Loan eligibility is affected by changes in credit hours taken and in the amount of outside and department aid received.

New York State Aid  Residents of New York state may be eligible for Tuition Assistance Program (TAP) grants of $100 to $1,100. Awards are based on N.Y.S. taxable income. Applications must be filed annually with the New York State Higher Education Services Corp., 99 Washington Avenue, Albany, NY 12255.

Students who receive tuition awards from Rensselaer are required to apply for a Tuition Assistance Program award if eligible; the Rensselaer award will be reduced by the amount of the TAP award.

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 1,000 international graduate students representing more than 80 countries 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; approximately 30% of accepted students are offered aid. 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 minimum provision for living and personal expenses for the 2005-06 academic year is approximately $10,722 beyond tuition and fees. 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.

**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 & Chemicals Grant-in-Aid** for graduate study in chemical engineering.
- **Philip L. Alger Fellowship** for graduate study in engineering ethics.
- **American Cyanamid Fellowship** for disadvantaged students.
- **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.
- **Cluett Peabody Fellowship** for disadvantaged students.
- **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.
- **Equitable Fellowship** for graduate study.
- **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 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.
General Electric Traineeships for disadvantaged students.
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.
Grumman Scholarship master’s award for graduate study.
GTE Foundation Fellowship for graduate study in electrical, computer, and systems engineering, and computer science.
Gulf Oil Fellowship for disadvantaged students.
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.
Carolyn and William A. Klein ’62 Fellowship for graduate study in entrepreneurship.
Stanley I. Landgraf ’46 Memorial Fellowship for graduate students with preference given to former recipients of the Barbara and Stanley Landgraf ’46 Scholarship.
Y. L. Liu Fellowship for graduates of Hong Kong universities.
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.

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.

Raytheon Co. Fellowship for disadvantaged students.

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.

Donald Sturges Memorial Fellowship for disadvantaged students in engineering and management.

Takats 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.

Stephen B. Zimmerman ’66 Memorial Fellowship for study in industrial and management engineering.
Bills covering the fees of any term are mailed 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 fees. 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.

The schedule below is effective as of the summer session of 2005.

**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 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 the bill will be subject to a late payment fee of $175. In addition to the $175 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. Readmittance after this leave is contingent upon payment of money owed and proof of financial capability for the next term.

**Tuition**

**Undergraduate Tuition** The tuition for a normal undergraduate program (12 to 21 credit hours a semester) is $31,000 per academic year. This includes use of apparatus, athletic fields, and gymnasium, but charges for breakage in laboratory classes are additional.

Summer session tuition for undergraduates is $969.00 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 $969.00 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 $969 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 $31,000 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 9 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 $1,320 for each credit hour exceeding 15 credits or for each credit taken in the summer sessions.

Part-time graduate tuition is paid on a per-credit-hour basis of $1,320 per credit hour.

**Registration in Absentia** Graduate students who are primarily engaged in pursuing research-based degrees, (Ph.D. and certain MS degrees), have completed their coursework, have passed their qualifying examinations (applies only to Ph.D. students), are physically located off campus, and are not using institutional resources*, can Register in Absentia, (RIA). Eligibility for RIA requires that the student has been registered in both the previous fall and spring semesters. Eligible master’s students are permitted one semester of RIA, while Ph.D. students are permitted two semesters. Summer RIA is generally unnecessary.

**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** Graduate 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 ($1,320 per credit hour for 2005/2006).

**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 dean of students 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>Time Period</th>
<th>Refund 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>0%</td>
</tr>
</tbody>
</table>

Graduate Tuition Refunds for Part-Time Graduate Students Fall and Spring Terms:

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Refund 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.

* Students Registered in Absentia may visit the campus on an occasional basis if academic issues arise. RIA also allows students to retain electronic access to library resources and campus email.
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 ............................................................................................... $3,866 to $6,102
Family Housing ...................................................................................................$514 to $755 monthly

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.

<table>
<thead>
<tr>
<th>Plan</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum</td>
<td>(unlimited meals plus $100 MAD* per semester)**</td>
<td>$4,178</td>
</tr>
<tr>
<td>Diamond</td>
<td>(unlimited meals plus $75 MAD* per semester)</td>
<td>$3,982</td>
</tr>
<tr>
<td>Gold</td>
<td>(unlimited meals from 10 a.m.-7:30 p.m. plus $50 MAD * per semester)**</td>
<td>$3,992</td>
</tr>
<tr>
<td>Emerald</td>
<td>(unlimited meals from 7:30 a.m.-9:30 a.m. and 4:00 p.m. -7:30 p.m. plus $60 MAD* per semester)**</td>
<td>$3,866</td>
</tr>
<tr>
<td>Silver</td>
<td>(unlimited meals Monday-Friday from 7:30 a.m.-7:30 p.m. plus $50 MAD* per semester)**</td>
<td>$3,734</td>
</tr>
<tr>
<td>Bronze</td>
<td>(unlimited meals from 7:30 a.m.-3:00 p.m. plus $200 MAD* per semester)</td>
<td>$2,876</td>
</tr>
</tbody>
</table>

**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.

Undergraduate students............................................................................................... $235.25 per term
Graduate students........................................................................................................ $122.00 per term
Summer students.........................................................................................................$114.60 Session I
                                              $57.30 Session II
                                              $57.30 Session III

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 $193.00 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 $69.00 per session.

**Includes late night dining on Monday-Thursday from 10:30 p.m. to 11:30 p.m. at Russell Sage Dining Hall.**

* MAD-Meal Plan Advantage Dollars
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 $339 each semester for the Rensselaer Student Accident and Sickness Insurance Plan. Like the Health Center Fee, coverage extends for six months (August 15 to February 15, February 15 to August 15). Details on this plan are mailed to all students prior to enrollment and are also available at the Health Center.

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). Enrollment/Waiver applications are included with your tuition bill. Enrollment/Waiver forms are also available at the Student Health Center. 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. Students are urged not to waive this inexpensive and important coverage.

Optional dependent insurance coverage is also available. Enrollment forms are available at the Student Health Center.

An option to add an additional coverage upgrade layer that will increase the lifetime maximum payable for all conditions combined to $250,000 is available. Contact the Student Health Center for further information.

**Dental Insurance Premium** All matriculated regular graduate students are charged $75.00 each semester for the Guardian 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.

**Graduate Thesis Fee** This fee is payable as soon as the thesis is accepted, as follows:

- Master’s candidates: $10 for binding one copy of the thesis.
- Doctoral candidates: $80, which covers binding two copies of the thesis for use of the Folsom Library, as well as microfilming and publication of the thesis text and an abstract.

**Orientation Fee** All entering first year and transfer students, will be charged for the opportunity to attend programs held during the summer or before fall or spring semester for overall orientation, academic advisement, and course registration. This year’s fees are $150 for first year students, $100 for transfer students, and $50 for spring admissions. This fee is nonrefundable except where withdrawal is made prior to the fall Final Registration date for fall admissions or prior to spring Final Registration for spring admissions.

**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, MasterCard, or Visa 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 undergraduate 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 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 graduate academic regulations. After consulting with their academic adviser, 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
Frances Bronet, Greene 210B
276-6866, fax 276-3034, e-mail: bronef@rpi.edu
or Mark Mistur, Greene 302, 276-6868, e-mail: mistum@rpi.edu

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

Humanities and Social Sciences
Elizabeth Large, Sage 5208
276-2576, fax 276-4871, e-mail: largee@rpi.edu

Management and Technology
Robert Sands, Pittsburgh 3202  
276-6585, fax 276-2665, e-mail: sandsr@rpi.edu  

Science  
Samuel Wait, SC 1C05  
276-6305, fax 276-2825, e-mail: waitsc@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.  
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, Thesis, or Research 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 Consortium Colleges**  
It is possible to register for courses, at no additional tuition charge, at 21 other colleges and universities in the Capital Region, all members of the Hudson Mohawk Association of Colleges and Universities:  
In addition to Rensselaer, consortium members include:  

Adirondack Community College  
Albany College of Pharmacy  
Albany Law School  
Albany Medical College  
The College of Saint Rose  
Empire State College  
Fulton Montgomery Community College  
Graduate College of Union University  
Hartwick College  
Hudson Valley Community College  
Maria College  
Massachusetts College of Liberal Arts  
Excelsior College  
The Sage Colleges  
Schenectady County Community College  
Siena College  
Skidmore College  
SUNY Cobleskill  
University at Albany  
Union College
Courses taken at one of the consortium 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 at a consortium college in any semester. Students cannot cross register for courses offered at Rensselaer.

For graduate students, prior to enrolling in a course taught at a consortium college, the course should appear on an approved Plan of Study. The Office of Graduate Education reserves the right not to accept the course toward a degree program if it was not listed on an approved Plan of Study.

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 ten 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 ten 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 9 credits is allowed. Full-time graduate students must maintain full-time status at all times throughout their graduate career.
- 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 with supporting documents from parties involved, such as instructors, adviser, or medical director.

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 chairperson of the department. Summer tuition is charged at $1,320 per credit hour for full-time students.

**Graduate Teaching Assistants** Graduate teaching assistants are not required to take more than 9 credits per semester. However, at their own discretion and with Department Chairperson and Office of Graduate Education approval, graduate assistants may take up to 15 credits per semester for the following reasons:

- 3 additional credits assigned to a research project for thesis.
- 3 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 either the Professional School or 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.

Undergraduates admitted to the Professional Program of the School of Engineering may have to take certain graduate courses and may elect other such courses with the adviser’s approval.

**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 126 for the Bachelor of Science (Building Sciences) degree in the School of Architecture, and 168 for the professional degree in the School of Architecture.
- The minimum grade point average (GPA) is 1.80.
- 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 and Social Sciences section of this catalog.
Every student is required to successfully complete a writing course or a writing intensive course for a grade. Students can also satisfy this requirement with an AP English score of at least four, an SAT verbal score of at least 670, or a transfer course meeting Institute requirements for a writing intensive course. Students with an SAT score less than 610 are strongly advised to satisfy this requirement by taking a writing course.

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 48 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 48 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.

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 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 and MFA require 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.
- Pay binding fee, if applicable.
- 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.

Degree candidates who at any point in their tenure at Rensselaer are, or become, full-time students must maintain continuous full-time registration throughout their Rensselaer academic career to be eligible to graduate. These students must be registered full-time during the semester in which they intend to graduate, and:
Be in good academic and disciplinary standing.

Satisfy the culminating experience requirement as specified by the department.

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 the Vice President responsible for Education for Working Professionals for an extension. Final approval may be granted by the Dean of Graduate Education.

The Office of Graduate Education may initiate a departmental review of any student who has accumulated 36 or more credits on a master’s degree program (66 or more for the Master of Business Administration) without satisfying degree requirements unless the individual’s Plan of Study has been approved for more than 36 (66) credits. The review will consider whether the student should be dropped from the graduate program.

Students enrolled in thirty-credit master’s programs must not list more than thirty credits on their Plans of Study, with the further restriction that these credits must be selected from the first thirty-six credits earned.

**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 chair.

The thesis or project report must be presented to the candidate’s adviser for review at least two weeks before the end of the term in which the degree is to be awarded. Any final examination on the thesis or
project is to be held by the date listed in the academic calendar for the year. Theses and certain multiple semester projects are graded either S (satisfactory) or U (failed). Professional projects and certain other multiple semester projects receive a standard letter grade.

The candidate must deposit a copy of the thesis (or certain multiple-semester projects), together with the adviser’s written approval of both content and format, at the Office of Graduate Education at least one week before the end of classes in the term in which the degree is to be awarded. The Office of Graduate Education must certify that the approved document has been deposited before the degree is awarded. 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.

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 doctor’s degree must:

- Complete a Plan of Study with satisfactory grades containing 90 credit hours beyond the bachelor’s degree including any appropriate work completed toward a master’s degree. In satisfying this requirement 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 21 credit hours of 4000-4990 courses are to be allowed.
- 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.
- Satisfy the binding fee requirement.
- 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 have either: maintained continuous full-time registration; maintained continuous full-time registration following a change of status from part-time to full-time; or been, at all times, a part-time student. Under no circumstances will a full-time student be allowed to transfer to part-time status and maintain eligibility for graduation.

Full-time degree candidates must be registered full-time during the semester in which they intend to graduate.
Residence and Time Limit
A student working for the doctor’s degree is required to take at least 45 credit hours of course and/or thesis work at the Troy campus. Residency requirements for the Troy campus may also be met within programs at certain off-campus sites (branch campuses).

For full-time students, all work for the doctorate must be completed within seven years of registration for the first credits applied toward the 90 credits required for the Ph.D. 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 chair of the student’s department assigns a temporary 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 a dissertation 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 department chair sends the nominations to the Office of Graduate Education, which approves the doctoral committee.

The committee must include at least four full-time tenure-track Rensselaer faculty members. One committee member must be outside the student’s department. Where special circumstances exist, an individual who is not a tenured or tenured-track Rensselaer faculty member may be approved as one of the four committee members, or as an additional fifth member from outside the university. In each case, the individual must receive prior approval by submitting a curriculum vitae to the academic department chair, and to the Dean of Graduate Education. The committee members represent the principal areas included in the student’s Plan of Study. They assume responsibility for this plan and also for the student’s candidacy and final examinations.

Plan of Doctoral Study
A prospective candidate for the doctorate ordinarily follows a Plan of Study of a minimum of 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 first ninety credits that are sufficient to meet the academic requirements for the doctoral degree. They should list these credits in chronological order of registration, and may not include credits taken after they have sufficiently met degree requirements.

Candidacy
A student may apply for the candidacy examination, given by the doctoral committee, when:

- His or her course work nears completion.
- He or she has the approval of the doctoral committee.
- The examination, usually the Candidacy Exam, that the department uses to formally determine a
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 should notify the Office of Graduate Education of the student’s candidacy. All degree requirements must be completed within three years of admission to candidacy.

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 manual, Thesis Writing, containing required format specifications, is available from the department, the Office of Graduate Education, or on the Web on the Office of Graduate Education’s home page at http://www.rpi.edu/dept/grad/gradschool.html. Before preparing your final manuscript, please check the Office of Graduate Education website for the most recent formatting and submission guidelines.

The dissertation is presented to the candidate’s dissertation adviser at least one month before the end of the term in which it is expected that the degree will 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 two weeks before the end of the term in which the degree is expected to be awarded, the candidate must deposit at the Office of Graduate Education two original copies of the dissertation in its final form including the required format specifications. A copy of the abstract, no longer than 350 words or 2,450 characters, with an abstract title page also must be included. The dissertation should be placed in a manila envelope with a copy of the title page on the front side. The original copy of the abstract with an abstract title page also must be included. The abstract title page should be the same as the dissertation title page except for the words “An Abstract of a Dissertation” etc. added. The title page for the dissertation must have the original signatures of the members of the doctoral committee. A Thesis/Project Examination Form, approving both content and format, signed by the chair of the doctoral committee must accompany these. The Office of Graduate Education must certify that the approved dissertation has been deposited before the degree can be awarded.

Publication of Dissertation
Before the candidate is certified for graduation, he or she must pay a dissertation fee to cover the costs of microfilming, publication of the abstract, and binding two original copies for preservation and use in the general library. A copy of the microfilm is deposited in the Library of Congress, and the abstract is published in the monthly journal, Dissertation Abstracts. Copies of the dissertation on microfilm and the journal then are available from University Microfilms, Ann Arbor, Michigan. The forms to be filled out for this purpose are available in the Office of Graduate Education and may be completed either prior to or at the time the dissertation is submitted.
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 _______________________ in the Department of _______________________ at Rensselaer Polytechnic Institute.”

The right of conventional publication is in no way abridged by microfilming, 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).

**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” or “C-” grade work is required for transfer credit.

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 desiring transfer credit must have the registrar of the other institution forward an official transcript and course descriptions (or the student may submit copies of catalog course descriptions) to the Rensselaer Registrar’s Office. When the Transfer Credit Approval form, the official transcript, and course descriptions are received, the Registrar’s Office will forward the material to the appropriate departments for their review (if approval was not previously obtained). Final grades will be checked for courses previously approved, and if at least a “C,” or “C-” credit can be given directly. 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.

Credit by Validation Exam

Academic credit for college-level proficiency may, in special cases, be established for formal study done in other than an accredited institution by validation exam. Only full-time students are eligible. A written statement submitted to the registrar detailing the basis of their experience is required. A student must obtain approval from the registrar and the adviser or department head in the area concerned. Validation examinations are not permitted for courses previously failed or audited. A fee is charged for each examination taken. Students should check with the Registrar’s Office for procedures and appropriate forms.

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 admission at Rensselaer. 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 doctor’s degree is 45 credit hours beyond the master’s degree, not more than 45 credit hours may be transferred toward the doctorate.
Double counting credits for multiple degrees is subject to approval by all departments.

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 “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.

Academic credit for college-level proficiency may, in special cases, be established for formal study done in other than an accredited institution by validation exam. A student must obtain approval from the registrar and the adviser or department head in the area concerned. A fee is charged for each examination taken. Students should check with the Registrar’s Office for procedures and appropriate forms. Normally a validation exam is used to satisfy a specific course requirement, thereby allowing the student to replace the required course with an appropriate elective on his or her Plan of Study. Credits earned by validation exam may not be used to satisfy residence requirements.

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 has to 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 to 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 dean of students for counseling.

A student who is a member of an authorized team or organization for which events are scheduled is excused 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 Samaritan 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 or, in the case of graduate students, by the Office of Graduate Education. Procedures for resolution of conflicts (i.e., examinations scheduled for the same time), 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 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 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 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

See online catalog for phase-in schedule.

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:

n Absence from a final examination.
n Student on class list who has never attended class.
n Student who wishes to do additional post-semester work in order to improve a grade.
n 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 “IP” (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 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 6 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 H&SS 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 by the Faculty Senate Curriculum Committee. Examples of such courses are seminar, thesis, or certain general electives, such as Tour of the Solar System, and others.
"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 and the grade points and credit hours corresponding to each are considered in computing the average.

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 1.60 at the end of the spring term; sophomores—1.70 at the end of the fall or spring term; juniors and seniors—1.80 at the end of the fall or spring term.

Probation is removed when the following minimum requirements are met during a term in a program of not less than 12 credit hours: freshmen—1.80 grade point average for the term and a cumulative grade point average of 1.60; sophomores—1.80 grade point average for the term and a cumulative grade point average of 1.70; juniors and seniors—1.80 grade point average for the term and a cumulative grade point average of 1.80.

A student on academic probation may have that status removed at the end of the summer session if he or she maintained a grade point average of 1.50 during the previous term and has raised his or her cumulative average to the following prescribed levels: entering sophomore year, 1.60; entering junior year, 1.70; entering senior year, 1.80.

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
The Office of Graduate Education will review the records of students recommended for suspension or dismissal by the department chair. The student will be notified in writing by the Office of Graduate Education of any decision to suspend or dismiss. 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.

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.

A meeting for this purpose must be arranged between the student and a member of the Dean of Students 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.

Withdrawal from Rensselaer
To leave the Institute in good standing, an undergraduate must submit a letter to the dean of students 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.

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 dean of students 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 submit a letter to the dean of students, 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, student are considered withdrawn.

Students may also be placed on an involuntary leave of absence from Rensselaer. There are four possible scenarios that might apply: (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 1st day of classes. (2) The student 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.

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 Dean of Students 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, (OGE). Leaves are generally granted only during the first eight weeks of classes. Tuition refunds are based on the schedule listed on page 65. 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 OGE. 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 1st 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 OGE. The Health Services Department and OGE 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 OGE 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 OGE 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 Dean of Students Office 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 Dean of Students Office.

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 Office of the 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 upon request of the Dean of Students.

Graduate Readmission
Graduate students desiring readmission must have the approval of the Office of Graduate Education. The student must fill out a Graduate Change of Status form, which is available in the Registrar’s Office. A student requesting readmission, will be required to have departmental approval. Academic departments and/or the Office of Graduate Education may require reapplication.

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.

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 who presents the best thesis involving research in any branch of engineering or science.

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.

**American Institute of Architects Medal (1934)** The American Institute of Architects each year awards a silver medal and a book to the member of the graduating class in the School of Architecture who is outstanding in scholarship, personality, and promise of a successful professional career.

**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 electric power or 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 Moles’ Award (1973) The award, consisting of a prize of $100 and an award certificate, is given by the Moles, a national association of men engaged in engineering construction. It is given to a student in engineering whose academic achievement and enthusiastic application show outstanding promise for personal development leading to a career in construction engineering and management.

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 PPG Industries Foundation Management Systems Award (1991)** An annual prize established by PPG Industrial Foundation awarded to an outstanding senior in the area of management systems.

**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.

Center for Finance & Technology Award (1999) An annual prize awarded to an academically outstanding undergraduate management student with a concentration in Finance.

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.
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** ..........................................................pp. 397

The Master of Science degree traditionally has been in a single subject matter, e.g. chemistry, physics, or mathematics. However, the working environment that college graduates face today and will face in the future is one in which their 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 of the past few decades and most current graduates are not educated adequately for today’s interdisciplinary world. Options exist in many areas of science.

**Biochemistry and Biophysics** ................................................pp. 398

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 graduate school and/or employment in various sectors of the rapidly developing biotechnology industry. It also provides an excellent background for students planning careers in medicine. An M.S. degree is also available in this interdisciplinary field and is ideal preparation for jobs in biotechnology, pharmaceuticals, and other related industry sectors.

**Bioinformatics and Molecular Biology** .......................................pp. 403

Biotechnology and information technology are emerging new fields that are changing the world. Anticipating the demand for graduates with a range of skills covering mathematics, chemistry, and physics, Rensselaer developed a B.S. degree program that provides solid background in all of these disciplines. At the program’s core are courses in the theory and practice of bioinformatics that deal with topics such as database design and search algorithms, sequence alignment, sequence analysis, and molecular modeling. This core includes a molecular biology sequence and training in drug discovery.

**Ecological Economics, Values, and Policy** ......................................pp. 292

The B.S. degree combines ecological economics, environmental policy studies, and social and cultural theory and practice. Offered by the Department of Economics and the Department of Science and Technology Studies, the program in Ecological Economics, Values, and Policy (EEVP) satisfies the curriculum requirements for the B.S. programs in both departments. The program combines the best of both departments: economic analysis and a broader humanities and social science analysis that emphasizes the roles science and technology play in today’s global economy and culture.

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) .......................................................pp. 290

The EMAC degree combines communication theory and practice with electronic media arts studio and theory. This program combines offerings in the Department of Language, Literature, and Communication and the Arts Department.

Environmental Science ...........................................................................................................pp. 407

The challenge of keeping the Earth safely inhabitable while still providing for an ever increasing population and its expanding needs ensures an ongoing demand for environmental scientists. Meeting this challenge requires broader perspective than any single discipline affords. In fact, expertise is necessary beyond just the sciences. Rensselaer's B.S. in Environmental Science addresses these challenges with a multifaceted program.

Information Technology ...........................................................................................................pp. 304

Rensselaer's unique cross-disciplinary degrees in Information Technology combine an innovative information technology curriculum with courses in other disciplines to give students the broad base of skills that industry is seeking. The program offers dual competencies: a grounding in information technology and expertise in a concentration such as management, the arts, engineering, architecture, science, and medicine. At Rensselaer, IT is understood in the broadest sense to incorporate the computing and communications industries, including hardware and software; the information, communications, and entertainment services; and the research and application of IT in and to all fields. The program leads to a Bachelor of Science in Information Technology and a Master of Science in Information Technology.

Interdisciplinary Science ........................................................................................................pp. 411

Always encouraging of students' interests outside the traditional disciplines and career paths, Rensselaer offers this B.S. program that allows for the combination of sciences in innovative ways. In addition it provides the opportunity to combine science with more humanistic studies such as management, law, education, communication, public service, economics, policy-making, or community affairs.

Interschool Minor in Energy .....................................................................................................p. 287

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.

Minds and Machines .................................................................................................................pp. 295

The Minds and Machines (M&M) program, which is closely affiliated with the Rensselaer Artificial Intelligence and Reasoning Laboratory (RAIR Lab), offers students a number of options for the B.S. degree. Course work and research are designed to prepare students to make smarter machines and to design the machines that make people smarter. As industry and government increasingly produce and deliver their products and services in computer-mediated environments, the demand is increasing for people who understand human intelligence, machine intelligence, and the social and organizational aspects of the interface between human and machine systems. For more information consult www.rpi.edu/dept/ppcs/MM/mm.uc.html.
Multidisciplinary Science.................................................................pp. 413

Increasingly, college graduates with traditional discipline oriented backgrounds are discovering that their jobs are bridging more than one area of specialization. Rensselaer’s M.S. and Ph.D. programs in multidisciplinary science are designed to help such individuals function more effectively in such multidisciplinary environments. Through these programs, students interact with faculty representing a variety of disciplines and participate in interdisciplinary research programs that bridge not only science disciplines but also science and engineering.

Product Design and Innovation.........................................................pp. 135, 234, 298

Product Design and Innovation merges the technical with the creative and stimulates originality. A dual major in one of four fields (Mechanical Engineering, Building Sciences, Management, and IT) and Science and Technology Studies combines engineering disciplines, STS courses, and design studios. A dual major in Building Sciences (School of Architecture) and Science and Technology Studies combines architecture and building science disciplines, STS courses, and design studios. The program in Product Design and Innovation (PDI) is jointly offered by the Schools of Engineering, Architecture, Humanities and Social Sciences, and the Lally School of Management and Technology. It offers four tracks; the first satisfies the requirements for the B.S. program in both Mechanical Engineering and Science, Technology, and Society (STS); the second satisfies the requirements for the B.S. programs in both Building Sciences and STS; the third satisfies the requirements for IT and STS; and the fourth satisfies the requirements for management and STS. For more information, consult www.rpi.edu/dept/sts/pdi.
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School of Architecture

**Dean:** Alan Balfour  
**Associate Dean:** Peter Parsons  
**Chair, Graduate Programs:** Ted Krueger  
**Chair, Undergraduate Programs:** David Riebe  

School of Architecture home page: [http://www.arch.rpi.edu](http://www.arch.rpi.edu)

Significant changes are occurring within the discipline and profession of architecture in the areas of globalization, interdisciplinary teamwork, and emerging technologies. Along with a strong creative focus, these issues are at the core of Rensselaer’s undergraduate and graduate architecture programs. The school offers extensive international study programs in locations such as Italy, India, and China; a culture that encourages study and research between disciplines; a studio environment that supports the most ambitious applications of information-based design and technology while encouraging critical innovation.

A strong permanent faculty of 15 professors and a complement of clinical and adjunct professors drawn from research and practices in New York, Boston, and Montreal center their instruction on design, which is the core of the undergraduate experience.

These same qualities characterize Rensselaer’s several areas of graduate study in architecture. Apart from the professional masters degree that is designed for those with undergraduate degrees in other fields, the School offers several areas of master’s level specialization: Architectural Acoustics, Building Conservation, Lighting, Building Systems Research, and Computation in Design. Each of these focuses on aspects of technology appropriate to Rensselaer and incorporates program elements of Rensselaer’s nationally renowned Lighting Research Center, a preeminent laboratory for lighting research. The Doctor of Philosophy 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.

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 physical 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 90,000 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 is growing to include microfiche and such electronic media as videos and architecture-related software. (More information can be found at the library’s web site: [http://www.rpi.edu/dept/library/html/architecture](http://www.rpi.edu/dept/library/html/architecture).)

Specialized facilities and equipment that enhance school activities include a testing room with a Hemi-anechoic chamber, the Binaural Listening and Auralization test station, computer labs, coupled laboratory spaces for acoustic telepresence research and investigation, 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 Lee Harris Pomeroy ’54 Advanced Visualization Lab; the Synthetic Environments Lab, the Laboratory of Human-Environment Interaction Research; the Electronic Studio 305; the Solar and Microclimate Laboratory, the School of Architecture Workshop, Field Study Facilities, Optical Tools, the Community Outreach Partnership Center in the Gurley Building, and various other laboratories. These are generally available to all students, although in some cases training may be required and some equipment is reserved for advanced students.
This combination of excellent programs and modern facilities endows all School of Architecture graduates with a distinctive creativity, pragmatism, independence, and a progressive outlook that makes them highly sought for not only architectural practice, but also for positions in their specific areas of specialization.

**Degrees Offered**

- Architecture: B.Arch., M.Arch.
- Building Conservation: M.S.
- Architectural Sciences: M.S., Ph.D.
  - Concentration in Architectural Acoustics
  - Concentration in Building Systems Research
  - Concentration in Computation in Design: M.S.
  - Concentration in Computation in Design: Ph.D.
  - Concentration in Lighting: M.S.

**Overview of Undergraduate Programs**

The School of Architecture offers a four-year Bachelor of Science in Building Sciences and 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 school designed for those ready to begin serious architectural study in the first year, the School of Architecture’s admissions decisions are based on three criteria: overall academic excellence, creativity demonstrated through work in the arts and other areas, and maturity and personal motivation. The School encourages visiting the campus and the Greene Building, home of the School of Architecture, along with a faculty interview. All undergraduate program applicants must also provide a portfolio. For portfolio requirements visit [www.arch.edu/undergraduate](http://www.arch.edu/undergraduate).

Students who have completed some architecture course work at other schools may apply for transfer 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 Graduate Programs**

Rensselaer’s School of Architecture offers both masters 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 10 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 Building Conservation
- Master of Science in Architectural Sciences (Concentration in Architectural Acoustics)
- Master of Science in Architectural Sciences (Concentration in Building Systems Research)
- Master of Science in Architectural Sciences (Concentration in Computation in Design)
- 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 four areas of concentrations. They include:

- Ph.D. in Architectural Sciences (Concentration in Architectural Acoustics)
- Ph.D. in Architectural Sciences (Concentration in Building Systems Research)
- Ph.D. in Architectural Sciences Concentration in Computation in Design
- Ph.D. in Architectural Sciences (Concentration in Lighting)

and also 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 many areas of communication acoustics such as advanced techniques for computational modeling of room acoustics. Examples of current research include modeling and perception of coupled acoustical spaces, including sound and vision, perception of early reflections due to scattering of sound by rough surfaces and the fine structure of reverberation, room sound coloration, acoustics of under-balcony environments, 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, MA; Troy First Niagara Savings Bank Hall, Troy, NY; and San Patrick Cathedral, Waterville, NY; to measure different 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 diffusitivity 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.

Active room acoustics and room tuning using electroacoustics
Electronic tuning can be very helpful in adapting the venue to the events taking place in it (music performances of different genres, conferences, etc.). Such dynamic tuning is very important to insure optimum acoustic quality in multipurpose spaces.

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 and setting targets for the design for sound quality for product applications such as automobile, household, etc., and the goal is to give sound to the work, the work in transmission sound quality focuses on the effect of transmission inaccuracies of speech systems, linear and nonlinear distortion in microphones and loudspeakers, and related applications.

Ultrasonic sensing
This research area is primarily concerned with finding cost-effective, fast and efficient methods of sensing the sonic environment using ultrasound for use with self-propelled robots and other devices needing remote sensing for interaction with the environment.

Light and health
The Lighting Research Center continues to seek funding 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 (SAD) 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 seeks funding for research to assist 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 seeks funding to expand research into the development of lighting as part of intelligent roadway systems.
Faculty*

Professors

Balfour, A.—M.F.A. (Princeton University); architecture and urban history and society.

Bronet, F.—M.S. (Columbia University); architectural design, structures technology, interdisciplinary design. Past President, ACSA.

Goebel, J. M.A.—M.Arch. (Staatliche Hochschule fur Music and Theater); music composition and performance.

Haviland, D.—M.Arch. (Rensselaer Polytechnic Institute); building industry, management, economics.

Leslie, R.—M.Arch. (Rensselaer Polytechnic Institute); lighting, daylighting, environmental comfort technologies.

Rea, M.—Ph.D. (Ohio State University); vision science; lighting theory and applications.

Associate Professors

Bell, D.—M.Arch. (University of Virginia); architectural design, theory, and history.

Dyson, A.—M.Arch. (Yale University); architectural design, structures technology, multidisciplinary design theory and ecology.

Krueger, T.—M.Arch. (Columbia University); human-environment interaction, architecture of extreme environments, design.

Massie, W.—M.Arch. (Columbia University); architectural design, computer applications and emerging technologies, architectural practice.

Mistur, M.—M.S. (Rensselaer Polytechnic Institute); architectural design, practice, technology.

Narendran, N.—Ph.D. (University of Rhode Island); remote source lighting, fiber-optic sensors, geometric and physical optics.

Parsons, P.—B.Arch. (Cornell University); architectural design, theory, and history.

Warriner, K.—B.Arch. (University of Florida); architectural and urban design and theory.

Xiang, N.—Ph.D. (Ruhr University, Bochum, Germany); architectural acoustics, acoustic signal processing.

Assistant Professors

Van Dessel, S.—Ph.D. (University of Florida); Dipl. Arch. (Vlamse Hogeschool voor Wetenschap en Kunst, Sint Lukas Institute) emerging materials and material development, sustainable architectural technologies.

Clinical Professors

Abbate-Gardner, C.—M.Arch. (University of Rome); architectural and urban design, practice, and Italian studies.

Ellinger, J.—M. Arch. (Columbia University); design.

Oatman, M.—M.F.A. (University at Albany); drawing, design, painter and installation artist.

Riebe, D.—M.S. (Columbia University); architectural design, emerging technologies and practice. practicing licensed architect.

Saunders, A.—M.Arch. (Harvard University); architectural design, emerging technologies and surface logic. SOM Fellow 2004.

Emeritus Faculty

Boyce, P.—Ph.D. (University of Reading); human factors.

Kroner, W.—M.Arch. (Rensselaer Polytechnic Institute); resources and sustainable architecture, advanced building technologies, futurism, and architectural design.

* 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 2005 Board of Trustees meeting.
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.

Williams, G.—M.Arch. (Rensselaer Polytechnic Institute); architectural design and practice.

Adjunct and Visiting Faculty

Akashi, Y.—Ph.D. (Musashi Institute of Technology); human factors in lighting.

Bedford, S.—Ph.D. (Columbia University); architectural history, regulatory compliance.

Benemore Duarte, E.—M.S. (Columbia University); architectural design, emerging technologies and drawing, licensed architect.

Bierman, A.—M.S. (Rensselaer Polytechnic Institute); mesopic vision, color vision, lighting controls, measurement of lighting efficiency.

Bucher, D.—B. Arch. (Rensselaer Polytechnic Institute); partner, historic preservation, building conservation.

Boyer, K.—Ph.D. (McGill University); urban design, information technology gender and work.

Bullough, J.—Ph.D. (Rensselaer Polytechnic Institute); psychological and biological effects of light, lighting for transportation, technology transfer.

Byszewski, V.—D.Sc., Ph.D., M.S. (Warsaw University), Ph.D. (Polish Academy); lighting technology.

Carpentier, Jr., D.—B.A. Historic Preservation (Empire State College); historic preservation.

Carroll, P.T.—Ph.D. (University of Pennsylvania); history of American science and technology, industrial archeology.

Cawley, F.—B.F.A. and B. Landscape Architecture (Rhode Island School of Design); historic preservation, landscape architecture, and urban design.

Ebbing, C.—M.S.E.E. (State University of New York at Buffalo); industrial acoustics, research special noise control.

Erdem, A.—M.Arch. (Rensselaer Polytechnic Institute); architectural design.

Facca, A.—M.S. (University of Virginia); urban planner.

Figueiro, M.—Ph.D. (Rensselaer Polytechnic Institute); architectural design and construction management.

Fleisher, S.—B.A. (Northeastern University); furniture design.

Foulks, W.—M.A. (Columbia University); restoration and preservation of historic buildings.

Freidman, D.—B.S. (Rensselaer Polytechnic Institute); historic buildings engineering practice.

Hartgen, K.—M.Arts (University at Albany); artifact preservation.

Hill, K.—M.Eng. (Cornell University); practicing structural engineer.

Hoffman, D.—B.A. (Carnegie Mellon University); theater, technical theater, stage design, stage lighting, theatrical engineering.

Holehan, J.—M.S. (Syracuse); planning, economics.

Holmes, O.—B.S. Mathematics (State University College Oneonta) B.S. Mechanical Engineering (Syracuse University), HVAC, building systems, energy management.

Horgan, W.—B.Arch. (Bath, UK); design and construction: Tracking EMPAC. UK licensed architect working in NYC for Grimshaw Architects PC.

Jatsch, M.—Ph.D. (Technical University of Munich, Germany); architectural design, emerging technologies, light and space production, practicing licensed architect.

Kim, J.—M.Arch. (Princeton); information and public space in architecture.

Levin, R.—Ph.D. (Stanford University); lighting optics, lighting application, nonionizing radiation.

Lewandowski, P.—AIA, LEED Accredited Professional, B.Arch, (Rensselaer Polytechnic Institute); professional practice, practicing architect.
McColgan, M.—Ph.D. Physics (University of Alabama in Huntsville); B.S. Optics (University of Rochester); light pollution, outdoor lighting, optical modeling.

Miller, N.—B.S. (Massachusetts Institute of Technology); energy-efficient lighting for residential and commercial uses, lighting quality and human factors.

Miner, D.—M.S. (Columbia University); preservation law.

Mintz, N.—M.S. (Columbia University); urban design, historic preservation.

Morante, P.—B.S. Electrical Engineering (Norwich University); marketing and electric power markets.

Nelson, B.—B.A., B.S. (Rensselaer Polytechnic Institute); professional practice, community planning, project management.

Oltrogge, B.—M.Arch. (Montana State) digital fabrication and modeling with emphasis on CAD/CAM technologies.

Palenzuela, N.—M.Arch. (University of Florida); design.

Pepi, R.—M.S. (Columbia University), architectural materials conservation and historic preservation.

Pierpont, R.—B.A., M.A. English (University at Albany); historic preservation.

Reilly, S.—B.Arch., B.S. (Rensselaer Polytechnic Institute), architectural design, practice, preservation technology.

Shaver, P.—B.A. Liberal Arts (Syracuse University); American history, architectural history.

Torres, Rendell—Ph.D. (Chalmers Tekniska Hogskola, Gothenburg, Sweden); architectural acoustics; auralization of sound fields, subjective effects of room acoustics.

Van Derlofske, J.—Ph.D. (University of Alabama in Huntsville); illumination systems, optical design, optical computer modeling, prototype development.
Undergraduate Programs

The School of Architecture offers two distinct undergraduate degrees. The five-year Bachelor of Architecture (B.Arch.) curriculum centers on the design studio and culminates in a year-long research and design project. Computing, theoretical, technological, and historical issues are progressively integrated into the design 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.

The second undergraduate curriculum is the four-year B.S. in Building Sciences, which prepares students for the broad range of building industry roles and opportunities. Rensselaer’s excellence in science and technology permits specialization within the Building Sciences program. Students enrolled in the Bachelor of Architecture program may, anytime after the second year, apply for transfer to the four-year Building Sciences degree program. Rensselaer’s Building Sciences students may also choose to concentrate in Information Technology as it relates to the building industry, energy efficiency in buildings, project and construction management, or lighting. In addition, independent studies are available in special topic areas. Another option is the interdisciplinary Product Design and Innovation dual degree program offered jointly between Building Sciences and the School of Humanities and Social Sciences’ Department of Science and Technology Studies.

Each of these degree programs are described in detail below.

Students in both School of Architecture undergraduate programs are required to complete courses in the arts, sciences, humanities, and social sciences as part of the Institute core requirements. The core courses are structured to provide exposure and breadth to each of these areas.

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 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.

- **Retention of Student Design Work**—All drawings and models done by students as part of the instructional program are the property of the Institute until they have been released by the instructor. The School of Architecture at its option, may retain certain works for academic purposes.

Baccalaureate Programs

**Bachelor of Architecture (B.Arch.) Curriculum**

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. The following statement is included in the catalog, pursuant to the requirement of the NAAB:
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 Accreditation Board, which is the sole agency authorized to accredit U.S. professional degree programs in architecture, recognizes two types of degrees: the Bachelor of Architecture and the Master of Architecture. A program may be granted a six-year, three-year, or two-year term of accreditation, depending on its degree of conformance with established educational standards.

Master’s degree programs may consist of preprofessional and undergraduate degree and a professional graduate degree, which, when earned sequentially, comprise an accredited professional education. However, the preprofessional degree is not, by itself, recognized as an accredited degree.

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 representation of ideas. The ability to freely manipulate space, surface, structure, and texture is central to the reformation 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 the 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 ability. The early semester-long studios introduce students to the 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 they present choices of project and faculty. Among these is the design development studio, in which a prior project is subjected to detailed structural, mechanical, construction materials, and professional practice considerations.

- **History and Theory**—A required five-course sequence presents the diversity of architectural works and ideas relative to the contexts within which architecture emerges and to key historical and theoretical issues in the field. Following this sequence, students may take additional advanced architectural history/theory electives as a part of their professional or free elective.

- **Technology and Building Science**—Technological issues are introduced from the beginning as essential to the conception and creation of architecture. New technologies can be the generative of form and inhabitable space. A series of six required technology courses consider 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 systems, including heating, ventilation, air conditioning, plumbing, and electrical systems; sensory environment, including the luminous, acoustical, and tactile environments; 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 and the act of creating in the required upper level design development studio.
Computing—Computer proficiency is central to the future of architecture. From the first year, students are able to expand their knowledge and skill through course work with key computing concepts and applications—in some cases integrated within the design studios—and through independent experimentation in the many computer labs at the School and Institute. Apart from well-supported general-purpose labs, the School offers high-end multimedia environments within the many design studios. Students have access to the latest in three-dimensional design software, virtual reality programming tools, and video and multimedia production hardware and software to investigate the value of these technologies to critical design practice. Students may experiment with immersive 3-D, VR collaboration, or video and animation-based investigations of architectural and urban form. Advanced software from film production and VR-based manufacturing is available in an environment designed for digital collaboration.

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, 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. A minimum of four credits must be from a designated list of history electives. 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 Structures Technology
- Advanced Technologies Seminar
- American Building—17th–19th Centuries and 20th
- Architectural Acoustics 1 and 2
- Architecture and Urban Design in the Italian Renaissance
- Bedford Technology Seminar
- Building Conservation 1 and 2
- Building Design/Construction
- Building Engineering Design Seminar
- Construction Industry Seminar
- Design: Built Ecologies and Natural Systems
- Drawing Historic Structures
- Electronic Media: Critical Visualization
- Electronic Media: Physical Design Processes
- Emerging Materials and Material Development
- Evolution of Housing in the 20th Century
- Extreme Drawing
- Geometry in Architecture
- History of Landscape
- Human Environment
- Human Factors in Lighting
- Lighting Design
- Lighting Technology
- Philosophies of Space in a Digital Culture
- Preservation Theory
- Recording Historic Structures
- Re-Painting the White Cube
- Seeing Digital
- Simulation
- Sustainable Community Design
- Understanding Computer Mediated Design
- Workshop: Material Exploration and Fabrication

The five-year B.Arch. program concludes with an individually initiated, planned, and developed comprehensive project. Planning begins in the fourth year through an exchange of ideas with and a critique by a faculty adviser and review committee. The resulting proposals form published faculty statements of interest combined with the students’ experiences and areas of special concern. These may emerge from a synthesis of previous work that applied gained knowledge to advanced issues or, alternatively, experiences to date may be used 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 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 dual majors may involve some variation from this template.

### Bachelor of Architecture Curriculum

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<td>ARCH-4690</td>
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</table>

¹ IHSS-1970 will fulfill the Institute writing requirement.

² Four credits of the Hum. or Soc. Sci 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.
All undergraduate students should develop a plan of study with their faculty adviser. The degree requires 168 credit hours.

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 the completion of the urban studio (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 and Social Sciences from an extensive list of course offerings (see Institute core requirements for greater detail). In addition, students have 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-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.
Bachelor of Science in Building Sciences Curriculum

The four-year Bachelor of Science degree in Building Sciences prepares students for the broad range of roles and opportunities presented by the building industry. Students enrolled in the B.Arch. program may, anytime after the second year, apply for transfer to Building Sciences. The building sciences focus on the design and construction of building systems such as structures, enclosures, environmental systems, lighting, and acoustics, as well as their management, performance, and building diagnostics.

Students in the Building Sciences program declare a concentration and submit a plan of study at the end of the second semester. The plan of study must be approved and filed with the Building Sciences program director. For the first two semesters, students follow the same curriculum as the B.Arch. students. For the remaining six semesters, they take concentration electives in place of design courses. Concentrations include computer applications, lighting, construction management, and advanced technology assessment. The degree requires 126 credit hours.

Building Science Curriculum

First Year

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
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<tbody>
<tr>
<td>ARCH-2110 The Building and Thinking of Architecture 1</td>
<td>ARCH-2120 The Building and Thinking of Architecture 2</td>
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<tr>
<td>ARCH-2200 Design Studio</td>
<td>ARCH-2210 Architecture Design 1</td>
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<td>MATH-1500 Calculus I</td>
<td>PHYS-1050 Physical Principles of Design</td>
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<td>ARCH-2510 Materials and Design</td>
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Second Year

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<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>ARCH-2360 Env. and Ecol. Systems 3</td>
</tr>
<tr>
<td>Professional Elective</td>
<td>ARCH-4500 Construction Industry Seminar</td>
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<tr>
<td>ARCH-2330 Structures 1</td>
<td>ARCH-4740 Bldg. Sys. and Env. 4</td>
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<td>MGMT-2100 Statistical Methods</td>
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Third Year

<table>
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<th>Fall Credit hours</th>
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<tr>
<td>Concentration Elective</td>
<td>ARCH-4510</td>
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<tr>
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<td>ARCH-4740</td>
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1 Four credits of the Hum. or Soc. Sci core requirements are embedded within The Building and Thinking of Architecture sequence: ARCH-2110 and ARCH-2120.

2 IHSS-1970 will fulfill the Institute writing requirement.

3 Four credits of the Institute core Science requirements are embedded within the Technology sequence: ARCH-2330, ARCH-2360, ARCH-4330, and ARCH-4740.
The degree requires 126 credit hours. All undergraduate students should develop a plan of study with their faculty adviser.

Concentrations
All Building Science program concentrations require five four-credit-hour courses (or equivalent) that are approved by a concentration coordinator and the director of the Building Sciences program. Concentration options and their associated courses include:

### Lighting
- LGHT-4840 Human Factors in Lighting (4)
- LGHT-4770 Lighting Technology and Applications (4)
- LGHT-4230 Lighting Design (4)
- LGHT-4940 Advanced Individual Projects in Lighting (8)

### Construction Management
- ARCH-4810 Advanced Technology Seminar (2)
- MGMT-1100 Intro. to Management (4)
- MGMT-4110 Operations Management I (4)
- ARCH-4940 Adv. Ind. Projects in Arch. and Env. (4)
- CIVL-2040 Professional Practice (3)
- CIVL-4270 Construction Management (3)

### Building Systems and Products
- MGMT-1100 Intro. to Management (4)
- ARCH-4940 Adv. Ind. Projects in Arch. and Env. (4)
- ARCH-4540 Professional Practice (2)
- CIVL-4270 Construction Management (3)

### Computer Applications
- CSCI-1100 Computer Science I (4)
- ARTS-1020 Media Studio: Imaging (4)
- ARCH-4460 Electronic Media: Critical Visualization (4)
- ARCH-4620 Intro. to Computation-Based Design and Programming (4)
- ARCH-4940 Advanced Individual Projects in Arch. for Env. Design (CAD) (4)

*This course is available at Hudson Valley Community College. Contact your adviser for further information.

### Dual Major Programs
Dual majors are available to students interested in pursuing two majors simultaneously and who can develop an acceptable program of study that meets the requirements for both majors. There are many possibilities, with the most common options combining civil engineering or management with architecture. The interdisciplinary degree in Product Design and Innovation has been specifically developed for Building Science majors and is explained in detail under the heading Interdisciplinary Programs and Research found at the end of the School of Architecture section of this catalog.

### Minor Programs
The School of Architecture offers minor options for both School of Architecture students and students majoring in other Rensselaer programs. These options are described below.
Architecture
A minor in architecture is directed toward Rensselaer students interested in architecture as a sociocultural 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.

A minor consists of an approved 16-credit program. ARCH-2110 Building and Thinking of Architecture 1 is required but students may select the remainder of the courses to build a concentration in architecture that supports their own disciplinary interests.

Architectural History
The minor in architectural history is open to all Rensselaer students interested in the history of architecture as a sociocultural 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.

Lighting
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 nonvisual, 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 program comprises 16 credits taken in the Lighting Research Center. The courses required are: LGHT-4840 Human Factors in Lighting; LGHT-4770 Lighting Technologies and Applications; LGHT-4230 Lighting Design; and LGHT-4940 Advanced Individual Project in Lighting.

Special Undergraduate Opportunities
Study Abroad
International study is a defining aspect of Rensselaer’s architectural education and the School of Architecture offers several international semester long programs of study. Offered 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 semester and above. Only 20–25 students (B.Arch and M.Arch) are selected each year on the basis of academic accomplishment. In addition to a Rensselaer faculty member who directs these students, adjunct faculty in the host city or institution provide instruction. There is a program fee for participation in each of these programs, which are described briefly below.

Italy—The Rome semester involves a design studio, an examination of the architectural development of Rome, courses in Italian language and culture, and travel throughout Italy. The program seeks to deepen appreciation of the city and the layers of its culture that have played a seminal role in the development of Western culture and architecture.

India—The program is based in the School of Architecture CEPT at Ahmedabad, India, a highly respected school for the study of architecture and urbanism. It offers students the opportunity to travel, study, and apply the lessons learned from Indian architecture and Indian history and theory within the context of a major research center.
n China—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 studios in design with Chinese faculty and students, and travel through central China augments additional courses in Chinese history and culture.

In addition the School of architecture offers occasional summer study abroad programs to places of special architectural interest. In recent years, these have included visits to Turkey and the Czech Republic.

**Exchange Programs**

Architecture students are eligible to apply for admittance into a student exchange program at the Swiss Federal Institute of Technology (ETH, Zurich). An agreement between Rensselaer and ETH provides for a year of study abroad. Other exchange and study abroad opportunities are also available.

**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. With sufficient enrollment, an eight-week upper level vertical studio is offered for students enrolling in ARCH-2230 Architecture Design 3 through ARCH-4260 Architecture Design 6.

**Co-op Experiences**

A number of architecture students 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 usually earn credit toward the professional Intern Development Program (IDP) requirement.

**Lectures and Exhibits**

Architecture and architectural education advance through full engagement in the world of ideas. The school offers visiting faculty and lecturers and provides field trips, student travel funds, seminars, and exhibitions. Each semester a lecture, exhibition, seminar, and workshop program is created. The lecture and exhibition series presents the work of internationally recognized faculty 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 and the local professional community.

**Graduate Programs**

The School of Architecture offers several graduate degrees at the master’s level. These include the Master of Architecture I as a first professional degree for students already holding at least a baccalaureate degree in any field of study.

Those who have accredited degrees in architecture and wish to pursue advanced studies related to architecture may seek a Master of Architecture, a Master of Science in Architectural Sciences, or a Master of Science as post-professional degrees in the School of Architecture. Master of Science and Master of Science in Architectural Sciences degrees are also available to applicants who have been enrolled in other related fields. The degrees offer the opportunity for advanced, focused, and intellectually rigorous study in architecture, building, and related sciences.

Included among these post-professional master’s programs are the Master of Architecture (M.Arch.) II, Master of Science in Building Conservation, Master of Science in Architectural Sciences (Concentration in Architectural Acoustics), Master of Science in Architectural Sciences (Concentration in Building Systems Research), Master of Science in Architectural Sciences (Concentration in Computation in
Design), Master of Science in Architectural Sciences (Concentration in Lighting), and the Master of Science in Lighting.

As a degree limited to applicants who have gained a professional degree in architecture, the Master of Architecture II is distinct from the Master of Science in Architectural Sciences and Master of Science. For students entering this program with a five-year first professional bachelor’s or master’s degree, the M.Arch. II is one path to a terminal degree (for teaching). Either the M.Arch.II or the M.S. involves a minimum 30 credit hours of study.

Among its offerings, the School of Architecture provides some specialized seminars of particular benefit to most graduate students, except those studying lighting and building conservation. These include:

- Research Design Seminar—Covering the essential bases of research work, whether to assist with the development of a Ph.D. dissertation, masters thesis, or masters project, this course builds students’ critical reading skills and ability to conduct a research project creatively and pragmatically. This course introduces students to external researchers who present work in progress and discuss and advise student projects.
- Graduate Thesis Seminar—Taken in a student’s second term, this course provides graduate students from the Architectural Acoustics, Building Systems Research, Computation in Design, and Lighting research programs a forum for publicly presenting and discussing their work.

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 B average in the following courses: Design Explorations (ARCH-6110, ARCH-6120 and ARCH-6130), Design Development (ARCH-4300), and Master’s Thesis (ARCH-6990). 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.

**Doctoral Programs**

Each of the Ph.D. in Architectural Sciences degree concentrations have different course requirements. In keeping with Rensselaer requirements, a candidate for the doctor’s degree must complete a plan of study with satisfactory grades containing a minimum of 90 credit hours beyond the bachelor’s degree or 60 hours beyond the master’s degree. Within those 90 credit hours there must be at least 30 credit hours of coursework. To satisfy this requirement, at least half of the total credit hours, excluding dissertation, must contain the suffix numbers 6000–6990 with the further limitation that no more than 16 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.)

Depending on the chosen concentration area and the agreed plan of study, candidates may either enter directly into the doctoral program or plan to complete a master’s degree before beginning doctoral study. All candidates must successfully take a qualifying exam for entry into doctoral study. The Ph.D. manual for Architectural Sciences is currently being edited. For the most up to date information, please contact the Director of the program.
Degree completion is possible in three years of full time study and 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.

Those pursuing doctoral study in architecture at Rensselaer may select from four areas of concentration. They include:

- Ph.D. in Architectural Sciences (Concentration in Architectural Acoustics)
- Ph.D. in Architectural Sciences (Concentration in Building Systems Research)
- Ph.D. in Architectural Sciences (Concentration in Computation in Design)
- Ph.D. in Architectural Sciences (Concentration in Lighting)

They may also concentrate on emerging areas of specialization in other aspects of architecture and technology.

**Master’s Programs**

**Master of Architecture I**

The curriculum for this professional degree program largely overlaps the B.Arch program, albeit in an accelerated manner. It features a distinct individualized 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).

This degree provides a balanced education in architectural design, history, theory, and technology. As with the undergraduate program, it centers on the design studio where projects address a multitude of 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, which is the sole agency authorized to accredit U.S. professional degree programs in architecture, recognizes two types of degrees; the Bachelor of Architecture and the Master of Architecture. A program may be granted a six-year, three-year, or two-year term of accreditation, depending on its degree of conformance with established educational standards.

Master’s degree programs may consist of preprofessional and undergraduate degree and a professional graduate degree, which, when earned sequentially, comprise 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, have earned a 3.0 cumulative average (on a 4.0 scale) and have within their undergraduate studies a course in free hand or life-study drawing. They must also have eight to 10 courses in humanities and social sciences, one year of mathematics with at least one course in calculus, one 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 Office of 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.
Like the B.Arch. program, the M.Arch. I program incorporates and interconnects the important elements of design, history and theory, technology and building science, and computing. For a detailed description of Rensselaer’s approach to these elements, please refer to the Bachelor of Architecture (B.Arch.) Curriculum section.

Also noted within the Bachelor of Architecture Curriculum description are the School’s many professional electives and topics offerings 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. 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. A sample of these courses can be found on page 111.

The M.Arch. I program concludes with an individually initiated, planned, and developed thesis. Planning begins in the third year and involves an exchange of ideas with and a critique by a faculty adviser and review committee. The resulting proposals are published statements of interest from the faculty combined with the students’ experiences and areas of special concern. These 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 sees as significant to architecture.

To provide the clearest possible picture of the M.Arch. I curriculum structure, a sample template is provided below.

**M.Arch. I Curriculum**

**Summer Session**
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.

**Summer Sessions 1 - 2 Credit hours**

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<td>Graduate Architecture Design 1</td>
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**First Year**

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<td>ARCH-6110</td>
<td>Design Explorations 1</td>
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</table>

In regard to the above template, please note that studios are generally sequential. ARCH-4300 Design Development studio should be taken after the completion of the ARCH-4360 Graduate Architecture Design 4 (urban) 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.

A plan of study is required for all graduate students. The degree requires 112 credit hours. Admission with advanced standing can fulfill a significant number of these credits, especially for students who have been enrolled in undergraduate pre-architecture programs or non-accredited professional programs.

Masters Degrees—Advanced Programs
Applications to any of these programs should be directed to Rensselaer Admissions. Since a match between student interests and faculty research capabilities is an integral part of this program, applicants must include a focus-of-study proposal and, where appropriate, a portfolio of design and other creative work, with critical commentary, as part of the application.

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<table>
<thead>
<tr>
<th>Second Year</th>
<th>Credit hours</th>
<th>Spring</th>
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<td>(Urban) ...........................................6</td>
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<td>Professional Practice 1 ..................2</td>
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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.
Building Conservation
Applicants to the M.S. in Building Conservation are generally architectural or engineering practitioners who wish to build expertise in historic structures and building conservation. However, the program welcomes graduate students with related degrees and professional experience.

Master of Science in Architectural Sciences Degrees

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.

Building Systems Research Applicants to the M.S. in Architectural Sciences (Concentration in Building Systems Research) are required to submit a portfolio and focused goal statement. This one year program combines faculty strength in energy efficient systems and technologies, new materials and applications, and whole systems integration.

Computation in Design Applicants to the M.S. in Architectural Sciences (Concentration in Computation in Design) are required to submit a portfolio related to the research interest. This 30-credit, one year program combines faculty expertise in the areas of computer-controlled design and fabrication, design and fabrication with new techniques and materials, and mediated human-environment interaction.

Lighting Applicants to the M.S. in Architectural Sciences should submit a portfolio or other examples of work and a statement of goals and objectives. They are also urged to complete two college-level math courses before applying to the program. This one-year 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.

Master of Building Sciences Degrees

Lighting Applicants to the M.S. in Lighting should submit a portfolio or other examples of work and a statement of goals and objectives. They are also urged to complete two college-level math courses before applying to the program.

M.Arch.II Applicants to this post-professional advanced degree program must hold a professional Architecture degree. Students within this program develop a special individualized plan of study drawn from the School’s various graduate offerings and must receive faculty guidance and approval.

For those accepted as candidates for these advanced Architecture master's programs, a thesis is normally required for degree completion. However in some subjects, and with faculty approval, degree requirements may be satisfied with either a research project or course work. The general institute criteria for the master’s thesis can be found in the Academic Information and Regulations section of this catalog.

Master of Science in Building Conservation
The School of Architecture’s M.S. in Building Conservation graduate program is a two-year, part-time course designed for mid-career professionals who are or intend to be involved in the care, repair, restoration, and adaptation of buildings, urban environments, and rural landscapes.

Both academically and geographically, Rensselaer is well-positioned to provide this course of study in historic resources conservation and management. The School of Architecture is noted for its technical emphasis and strong design concerns. Buttressing this foundation for the M.S. in Building Conservation are adjunct and clinical faculty drawn from a coterie of highly qualified preservationists in New
York’s historic Capital District, which includes some of the country’s top preservation architects, planners, engineers, conservators, not-for-profit managers, and enlightened public officials. Potential institutional partners in the Building Conservation program include New York state agencies such as the Office of Parks, Recreation, and Historic Preservation and the Departments of State and Environmental Conservation; the Preservation League of New York State; the Hudson Mohawk Industrial Gateway; community-based organizations such as the Troy Rehabilitation and Improvement Program; Heritage corridor programs such as those in the Hudson and Mohawk River valleys; and local and county governments.

The Master of Sciences in Building Conservation program prepares students to assume responsible employment positions in the preservation, conservation, and management of historic resources. It also provides a thorough understanding of the theory and practice of historic preservation and building conservation. Students receive training in disciplines such as identification and analysis of specific building materials to structural stabilization, restoration, and reuse of historic structures; planning for wise development of entire urban and rural areas; and the legal, economic, and political factors that make these endeavors possible. In addition, they gain real-world, hands-on experience through extensive fieldwork and the program's close affiliation with regional architectural and engineering firms and with not-for-profit, state, and municipal, community-based, educational, and social service agencies.

The program is presented through alternate on-campus, two-day weekend sessions of class and fieldwork for two academic years (September–May) for a total of 30 weekends. It begins with a five-day residency and concludes with a three-day residency each year. This structure allows students to continue working, remain with their families, and pursue other interests while earning their degree. Students are generally expected to be architectural or engineering practitioners. However, the program welcomes graduate students with related degrees and professional experience.

Degree candidates follow the curriculum template outlined below in sequence. Teamwork is encouraged on campus, and students are required to complete 20–25 hours of home assignments between alternate weekend sessions. Students have access to such facilities as the objects conservation laboratories of the Metropolitan Museum of Art and Building Conservation Associates in New York City, a private museum of nineteenth century buildings in rural Rensselaer County, New York, and Rensselaer’s Libraries and Information Services.

Building Conservation Curriculum

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td><strong>Spring</strong></td>
<td></td>
</tr>
<tr>
<td>ARCH-4640</td>
<td>American Building—17th–19th</td>
<td>ARCH-4650</td>
<td>American Building—20th Century...2</td>
</tr>
<tr>
<td></td>
<td>Centuries .........................................2</td>
<td>ARCH-6700</td>
<td>Recording Historic Structures..........2</td>
</tr>
<tr>
<td>ARCH-6610</td>
<td>Preservation Theory ...............................1</td>
<td>ARCH-6670</td>
<td>Structural and Mechanical Systems ..1</td>
</tr>
<tr>
<td>ARCH-4610</td>
<td>Building Conservation 1  .......................2</td>
<td>ARCH-6710</td>
<td>Preservation Design Studio 1 ..........4</td>
</tr>
<tr>
<td>ARCH-6680</td>
<td>Researching Historic Structures ...............2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARCH-6690</td>
<td>Drawing Historic Structures ...................1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The degree requires 32 credit hours.

Master of Science in Architectural Sciences (Concentration in Architectural Acoustics)

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 Workshop, and Rensselaer’s Libraries and Information Services.

Individuals applying for admission to this program must have a bachelor-level degree (B.Arch., B.S., or B.A.) in Architecture, Engineering, Music, Physics, Mathematics, Computer Science, Acoustics, Electronic Media, Theater Technology, or other related fields. Those with other degrees or experience (e.g., who have worked in the field) and with keen interest in Architectural Acoustics will also be considered. Those receiving an M.S. in Building Sciences (Concentration in Architectural Acoustics) will be well prepared to enter the field at post-entry positions.

Architectural Acoustics Curriculum

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>ARCH-4630</td>
<td>Building Conservation 2 ...............2</td>
<td>ARCH-4680</td>
<td>Traditional Trades and</td>
</tr>
<tr>
<td>ARCH-4660</td>
<td>Historical Archeology ................1</td>
<td>ARCH-4640</td>
<td>Craftsmanship..............2</td>
</tr>
<tr>
<td>ARCH-4670</td>
<td>Industrial Archeology ...............1</td>
<td>ARCH-6620</td>
<td>Historic Preservation Law ........1</td>
</tr>
<tr>
<td>ARCH-6650</td>
<td>Architectural Materials Testing ........2</td>
<td>ARCH-6720</td>
<td>Contemporary Preservation Practice ...1</td>
</tr>
<tr>
<td>ARCH-6630</td>
<td>Economics of Historic Preservation ..1</td>
<td>ARCH-6640</td>
<td>Preservation Design Studio ..........4</td>
</tr>
</tbody>
</table>

The degree requires 32 credit hours.

Possible Concentration Electives include (but are not limited to):

- ARCH-6940 Advanced Individual Projects (e.g., Ind. Study) ..........1–6 credits
- ARTS-2310 Chorale: Performance Studies .........................2 credits
- ARTS-6010 Computer Music Studio ........................................4 credits
- ECSE-4500 Probability for Engineering Applications .................4 credits
- ECSE-4510 Discrete Time Systems ........................................3 credits
- ECSE-4540 Introduction to Voice and Image Processing ...............3 credits
- ECSE-4560 Signal Processing Design ......................................3 credits
- MANE-4610 Vibrations ..........................................................3 credits
- MANE-4830 Acoustics Engineering .........................................3 credits

The degree requires 30 credit hours.
**Master of Science in Architectural Sciences (Concentration in Building Systems Research)**

The Building Systems Research program focuses on three major areas of inquiry: (1) measuring the impact of architectural design on human performance particularly creativity and productivity; (2) the design and testing of architectural innovations that improve the microclimate of buildings; and (3) research and design related to building systems and engineering. In the case of microclimate the program focuses its expertise on the luminous, thermal, and acoustical aspects of the microclimate. This area of building systems is particularly interested in the potentiality of dynamic design and its impact on the building’s microclimate, energy efficiency, and spatial qualities.

**Building Systems Research Curriculum**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>Breadth Elective</td>
<td>.................</td>
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<tr>
<td>Concentration Elective</td>
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<td>..................</td>
<td>..................</td>
</tr>
<tr>
<td>ARCH-4810 Advanced Technology Seminar</td>
<td>2</td>
<td>ARCH-4510 Construction Industry Seminar</td>
<td>2</td>
</tr>
<tr>
<td>ARCH-4530 Systems Building Seminar</td>
<td>4</td>
<td>ARCH-6900 Graduate Thesis Seminar</td>
<td>2</td>
</tr>
<tr>
<td>ARCH-6810 Research Design Seminar</td>
<td>2</td>
<td>ARCH-6980 Master’s Project or</td>
<td>..................</td>
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<tr>
<td>ARCH-6980 Master’s Project or</td>
<td>..................</td>
<td>ARCH-6990 Master’s Thesis</td>
<td>..................</td>
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<tr>
<td>ARCH-6990 Master’s Thesis</td>
<td>..................</td>
<td>ARCH-6990 Master’s Thesis</td>
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</tr>
</tbody>
</table>

The degree requires 30 credit hours.

**Master of Science in Architectural Sciences (Concentration in Computation in Design)**

The introduction of computation as a method, a material, and a subject of design activity has transformed contemporary culture over several decades. This program engages the relationship between computation and design across a spectrum of issues using methodologies drawn from the social sciences, critical theory, technology, scientific investigation, and design methods. Of particular interest are those issues arising from the relationship between the digital domain and the embodied experience of human environments. Research topics include the relationship between physical and digital or tele-environments, digital design and digital fabrication methods, and interface design for computationally augmented environments. This field of investigation is intrinsically multi-disciplinary.

**Computation in Design Curriculum**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computation Theory Seminar</td>
<td>.................</td>
<td>ARCH-6900 Graduate Thesis Seminar</td>
<td>2</td>
</tr>
<tr>
<td>Concentration Elective</td>
<td>.................</td>
<td>ARCH-6980/6990 Master’s Project or</td>
<td>..................</td>
</tr>
<tr>
<td>ARCH-6420 Experimental Research Lab</td>
<td>2</td>
<td>ARCH-6980/6990 Master’s Project or</td>
<td>...............</td>
</tr>
<tr>
<td>ARCH-6810 Research Design Seminar</td>
<td>2</td>
<td>ARCH-6980/6990 Master’s Project or</td>
<td>..................</td>
</tr>
<tr>
<td>ARCH-6990 Concentration Elective or</td>
<td>..................</td>
<td>ARCH-6980/6990 Master’s Project or</td>
<td>..................</td>
</tr>
<tr>
<td>Master’s Thesis</td>
<td>..................</td>
<td>ARCH-6980/6990 Master’s Project or</td>
<td>..................</td>
</tr>
</tbody>
</table>

The degree requires 30 credit hours.

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1 The Informatics Theory Elective can be (but is not limited to) one of the following courses:
ARCH-6400 Philosophies of Space in a Digital Culture
ARCH-6961 Human-Environment Interaction
Master of Science in Architectural Sciences (Concentration in Lighting)

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 professionals either currently working or wishing to pursue careers in the lighting industry or design fields, this one-year, 30-credit degree exposes students to a wide range of topics within lighting including the physics of light, lighting technology, human factors, design, and application. It also allows students to 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 6-credit culminating master’s project.

Concentration in Lighting Curriculum

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGHT-4230 Lighting Design</td>
<td>4</td>
<td>LGHT-4770 Lighting Technologies and Applications</td>
<td>4</td>
</tr>
<tr>
<td>LGHT-4840 Human Factors in Lighting</td>
<td>4</td>
<td>LGHT-6760 Lighting Workshop</td>
<td>4</td>
</tr>
<tr>
<td>LGHT-6830 The Physics of Light</td>
<td>4</td>
<td>LGHT-6770 Light and Health or Lighting Leadership Seminar</td>
<td>4</td>
</tr>
<tr>
<td>LGHT-6940 Advanced Individual Project in Lighting</td>
<td>3</td>
<td>LGHT-6940 Advanced Individual Project in Lighting</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: Any student intending to continue to the Ph.D. program must fit ARCH-6810 Research Design Seminar (2 credits) into the Plan of Study before taking their candidacy exam. The degree requires 30 credit hours.

Master of Science

Master of Science in Lighting

The School of Architecture, in association with the Lighting Research Center, offers a Master of Science in Lighting degree to students who complete a 48-credit, two-year curriculum. 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. in Lighting Curriculum

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGHT-4230 Lighting Design</td>
<td>4</td>
<td>LGHT-4770 Lighting Technologies and Applications</td>
<td>4</td>
</tr>
<tr>
<td>LGHT-4840 Human Factors in Lighting</td>
<td>4</td>
<td>LGHT-6750 Lighting Research Design</td>
<td>4</td>
</tr>
<tr>
<td>LGHT-6830 The Physics of Light</td>
<td>4</td>
<td>LGHT-6770 Light and Health</td>
<td>4</td>
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</tbody>
</table>

Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-6810 Research Design Seminar</td>
<td>2</td>
<td>ARCH-6900 Graduate Thesis Seminar</td>
<td>2</td>
</tr>
<tr>
<td>LGHT-6780 Lighting Leadership Seminar</td>
<td>4</td>
<td>LGHT-6760 Lighting Workshop</td>
<td>4</td>
</tr>
<tr>
<td>LGHT-6940 Advanced Individual Projects in Lighting</td>
<td>2</td>
<td>LGHT-6940 Advanced Individual Project in Lighting</td>
<td>2</td>
</tr>
<tr>
<td>LGHT-6990 Master’s Thesis</td>
<td>4</td>
<td>LGHT-6990 Master’s Thesis</td>
<td>4</td>
</tr>
</tbody>
</table>

The degree requires 48 credit hours.

Master of Architecture
(Post –Professional Degree) Curriculum

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 program includes 30 credits of project and course work (including a thesis) and normally requires three semesters to complete.

Fall

<table>
<thead>
<tr>
<th>ARCH-6810 Research Design Seminar</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-6990 Master’s Thesis</td>
</tr>
<tr>
<td>Electives</td>
</tr>
</tbody>
</table>

Spring

<table>
<thead>
<tr>
<th>ARCH-6900 Graduate Thesis Seminar</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-6990 Master’s Thesis</td>
</tr>
<tr>
<td>Electives</td>
</tr>
</tbody>
</table>

Fall

<table>
<thead>
<tr>
<th>ARCH-6990 Master’s Thesis</th>
</tr>
</thead>
</table>

This degree requires 30 credit hours.

Special Master’s Opportunities

Study Abroad (M.Arch 1)

International study is a defining aspect of Rensselaer’s architectural education and the School of Architecture offers several semester-long international programs of study. Offered in Italy, India, and China, these programs are open by competitive application to M.Arch.I students. Only 20–25 students (B.Arch and M.Arch) are selected each year on the basis of academic accomplishment. In addition to direction from a Rensselaer faculty member, adjunct faculty in the host city or institution provide instruction. There is a program fee for participation in each of these programs, which are described briefly on the next page.
China—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 studios in design with Chinese faculty and students and travel through central China augments additional courses in Chinese history and culture.

India—The program is based in the School of Architecture CEPT at Ahmedabad, India, a highly respected school for the study of architecture and urbanism. It offers students the opportunity to travel, study, and apply the lessons learned from Indian architecture and Indian history and theory within the context of a major research center.

Italy—The Rome semester involves a design studio, an examination of the architectural development of Rome, courses in Italian language and culture, and travel throughout Italy. The program seeks to deepen appreciation of the city and the layers of its culture that have played a seminal role in the development of Western culture and architecture.

In addition, the School of Architecture offers occasional summer study abroad programs to places of special architectural interest. In recent years, these have included visits to Turkey and the Czech Republic.

For specific information regarding admission to the School of Architecture’s graduate programs see the Admissions section of this catalog.

Doctoral Programs

Rensselaer’s Ph.D. program in Architecture offers concentrations in Architectural Acoustics, Building Systems Research, Computation in Design, and Lighting. Thematic issues of interest are the impact of augmented and virtual reality systems, computational design systems; soft-computing and spatial databases, urban and architectural modeling and simulation, artificial cognition and spatial communication, spatial sound simulation and reproduction, and spatialized applications of computer vision.

A general template for developing individual programs of study and determining specific course requirements for these programs is as follows:

- Minimum time for degree: three years.
- Total credit hours for degree: 90
- 30 credit hours (which could be transferred from the master’s degree) satisfy the basic Institute course requirements for the doctoral degree. All additional coursework is determined either by the area of specialization or in consultation with an adviser.
- In addition to the degree-specific and core requirements, individual plans of study are defined between student and adviser.

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.

Ph.D. in Architectural Sciences (Concentration in Architectural Acoustics)

Advanced study in Architectural Acoustics represents a unique opportunity for students to combine existing courses and research to provide an education that integrates scientific, computational, cognitive, and psychological research with experimental applications. The work will not only be multidisciplinary in scope but also 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 interior spaces, wherein the physical sound field of a space and its corresponding aural quality are primarily determined by architectural parameters such as shape, volume, and surface properties. The acoustical quality of a space is relevant not only for cultural settings (e.g., room acoustics) but also for any environment that values human health, performance, and productivity (e.g., effects of noise). Architectural
Acoustics is also necessary for the accurate and realistic simulation of virtual spaces, e.g., for prototyping, education, training, design, or experimental research with non-physical sound fields. Such virtual spaces can also lead to new developments of “sonic architecture” and time-variant sound-scapes.

Architectural Acoustics thus encompasses and links many traditionally disparate disciplines to design: physics, hearing perception, mathematics, computer modeling, engineering, music, psychological and physiological acoustics, cognitive science, and electro-acoustics. Thus the Ph.D. in Architectural Acoustics can also involve communication acoustics in its widest sense.

Examples of research topics of current interest are

- Training of auditory perception capabilities with regard to reverberation
- Sound quality of scattered sound
- New algorithms for the prediction of room acoustic transmission sound quality
- Improved methods for feature extraction in room acoustic measurement
- Physical scale modeling made simple
- Spatial properties of reverberation
- Product sound quality metrics and their relationship to the meaning of sounds
- Quantification of transmission sound quality of audio equipment

Ph.D. in Architectural Sciences (Concentration in Building Systems Research)

The Building Systems Research program focuses on three major areas of inquiry: (1) measuring the impact of architectural design on human performance, particularly creativity and productivity; (2) the design and testing of architectural innovations that improve the microclimate of buildings; and (3) research and design related to building systems and engineering. In the case of microclimate, the program focuses its expertise on the luminous, thermal, and acoustical aspects of the microclimate. This area of building systems is particularly interested in the potentiality of dynamic design and its impact on the building’s microclimate, energy efficiency, and spatial qualities.

Examples of research topics:

- To perform in-situ or laboratory tests on innovative Building Systems Research and its impact on human performance.
- To identify user preferences for individual control of microclimate system technologies.
- To determine the economic benefit/liabilities of innovative Building Systems Research and technologies.
- To research, design, and develop integrated systems that utilize emerging materials and technologies to achieve increased levels of building performance.
- To test the impact of integrated control systems that share control by central management systems and individual local control.

Ph.D. in Architectural Sciences Concentration in Computation in Design

The Ph.D. is an advanced study in Computation in Design Architecture involving a rethinking of architectural practice based on information technologies and their social, political, and cultural implications. Students are asked to frame their ideas about design practices with progressive concerns for society, the environment, and the future of technological development. By engaging directly with the tools and techniques of computation, students are given the opportunity to impact the future of research and practice in these burgeoning areas of design.

At a broader level Computation in Design involves a rethinking of design practice based on computational technologies. The field of study involves the full range of applications of computation and information technologies in the environment. The relationship of physical and digital spaces, the use of
computational techniques in the generation, development, representation, fabrication and installation of constructed environments and the integration of advanced technologies into the fabric of the environment are considered in relation to technical, social, cultural, and philosophical implications.

Above all, the program strives to broaden our student’s understanding of architecture as it relates to media culture, advanced building technology, and computation. Coursework and advising requires the explicit integration of critical study and technological development—we believe that it is only through the thoughtful integration of these that important advances can be made in the field.

**Ph.D. in Architectural Sciences (Concentration in Lighting)**

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, bringing them together within the context of scientific inquiry, research, and discovery. Students in the program are 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. Each student will formulate an individual plan of study in consultation with their adviser. Areas of research concentration will also be selected in consultation with the adviser 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.

**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 record and ability in areas such as teaching and research.

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 Graduate School may request that the doctoral committee conduct a formal review to determine whether continuation is warranted. The student’s adviser, with the consent of the student’s doctoral committee, may recommend to the Graduate School 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.
Applicant Requirements
Individuals applying for degree-seeking status must have official transcripts of previous college-level study sent directly from all institutions attended. Two faculty references or relevant employer references are required of all degree-seeking applicants. The faculty from a given area of concentration may waive the portfolio requirement. The Institute currently requires a minimum GRE score of 500 for any type as well as a minimum GPA of 3.0. The program director may ask for a waiver from these requirements for truly exceptional students.

Applicants whose native language is not English must have scores from the Test of English as a Foreign Language (TOEFL) submitted directly by the Educational Testing Service, Princeton, NJ. A minimum score of 570 is required. (For the electronic version of TOEFL, a minimum score of 230 is required.)

Interdisciplinary Degree Programs
Product Design and Innovation
Chair: Sharon Anderson-Gold, anders@rpi.edu
Chair: Mark Steiner

The dual major program in Product Design and Innovation (PDI) is jointly offered by the Schools of Engineering, Architecture, and Humanities and Social Sciences. The PDI curriculum satisfies the requirements for the B.S. programs in both Building Sciences and Science, Technology, and Society (STS).

The PDI program prepares students to become innovative designers who will develop and design the advanced products and technologies for the coming century. Built around a design studio every semester, PDI combines the technical, aesthetic, and cultural sophistication of Rensselaer’s building science curriculum with the insight and vision of the humanities and social sciences disciplines in the STS curriculum.

The core of PDI is the design studio that students take every semester, giving them a hands-on opportunity to bring together the two major curricula. The building science curriculum provides a fundamental education in building science and architectural design through basic and advanced courses in structures, environmental and construction systems, as well as physical and theoretical approaches in design. The STS curriculum provides a fundamental education in the economic, ethical, cultural, and political dimensions of product development and innovation, including numerous case studies of successes and failures that will give students the opportunity to learn what it takes to be effective design team leaders. On this basis, the design studios help students to explore and develop their creativity while a portfolio of design experiences continuously builds throughout all four years.

The design experiences range over a breadth of problems, from larger systemic problems to smaller focused ones, so students have a broad exposure to all the different applications of design practice. Some fall and spring semester studios are taught as a sequence to give students experience with the design process from conception to 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, they provide everything necessary to put their creativity to work as leaders of design and innovation, whether it is in a multi-national business at the cutting edge of the global market or in a smaller business that creates an unusual solution to a local problem.
# PDI Curriculum in Building Science and STS

## First Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
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<tr>
<td></td>
<td>MATH-1010</td>
<td>Calculus I ........................................4</td>
<td>STSH-296x</td>
<td>Design, Culture, and Society ..........4</td>
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<td></td>
<td>ARCH-2110</td>
<td>The Building And Thinking of Arch.1 ........................................4</td>
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<td>Physical Principles of Design ..........4</td>
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<td>ARCH-2120</td>
<td>The Building And Thinking of Arch.2 ......4</td>
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<td>ARCH-2510</td>
<td>Materials and Design ....................2</td>
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## Second Year

<table>
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<tr>
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<th>Spring</th>
<th>Credit hours</th>
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<tr>
<td></td>
<td>IHSS-2500</td>
<td>PDI Studio 3 (Industrial Design) ....4</td>
<td>ENGR-2050</td>
<td>Introduction to Eng. Design ..........4</td>
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<td>STSS-1110</td>
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<td>Env. and Ecol. Systems .................4</td>
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<tr>
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<td>ARCH-2330</td>
<td>Structures 1 ................................4</td>
<td>ARCH-2140</td>
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<td>ARCH-xxxx</td>
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<td>BIOL-1010</td>
<td>Intro. to Biology ......................4</td>
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## Third Year

<table>
<thead>
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<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td></td>
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<td>Design Studio 5 .....................4</td>
<td>ARCH-4960</td>
<td>Design Studio 6 ......................4</td>
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<td>STSS-4xxx</td>
<td>STS Advanced Option 5 .................4</td>
<td>STSS-4800</td>
<td>Public Service Internship .............4</td>
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<tr>
<td></td>
<td>ARCH-4330</td>
<td>Structures 2 ................................4</td>
<td>ARCH-4740</td>
<td>Bldg. Sys. and Env .....................4</td>
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<td>DSES-2010</td>
<td>Statistics ................................4</td>
<td>Math Elective</td>
<td>Math Elective ........................4</td>
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<td>ARCH-4810</td>
<td>Advanced Technology Seminar ..........2</td>
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## Fourth Year

<table>
<thead>
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<th>Year</th>
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<th>Credit hours</th>
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<tr>
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<td>Capstone Design Studio with B.S. ........4</td>
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<td>Construction Industry Seminar ..........4</td>
<td>Elective</td>
<td>Elective ..............................4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective .......4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The degree requires 132 credit hours.

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1. For PDI students, IHSS-2500 may be substituted for the second STS concentration option.
2. Four credits of the Institute core Science requirements are embedded within the Technology sequence: ARCH-2330, ARCH-2360, ARCH-4330, and ARCH-4740. The science sequence may be selected, with the assistance of the student’s adviser, from among 1000-level introductory sequences in Biology, Chemistry, Geology, or Physics, including ERTH-1030, ERTH-1040.
3. Or other studio course as approved by advisers.
4. These special design studios meet jointly with ENGR-4960 Design Studios 6, 7.
5. Candidate courses include: STSS-4350, STSS-4960, STSS-4230; STSS-4110, STSS-4250, STSS-4310, STSS-4560, and STSS-4650.
6. The STS Senior Project can be combined with the Capstone Design Studio to make an eight-credit capstone studio project.
Course Descriptions
Courses related to all Architecture curricula are described in the Course Descriptions section of this catalog under the department code ARCH.
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School of Engineering

Dean: Alan W. Cramb
Associate Deans: Lester A. Gerhardt, Richard N. Smith
Director of Core Engineering: Mark W. Steiner

School of Engineering Home Page: http://www.eng.rpi.edu

Rensselaer’s School of Engineering is committed to technological excellence in integrating research and education and in educating for career success.

Outstanding leadership in innovative and progressive education is a Rensselaer hallmark. Rensselaer is renowned for producing visionary and versatile technological leaders with a superior reputation for their global impact. Solidly endowed with the fundamentals of math, science, and engineering as well as invaluable research, communication, and entrepreneurial expertise, Rensselaer engineering graduates demonstrate an exceptional propensity for practical application of their knowledge. In addition, the inclusion of a strong humanities and social sciences component within this broad education and a full spectrum of activities, both in and out of the classroom, enhance human relations skills and generate a commitment to ethical behavior and social responsibility.

Highly cognizant of the constant evolution in the field of engineering, Rensselaer is dedicated to continually enhancing and revitalizing its curricula and facilities. Evidence of this dedication is its initiatives in such emerging fields as information technology and biotechnology. Among these are the new biotechnology and interdisciplinary research building, the ongoing attraction of leaders in these fields to our already excellent engineering faculty, and the development of expanded opportunities for research within these and other developing fields at both the graduate and undergraduate levels.

Key to promoting such new initiatives, as well as enhancing traditional disciplines, is Rensselaer’s world-class faculty, all of whom hold the highest attainable degree in their fields. In addition to being actively engaged in research and teaching, most also keep their finger on the pulse of the world through consulting or entrepreneurial endeavors.

Especially appealing to Rensselaer’s exceptional faculty and students alike are its superlative laboratories and facilities that enable them to conduct outstanding research and innovation in education pedagogy. These include studio classrooms that, in addition to being 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.

Commitment to mobile computing and interactive delivery are also features that distinguish Rensselaer engineering programs from those at other universities. As noted in the Educational Programs and Resources section of this catalog, the Institute mandated that all undergraduate students have laptop computers as of the fall of 2002. This mandate was issued in recognition that the entire world is moving in the direction of near constant computer access. In addition, the program supports the interactive delivery initiative, in which lectures are combined with recitation, modeling, simulation, and laboratory exercises. Unlike the traditional professor-centered straight lecture format, interactive delivery centers on the students and allows them to interact with each other as well as the instructor. Through these new programs, students experience greater freedom, are no longer tied to a desk for their computing needs, and are prepared for what they will find in the real world.
Teambuilding 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 is access to numerous research centers and computing resources. These include one of the largest Class 100 clean-room facilities on an academic campus, a 100-ton-g centrifuge, a linear accelerator (LINAC), the Advanced Manufacturing Laboratories, and the student-faculty shop. Engineering students use extensive interactive workstation facilities for studies in computer-aided design, analysis, and/or manufacturing. Taught and researched in the clean-rooms are integrated circuit and interconnect technology. The centrifuge, part of an NSF-funded NEES center, is used for geotechnical research and is a state-of-the-art facility. The manufacturing laboratories provide students an opportunity to design and manufacture their own product to realistic specifications.

Other specialized and more discipline-oriented facilities include laboratories in areas such as fluidization, heat transfer, biological engineering, biomedical engineering, structures, earthquake engineering, image processing, plasma dynamics, mechatronics, microelectronics, microwaves, photonics, electrical machines, electron microscopy and materials characterization, subsonic and supersonic flow, tribology, viscoelasticity, two-phase flow, mass spectrometry, and ion physics.

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 Academy for Electronic Media, Center for Advanced Technology (CAT), Center for Biotechnology and Interdisciplinary Studies, the Center for Integrated Electronics (CIE), The Center for Nanotechnology Research, and the Scientific Computation Research Center (SCOREC). These centers are interdisciplinary, so that center projects include students from each of several curricula. For example, in the CIE, students from many departments (e.g., Physics; Materials Science and Engineering; Mechanical, Aerospace; and Nuclear Engineering; Electrical, Computer, and Systems Engineering; Chemical and Biological Engineering; and Civil and Environmental) are members of teams that conduct government- and industry-supported basic and applied research.

Projects in CIE currently under way include multilevel interconnects, chemical-mechanical polishing, polymers for interlevel dielectrics, compound semiconductors, and wireless manufacturing programs that employ flexible technologies and organizations, as well as improved communications to help solve manufacturing problems. Also world-renowned is SCOREC’s simulation-based engineering approach in which state-of-the-art computers and numerical models are applied to problems of great societal need.

In addition to the major Institute centers, the School of Engineering conducts research in its own multidisciplinary centers. These include the Center for Infrastructure and Transportation Studies, the Center for Image Processing Research, the Center for Multiphase Research, and the Center for Earthquake Engineering Simulation. At the department level, the School offers seven additional centers: the Bioseparations Research Center, the Center for Services Research and Education, the Statistical Consulting Research Center, the Center for Glass Science and Technology, and the Flexible Manufacturing Center.
Substantial Rensselaer research is also conducted outside these major centers, some involving multiuniversity collaboration. These research centers complement the following seven academic departments: Biomedical Engineering; Chemical and Biological Engineering; Civil and Environmental Engineering; Decision Sciences and Engineering Systems; Electrical, Computer, and Systems Engineering; Materials Science and Engineering; and Mechanical, Aerospace, and Nuclear Engineering.

All departments offer both undergraduate and graduate curricula and degree programs in their fields.

### Degrees Offered and Associated Departments

- **Aeronautical Engineering**
  - Mechanical, Aerospace, and Nuclear Engineering
- **Biomedical Engineering**
  - Biomedical Engineering
- **Chemical Engineering**
  - Chemical and Biological Engineering
- **Civil Engineering**
  - Civil and Environmental Engineering
- **Computer Systems Engineering**
  - Electrical, Computer, and Systems Engineering
- **Decision Sciences and Engineering Systems**
  - Decision Sciences and Engineering, Systems
- **Electric Power Engineering**
  - Electrical, Computer, and Systems Engineering
- **Electrical Engineering**
  - Electrical, Computer, and Systems Engineering
- **Engineering Physics**
  - Mechanical, Aerospace, and Nuclear Engineering
- **Environmental Engineering**
  - Civil and Environmental Engineering
- **Industrial and Management Engineering**
  - Decision Sciences and Engineering Systems
- **Manufacturing Systems Engineering**
  - Decision Sciences and Engineering Systems
- **Materials Engineering**
  - Materials Science and Engineering
- **Mechanical Engineering**
  - Mechanical, Aerospace, and Nuclear Engineering
- **Mechanics**
  - Mechanical, Aerospace, and Nuclear Engineering
- **Nuclear Engineering**
  - Mechanical, Aerospace, and Nuclear Engineering
- **Nuclear Engineering and Science**
  - Mechanical, Aerospace, and Nuclear Engineering
- **Operations Research and Statistics**
  - Decision Sciences and Engineering Systems
- **Transportation Engineering**
  - Civil and Environmental Engineering

### 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 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 nonengineering 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 education 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. 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 takes place 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
The core engineering program forms the foundation for all engineering curricula. In addition to providing a solid base for later specialization, it allows 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 the general format is presented on the following pages. Specific curricula 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. Two kinds of programs are listed under each discipline: (1) a four-year baccalaureate program leading to the Bachelor of Science degree; (2) a professional program, taken in the fourth and fifth years, leading to the B.S. and M.Eng. degrees.

While 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 second 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 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 course Introduction to Engineering Design is intended to enhance the student’s ability to apply knowledge resourcefully to resolve engineering problems.

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 curricula, including both core and discipline-specific courses, are under continuous review to ensure the application of new pedagogues 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, the core engineering program proceeds as follows:

**First Year**

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100 Intro. to Engineering Analysis 4</td>
<td>ENGR-1300 Engineering Processes 1, 2, or 1</td>
</tr>
<tr>
<td>ENGR-1200 Engineering Graphics and CAD 1, 1</td>
<td>ENGR-1310 Intro. to Engineering Electronics 1, 1</td>
</tr>
<tr>
<td>MATH-1010 Calculus I 4</td>
<td>MATH-1020 Calculus II 4</td>
</tr>
<tr>
<td>CHEM-1300 Chemistry Principles for Engineers 4</td>
<td>PHYS-1100 Physics I 4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective 4</td>
<td>Science Elective 4</td>
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**Second Year**

<table>
<thead>
<tr>
<th>Credit hours</th>
<th>Spring Credit hours</th>
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<tbody>
<tr>
<td>MATH-2400 Intro. to Differential Equations 4</td>
<td>ENGR-2040 Intro. to Engineering Design (with PDI) 4</td>
<td></td>
</tr>
<tr>
<td>PHYS-1200 Physics II 4</td>
<td>Engineering Elective 4</td>
<td></td>
</tr>
<tr>
<td>Engineering Elective 4</td>
<td>Hum. or Soc. Sci. Elective 4</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective 4</td>
<td>CSCI-1190 Beginning C for Engineers 1</td>
<td></td>
</tr>
</tbody>
</table>

1 These required courses may be taken in either order.
2 Depending on major.
Electives
In the core engineering curriculum, electives may be selected from, but are not limited to, the following list of suggested courses. However, in most engineering curricula, specific electives are required or recommended during the core engineering phase. Students should consult the curriculum information for their intended fields of specialization before selecting electives.

Engineering Electives

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2090</td>
<td>Engineering Dynamics</td>
</tr>
<tr>
<td>ENGR-2250</td>
<td>Thermal and Fluids Engineering I</td>
</tr>
<tr>
<td>ENGR-2350</td>
<td>Embedded Control</td>
</tr>
<tr>
<td>ENGR-2530</td>
<td>Strength of Materials</td>
</tr>
<tr>
<td>ENGR-2600</td>
<td>Modeling and Analysis of Uncertainty</td>
</tr>
<tr>
<td>MANE-2830</td>
<td>Nuclear Phenomena for Engineering</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGR-4300</td>
<td>Electronic Instrumentation</td>
</tr>
<tr>
<td>ENGR-4750</td>
<td>Engineering Economics and Project</td>
</tr>
<tr>
<td></td>
<td>Management</td>
</tr>
<tr>
<td>CHME-2010</td>
<td>Material, Energy, and Entropy</td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>ECSE-2010</td>
<td>Electric Circuits</td>
</tr>
<tr>
<td>ECSE-2410</td>
<td>Signals and Systems</td>
</tr>
<tr>
<td>ECSE-2610</td>
<td>Computer Components and Operations</td>
</tr>
<tr>
<td>MANE-2060</td>
<td>Aerospace Fundamentals</td>
</tr>
<tr>
<td>DSES-2210</td>
<td>Production and Cost Accounting</td>
</tr>
<tr>
<td>MATH-4800</td>
<td>Numerical Computing</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I</td>
</tr>
<tr>
<td>ENGR-1600</td>
<td>Materials Science for Engineers</td>
</tr>
</tbody>
</table>

For a complete description of all engineering courses, see the Course Description 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
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. Although many co-op students complete their academic program in four years, some delay graduation for a 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 Career Development Center.

Study Abroad/Exchange Programs
Rensselaer’s School of Engineering 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 E’) 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.
Application involves completing forms regarding required courses or desired electives. The Institute for International Education, which administers this program, matches the student to a participating university based on that student’s educational discipline requirements, cultural experience, and language background. The student continues to pay tuition at the home institution (Rensselaer) and continues to be covered by financial aid mechanisms, insurance, etc. However, the student pays room and board to the host institution. Consequently, except for travel expenses, students participating in this program should incur no additional costs.

Global E3 offers students the chance to study and learn in the native language of the host country. Such opportunities, for example, are available in France, Germany, Italy, Spain, and Austria. Additional opportunities allow students to pursue foreign study opportunities at universities where the courses are presented and taught in English. These include the Technical University of Denmark, Budapest University of Hungary, and universities in the United Kingdom, Finland, Korea, Singapore, and Japan, among others. 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 30 U.S. universities and over 75 universities in the rest of the world participate in the Global E3 program. Included among these nations are: Australia, China, Austria, Denmark, Finland, France, Germany, Hungary, Italy, Japan, Korea, Mexico, Singapore, Spain, Sweden, and the United Kingdom. People interested in the program should contact Professor Lester A. Gerhardt, Acting Dean, at (518) 276-6203 or via e-mail at gerhal@rpi.edu. The program’s Web site can be found at http://www.iie.org/pgms/global-e3.

Additional opportunities designed for the Rensselaer population in general are also available. Information on these opportunities can be found in the Educational Programs and Resources section of this catalog.

Overview of Graduate Programs

In preparing students to reach the pinnacle of their expertise within their chosen profession, the School of Engineering’s graduate programs strive to:

n Develop students’ skills for conceiving, conducting, and communicating creative thought through advanced study in the classroom and inquiry-based independent and collaborative original research.

n Deepen students’ knowledge while refining their ability to think critically and nurturing their ability to identify new areas for expanding knowledge and transferring it to application and practice.

The School of Engineering offers four graduate degrees through which students may achieve these 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**

**Chair:** Natacha DePaola, Acting Chair  
**Department Home Page:** [http://www.bme.rpi.edu/](http://www.bme.rpi.edu/)

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 becoming increasingly involved in cellular and molecular biology for basic research and design of new devices and technologies. For instance, many 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 requisite 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 a mechanical or materials concentration to develop knowledge and skills in cell and tissue engineering or implant design.
Research Innovations and Initiatives

Cell and Tissue Engineering
Cultured mammalian cells are used to study in vitro and at the molecular level, systems of biomedical interest. Experimental projects in progress include investigations of the mechanisms of osteoblast interactions with orthopedic/dental implant materials; structure and biochemistry of the cell/biomaterial interface; the effects of mechanical stresses on cellular function, morphology, and structure; and the development of engineered tissues to repair or replace damaged tissues. Theoretical approaches are used in modeling proliferation of anchorage-dependent, contact-inhibited cells, and in quantifying morphological responses of cells to mechanical forces.

Computational Bioengineering
The level of complexity inherent in the study of human systems such as musculoskeletal or cardiovascular systems frequently dictates the need for numerical solution methods. Rensselaer is developing and applying high-performance computational methods to the study of diarthrodial joint mechanics, cardiovascular mechanics, dental mechanics, and imaging. Projects involving the development of computational methods for bioengineering applications are done in collaboration with Rensselaer’s Scientific Computation Research Center, as well as the Center for Subsurface Sensing and Imaging Systems (CenSISS).

Implantable Sensors
Ongoing research includes the design, packaging and integration of novel sensors into chronic implants to facilitate direct experimental measurement of physical parameters in vivo in (1) oral implants, (2) fracture fixation devices, and (3) spinal implants.

Musculoskeletal Biomechanics
In an aging individual, musculoskeletal well-being is a key factor that contributes towards quality of life. The Orthopedic Biomechanics Laboratory uses a combination of cellular and tissue-level approaches to (1) identify changes in the biological and mechanical characteristics of skeletal tissues with emphasis on aging and osteoporosis; and (2) develop microenvironments conducive to regeneration of lost or damaged matrix. Current research areas include biology and mechanics of hard tissue, cellular control of tissue growth and development, mechanobiology of skeletal tissue regeneration, and fatigue fractures of long bones. Other research focuses on characterizing the response of the intervertebral disc and subchondral bone to mechanical stimuli, as well as the biomechanical effects of spine implants and tissue substitutes.

The Tissue Interface
In oral/maxillofacial surgery, orthopedic surgery, and tissue engineering, events at the bone-implant interface ultimately determine clinical implant performance. All such interfaces transmit loads, so interfacial biomechanics and biomaterials become extremely relevant. Continuing projects include (1) characterization of implant biomechanics, and (2) assessment of bone biology at loaded verses unloaded bone-implant interfaces. New aspects of these projects include digital image-based strain analysis of interfaces and cellular/molecular-level approaches to understand interfacial bone healing and remodeling under the influence of interfacial biomechanics and biomaterials.

Other Research
Biomedical engineering research at Rensselaer involves three schools within the Institute and interactions with Albany Medical College, the University of Pennsylvania, Columbia University, Université de Montreal, Johns Hopkins, Stanford University, Union College, the Center for Tissue Integrated Prostheses (Spokane, Wash.), and several other hospitals.
Faculty*

Professors
Bizios, R.—Ph.D. (Massachusetts Institute of Technology); cellular bioengineering, cell/biomaterial interactions, biomaterials.
Brunski, J.B.—Ph.D. (University of Pennsylvania); dental biomechanics and implants, bone healing at interfaces, biomaterials.
DePaola, N.—Ph.D. (MIT-Harvard Medical School); biofluid mechanics, cellular bioengineering (Department Acting Chair).
Newell, J.C.—Ph.D. (Albany Medical College); cardiopulmonary physiology, systems modeling, impedance imaging.
Roysam, B.—D.Sc. (Washington University); electrical, computer, and systems engineering; intelligent imaging at low SNR; parallel computation; biomedical applications.
Spilker, R.L.—Sc.D. (Massachusetts Institute of Technology); computational mechanics and biomechanics.
VonMaltzahn, W.W.—Ph.D. (University of Hannover, Germany) bioinstrumentation, physiological measurements and modeling.

Associate Professors
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.

Assistant Professors
Plopper, G.—Ph.D. (Harvard University Medical School); extracellular matrix and tissue engineering.
Stegemann, J.P.—Ph.D. (Georgia Institute of Technology); cell and tissue engineering, vascular biology, extracellular matrix biology.
Thompson, Deanna M.—Ph.D. (Rutgers University); tissue engineering (neural), microfluidics, microelectro-mechanical systems (MEMS).
Vashishth, D.—Ph.D. (University of London, UK); orthopedics biomechanics, hard tissue biology (aging and osteoporosis), sports medicine (stress fractures and running injuries), skeletal tissue regeneration.

Research Assistant Professors
Ledet, E.—Ph.D. (Rensselaer Polytechnic Institute); in vivo sensor development, degenerative diseases of the spine, biomechanics of fracture fixation.
Mehta, S.—Ph.D. (University of Texas Southwestern Medical Center); biotechnology management and entrepreneurship.

Affiliated Faculty
Cheney, M.—Ph.D. (Indiana University); professor of mathematical sciences; applied mathematics, differential equations, mathematical computed tomography.
Doremus, R.D.—Ph.D. (University of Illinois, University of Cambridge); professor of glass and ceramics science; physical chemistry, solutions of polyelectrolytes and proteins.
Isaacson, D.—Ph.D. (New York University); professor of mathematics and computer science; electric current computed tomography.

* 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 2005 Board of Trustees meeting.
Adjunct Faculty
Bowser, S.S., Jr.—Ph.D. (University at Albany); cell structure and function, particularly cell motility and cytoskeleton-membrane interactions, effects of mechanical forces on cell physiology, biology of benthic foraminifera.
Del Vecchio, P.J.—Ph.D. (Fordham University); biology, vascular endothelium.
Flaherty, L.—Ph.D. (Cornell University Medical College); molecular genetics; mammalian genetics. Director, Genomics Institute, Wadsworth Center of the NYS Dept. of Health.
Metzger, D.—Ph.D. (University of Illinois at Chicago); regulation of immunity, mucosal immunology, immune response to xenogenica tissue implants.
Rangert, B.—Ph.D. (Chalmers Institute of Technology); dental implants, biomaterials, biomechanics.
Singer, H.—Ph.D. (University of Virginia); vascular smooth muscle cell biology, calcium/calmodulin-dependent protein kinases, intracellular regulation of smooth muscle contractility.
Turner, J.N.—Ph.D. (State University of New York, Buffalo); biophysics, anatomic pathology, quantitative light microscopy.

Emeritus Faculty
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.

Undergraduate Programs

Objectives of the Undergraduate Curriculum in Biomedical Engineering
Graduates of the Department of Biomedical Engineering will:

- Have a solid foundation in mathematics and computation and in the biological and physical sciences.
- Function in a technically competent manner in applying the engineering problem-solving skills of analysis, modeling, and simulation to current problems in medicine and biology.
- Have the ability to design biomedical products, processes, and systems.
- Have specialized technical expertise that applies to industrial, academic, or other careers in biomedical engineering.
- Have strong written and oral presentation skills, as well as the ability to lead and contribute to multidisciplinary teams in industrial, academic, and clinical environments.
- Have a broad educational background, including the study of the humanities and social sciences, with an emphasis on ethics and social responsibility.
- Understand the importance of life-long learning.

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.
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 131–134 credits.

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
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<td><strong>Spring</strong></td>
<td></td>
</tr>
<tr>
<td>ENGR-1100</td>
<td>Intro. to Engineering Analysis .................4</td>
<td>ENGR-1200</td>
<td>Engineering Graphics and CAD ..........1</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers .............4</td>
<td>MATH-1020</td>
<td>Calculus II ........................................4</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I .............................................4</td>
<td>PHYS-1100</td>
<td>Physics I ............................................4</td>
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<tr>
<td>BMED-1330</td>
<td>Intro. to BME 1 ....................................1</td>
<td>BMED-2200</td>
<td>Hum. or Soc. Sci. Elective 2 ............4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective 2 ..................4</td>
<td>BIOL-1010</td>
<td>Intro. to Biology ................................4</td>
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<td><strong>Spring</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>ENGR-1200</td>
<td>Engineering Graphics and CAD .................1</td>
<td>MTLE-2100</td>
<td>Structure of Engr. Materials 3 ........4</td>
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<tr>
<td>ENGR-1600</td>
<td>Mat. Sci. for Engrs. ..........................4</td>
<td>BMED-2200</td>
<td>Dynamic Systems for Biomedical Engineering ..........4</td>
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<tr>
<td>PHYS-1200</td>
<td>Physics II ...........................................4</td>
<td>BMED-4300</td>
<td>Electronic Instrumentation ...............4</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations .............4</td>
<td>ENGR-2050</td>
<td>Intro. to Engineering Design ............3–4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Sec. Sci. Elective 2 ..................4</td>
<td>ENGR-2600</td>
<td>Mod. &amp; Analysis of Uncertainty ..........3</td>
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<td><strong>Second Year</strong></td>
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<td>CSCI-1190</td>
<td>Beginning C Prog. for Engrs. ................1</td>
<td>BMED-4240</td>
<td>Tissue Biomaterials Interaction ..........4</td>
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<tr>
<td>ENGR-1600</td>
<td>Mat. Sci. for Engrs. ..........................4</td>
<td>BMED-4500</td>
<td>Advanced Systems Physiology ..........4</td>
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<tr>
<td>PHYS-1200</td>
<td>Physics II ...........................................4</td>
<td>ENGR-4300</td>
<td>Electronic Instrumentation ...............4</td>
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<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations .............4</td>
<td>BMED-4500</td>
<td>Advanced Systems Physiology ..........4</td>
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<tr>
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<td>Hum. or Sec. Sci. Elective 2 ..................4</td>
<td>ENGR-2050</td>
<td>Intro. to Engineering Design ............3–4</td>
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<td><strong>Third Year</strong></td>
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<tr>
<td>BIOL-4290</td>
<td>Human Physiological Systems..................4</td>
<td>BMED-4240</td>
<td>Tissue Biomaterials Interaction ..........4</td>
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<tr>
<td>BMED-4540</td>
<td>Biomechanics ........................................4</td>
<td>BMED-4500</td>
<td>Advanced Systems Physiology ..........4</td>
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<tr>
<td>ENGR-2250</td>
<td>Thermal and Fluids Engineering I 4 ........4</td>
<td>ENGR-4500</td>
<td>Electronic Instrumentation ...............4</td>
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<td>Concentration II ..................................3–4</td>
<td>BMED-4500</td>
<td>Advanced Systems Physiology ..........4</td>
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<tr>
<td></td>
<td>Free Elective I 5 ..................................3</td>
<td>BMED-4500</td>
<td>Advanced Systems Physiology ..........4</td>
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<tr>
<td><strong>Fourth Year</strong></td>
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<td></td>
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<tr>
<td>BMED-4010</td>
<td>Biomedical Engineering Lab ....................4</td>
<td>BMED-4600</td>
<td>BME Design 1 .......................................3</td>
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<tr>
<td></td>
<td>Concentration III ................................3</td>
<td>BMED-4600</td>
<td>Free Elective IV 3 .............................3–4</td>
</tr>
<tr>
<td></td>
<td>Free Elective I 4 ................................3</td>
<td>BMED-4600</td>
<td>Concentration V ................................3</td>
</tr>
<tr>
<td></td>
<td>Free Elective III 4 .............................3</td>
<td>BMED-4600</td>
<td>Professional Development III ..........1</td>
</tr>
<tr>
<td></td>
<td>Concentration Course IV ........................3</td>
<td>BMED-4600</td>
<td>Hum. or Sec. Sci. Elective 5 .............4</td>
</tr>
</tbody>
</table>

1 BMED-1330 or ENGR-1300 may be taken in the first or second term.
2 Placement of humanities and social science electives can be varied with free electives. The courses counted as free electives must show a minimum of twelve (12) credit hours.
3 This course will be substituted by a biomedical-specific course in Biomaterials Science and Engineering.
4 This course will be substituted by a biomedical-specific course in biotransport phenomena.
5 The minimum total credit hours of free electives is twelve (12), with no restrictions on the included number of 3 and 4 credit hour courses.
6 Professional Development II will be fulfilled from a published list at the start of each semester and can be taken either semester.
7 Capstone writing-intensive course.
8 Professional Development III can be taken either semester of the senior year. Professional Development I is part of ENGR-2050.
Concentrations

None of the courses proposed in the lists below should appear in more than two concentrations.

**Biomechanics: Choose 5 with at least 1 non BME course**

- Strength of Materials (ENGR-2530; 4 CR)
- Mechanobiology (BMED-6500; 3 CR)**
- Biomech. of Hard Tissues (BMED-6290; 3 CR)** or Biomech. of Soft Tissues (BMED-6280; 3 CR)**
- Cell Biomechanics (BMED-6550; 3 CR) **
- Intro. To Finite Elements (MANE-4240; 4 CR)
- Vibrations (MANE-4610; 4 CR)
- Fluid Dynamics & Transport in the Vascular Circulation (BMED-6350 **

A course in Commercializing Biomedical Technology is also available in this concentration.

**Biomaterials: Choose 5 with at least 1 non BME course**

- Intro. to Polymers (MTLE-4050; 4 CR)
- Intro. to Cell & Tissue Engineering (BMED-4650; 3 CR)
- Mechanobiology (BMED-6500; 3 CR)**
- Structure of Engineering Materials (MTLE-2100)
  or Properties of Engineering Materials (MTLE-4250)

New courses in BioMEMS and Biology & Engineering of the Extracellular Matix are available in this concentration. Also available is a course in Commercializing Biomedical Technology.

**Biochemical: Choose 5 with at least 1 non BME course**

- Intro. to Polymer Chemistry (CHEM-4620; 4 CR)
- Intro. to Cell & Tissue Engineering (BMED-4650; 3 CR)
- Intro. to Biochemical Engineering (CHME-4430; 3 CR)
- Chemical Process Dynamics and Control (CHME-4030)
- Fluid Dynamics & Transport in the Vascular Circulation (BMED-6350) * **

Other concentrations (Biomedical Imaging, Bioinformatics or Premedical) could be added without changing the basic BME template. For example, in consultation with your adviser, a concentration such as the following “Bioinformatics” could be developed:

**Bioinformatics: Choose 5 with at least one BME course**

- Organic Compounds & Reactions (CHEM-2210)
- Molecular Biology (BIOL-4620)
- Molecular Biochemistry I (BIOL-4760)
- Bioinformatics I (BIOL-4540)
- Bioinformatics II (BIOL-4550)

**Humanities and Social Sciences Electives**

In this area, electives are based on the Institute and School of Engineering requirements. Students are urged to select humanities and social science sequences with adequate breadth and depth in subject areas. Students desiring minors in humanities or social sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

* This course will be substituted by its revised version, Advanced Biotransport Phenomena.

** Pending approval of the School of Engineering Curriculum Committee, courses with this symbol will be re-numbered to reflect that they are available to undergraduates under a 4000-level number.
Minor Programs
The Department of Biomedical Engineering offers a minor in biomedical engineering for undergraduates majoring in other engineering and science fields. The selection of courses must have the prior approval of the department and must form a coherent program. Below is a list of suggested courses for a minor in biomedical engineering.

For Mechanical or Materials Engineering Majors

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BMED-4010</td>
<td>Biomedical Engineering Laboratory</td>
</tr>
<tr>
<td>BIOL-4290</td>
<td>Human Physiology Systems</td>
</tr>
<tr>
<td>BMED-4500</td>
<td>Advanced Systems Physiology</td>
</tr>
<tr>
<td>BMED-4540</td>
<td>Biomechanics</td>
</tr>
<tr>
<td>BMED-4240</td>
<td>Tissue-Biomaterial Interactions</td>
</tr>
</tbody>
</table>

Graduate Programs
The department offers programs leading to M.S., D.Eng., and Ph.D. degrees. Persons seeking admission to any of these graduate degree programs in biomedical engineering should have their Graduate Record Examination (GRE) aptitude test scores sent to Graduate Admissions Office. Applicants who cannot take the test should attach an explanation to the application. Submission of the GRE advanced test scores is also recommended. For further information on the GREs, write to Graduate Record Examinations, Box 955, Princeton, NJ 08541.

Master’s Programs
Rensselaer requires completion of at least 30 credit hours (with satisfactory grades) beyond the bachelor’s degree. At least 15 of these credit hours must have suffix numbers 6000–6990.

Master of Science
The Biomedical Engineering M.S. degree can be obtained with or without a thesis. The latter option is recommended for students who do not plan further graduate studies. The thesis option is advised for students who plan to obtain a higher graduate degree. The master’s thesis should contribute new knowledge to the field of study.

Students pursuing either M.S. option must complete a minimum of 30 credits. In consultation with their adviser, they must develop a plan of study that satisfactorily meets Institute requirements, core concentration requirements, and recommended technical electives. For students completing a thesis, at least 24 credits must be met in these requirements.

Concentrations
At the M.S. level in Biomedical Engineering, programs of study fall into two different concentration areas:

Biomaterials
Engineering applications for the design of prosthetic devices such as implants or tissue-engineered constructs require sophisticated knowledge of the structure, properties, and behavior of a wide range of materials—metals, ceramics, glasses, polymers, composites, and biological materials. Implant design and the new field of tissue engineering involve a working knowledge of material properties, tissue-biomaterial interactions, and biocompatibility.

Biomechanics
Mechanics has helped solve problems involving cell physiology, blood flow, skin rheology, bone mechanics, load-bearing prostheses design, joint lubrication methods, and countless other items of interest in medicine. Continuum mechanics, finite element analysis, strain gauge techniques, model analysis techniques, and micromechanics are some of the methods used to attack these problems in biomechanics.
**Biomedical Engineering Requirements**

In addition to the Biomedical Engineering core requirements, students must also meet the concentration and elective requirements.

**Core Requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>BMED-4010</td>
<td>Biomedical Engineering Lab I</td>
</tr>
<tr>
<td>BMED-4500</td>
<td>Advanced Systems Physiology*</td>
</tr>
</tbody>
</table>

**Biomaterial Concentration requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-6020</td>
<td>Design of Experiments (or an equivalent course)</td>
</tr>
</tbody>
</table>

**Biomechanics Concentration requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED-4540</td>
<td>Biomechanics</td>
</tr>
<tr>
<td>DSES-6020</td>
<td>Design of Experiments (or an equivalent course)</td>
</tr>
</tbody>
</table>

Technical electives can be chosen from BME courses and from other engineering and science courses at Rensselaer in consultation with the adviser.

**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 of the Department of Biomedical Engineering and an interdisciplinary committee. Usually 54 credits of formal courses are required in addition to the residency and thesis requirements. These requirements are formalized in a plan of study that is prepared in consultation with the research adviser and doctoral committee.

Technical electives can be chosen from BME courses and from other engineering and science courses at Rensselaer in consultation with the adviser.

**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.

**Chemical and Biological Engineering**

**Acting Chair:** Steven M. Cramer  
**Director, Industrial Liaison Program:** E. Bruce Nauman  
**Department Home Page:** http://www.eng.rpi.edu/dept/chem-eng/

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 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 and Innovation 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.

**Molecular 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). Molecular simulation techniques are also being applied to polymeric systems to understand penetrant solubility and diffusivity in polymers.

**Advanced Materials**
Research interests are centered on developing and understanding the phenomena involved in producing advanced materials for the optical, electronic, and allied industries. Thermodynamic, transport, and
chemical processes governing the formation and subsequent behavior of these materials are under active investigation. Research areas include modeling and optimizing CVD-reactor-system designs for producing high-efficiency, epitaxial layers economically in an environmentally sound manner, and developing nonlinear and electro-optic inorganic and organic materials for switching and memory applications. Additional research areas are understanding phenomena involved in the production and use of microlens arrays, wave-guide lasers, and determining the composition, property, and structure relationships of crystalline and glassy materials.

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 nonconventional 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.

High-Temperature Kinetics
The development of more efficient, less polluting, combustion systems, requires accurate chemical kinetic input data on individual reactions over large temperature ranges. Rensselaer is pioneering the development of experimental techniques for obtaining such data. This work includes design, construction, experimentation, and the generation of data for use by reaction system modelers. Both fast-flow thermal and pseudostatic photochemical systems are used. Various light sources, such as lasers, combined with electro-optical detection techniques are employed to determine the time history of reactants. Larger reactants and products are observed mass spectrometrically. Microcomputers are used for experimental control and data handling. In some work, the light-emitting and electrical-charge generation aspects of reactions are also investigated. In addition to combustion, this work is important to technological fields, such as semiconductor processing, metals refining, and optical fiber and carbon black manufacturing, as well as models of the atmosphere. A better understanding of the temperature dependence of reaction rate coefficients is a significant result of this work.

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; 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. Research into state-of-the-art design and optimization of CVD reactors for semiconductor production is conducted jointly with the Center for Integrated Electronics. 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, minicomputers, and microcomputers. 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. The Howard Isermann Biochemical Engineering Laboratory was established in the department exclusively for conducting biochemical engineering research. 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.
Bizios, R.—Ph.D. (Massachusetts Institute of Technology); cellular bioengineering, cell/biomaterial interactions, biomaterials.
Cale, T.S.—Ph.D. (University of Houston); microelectronic materials processing and simulation.
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.
Glicksman, M.E.—Ph.D. (Rensselaer Polytechnic Institute); transport phenomena of crystal growth.
Hirsa, A.—Ph.D. (University of Michigan); fluid mechanics, experimental gas dynamics.

* 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 2005 Board of Trustees meeting.
Kumar, S.K.—Ph.D. (Massachusetts Institute of Technology) Synthetic-and bio-polymers, nano composites and nanomaterials.

Lahey, R.T., Jr.—Ph.D. (Stanford University); two-phase flow and boiling heat transfer.

Nauman, E.B.—Ph.D. (University of Leeds, England); reaction engineering, dispersion theory, laminar heat transfer.

Plawsky, J.L.—Sc.D. (Massachusetts Institute of Technology); optical, nonlinear and electrooptic, crystalline, and glassy materials.

Associate Professors

Garde, S.S.—Ph.D. (University of Delaware); molecular simulation.

Assistant Professors

Kane, R.S.—Ph.D. (Massachusetts Institute of Technology); biomedical engineering, polymers, surfaces, nanomaterials.

Martin, L.L.—Ph.D. (University of California, Los Angeles) process systems engineering, design for waste minimization and pollution prevention.

Sharfstein, S.T.—Ph.D. (University of California, Berkeley); biochemical engineering, mammalian cell culture.

Distinguished Research Professors

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.

Wayner, P.C., Jr.—Ph.D. (Northwestern University); heat transfer, interfacial phenomena.

Adjunct Faculty

Belfort, M.—Ph.D. (University of California, Irvine); molecular biology.

Emeritus Professors

Abbott, M.M.—Ph.D. (Rensselaer Polytechnic Institute); thermodynamics.

Altwicker, E.R.—Ph.D. (Ohio State University); air pollution control, atmospheric chemistry.

Bungay, H.R., III—P.E., Ph.D. (Syracuse University); water resources, biochemical engineering.

Chung, C.I.—Ph.D. (Rutgers University); polymer processing, polymer melt rheology, relaxation behavior in polymer solids.

Littman, H.—Ph.D. (Yale University); fluidization, fluid-particle systems.

Muckenfuss, C.—Ph.D. (University of Wisconsin); kinetic theory, transport phenomena.

Van Ness, H.C.—P.E., D.Eng. (Yale University); thermodynamics.

Undergraduate Programs

Objectives of the Undergraduate Curriculum

Graduates of the Howard P. Isermann Department of Chemical and Biological Engineering will:

- Have a solid background in chemistry, mathematics, basic science, and engineering science.
- Have technical knowledge of fundamental chemical engineering concepts of balance equations, thermodynamics, transport phenomena, chemical reaction engineering, separations processes, and process systems engineering.
- Be able to communicate technical material through written reports and oral presentations.
- Apply chemical engineering principles and economic analysis to the synthesis of chemical processes and products. These complex problems require teamwork and the ability of individuals to serve as leaders and contributors.
Be prepared equally for professional practice or further graduate study in chemical engineering and biological engineering.

As with all engineering disciplines, be informed citizens, broadly educated in the humanities and social sciences.

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 below.

**Baccalaureate Programs**

The chemical engineering program comprises a minimum of 37 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 128 credit hours.

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100 Intro. to Engineering Analysis</td>
<td>4</td>
<td>ENGR-1200 Eng. Graphics and CAD 1</td>
<td>1</td>
</tr>
<tr>
<td>ENGR-1300 Engineering Processes 2</td>
<td>1</td>
<td>ENGR-1600 Materials Science for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1300 Chemistry Principles for Engineers</td>
<td>4</td>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1010 Calculus I</td>
<td>4</td>
<td>PHYS-1100 Physics I</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
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</tbody>
</table>

1 These required courses may be taken in either order.
2 May be replaced by ENGR-1310.

### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHME-2010 Material, Energy, and Entropy Balances</td>
<td>4</td>
<td>CHME-2020 Energy, Entropy, and Equilibrium 1</td>
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</tr>
<tr>
<td>MATH-2400 Intro. to Differential Equations</td>
<td>4</td>
<td>ENGR-2600 Modeling and Analysis of Uncertainty</td>
<td>3</td>
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<tr>
<td>PHYS-1200 Physics II</td>
<td>4</td>
<td>CSCI-1190 Beginning C Programming for Engineers</td>
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<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Free Elective 4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
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</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHME-4010 Fluid Mechanics and Heat Transfer</td>
<td>4</td>
<td>CHME-4020 Heat and Mass Transfer</td>
<td>3</td>
</tr>
<tr>
<td>CHEM-2210 Organic Compounds &amp; Reactions</td>
<td>4</td>
<td>CHEM-4030 Chemical Process Dynamics and Control</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
<td>CHEM-4460 Microscopic Physical Chemistry</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>CHEM-4530 Modern Techniques in Chemistry</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Professional Development II 2</td>
<td>2</td>
</tr>
</tbody>
</table>

1 These required courses may be taken in either order.
2 May be replaced by ENGR-1310.
3 Includes Professional Development I.
4 Students are encouraged to select a life sciences course such as BIOL-1010.
5 This course will be fulfilled from a list published at the start of each semester. It may be taken either semester in Year 3.
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 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 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 and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities 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 ten additional courses beyond the baccalaureate degree and will be awarded the M.Eng. degree. This program is described in detail below.

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:

<table>
<thead>
<tr>
<th>Fourth Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>Fall</td>
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<td></td>
<td></td>
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<tr>
<td>CHME-4040</td>
<td>Chemical Engineering Separations...3</td>
<td>CHME-4050</td>
<td>Chemical Process Design ..........3</td>
</tr>
<tr>
<td>CHME-4500</td>
<td>Chemical Reactor Design ..................3</td>
<td>ENGR-4010</td>
<td>Professional Development III ........1</td>
</tr>
<tr>
<td></td>
<td>Free Elective ................................4</td>
<td></td>
<td>Engineering Elective ................4</td>
</tr>
<tr>
<td></td>
<td>Chemical Engineering Elective ............3</td>
<td></td>
<td>Chemistry Elective .................4</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>CHME-4050</td>
<td>Chemical Process Design ..........3</td>
</tr>
<tr>
<td>CHME-4160</td>
<td>Chem. Eng. Lab. II..................2</td>
</tr>
<tr>
<td>ENGR-4010</td>
<td>Professional Development III ........1</td>
</tr>
<tr>
<td></td>
<td>Engineering Elective ................4</td>
</tr>
<tr>
<td></td>
<td>Chemistry Elective .................4</td>
</tr>
</tbody>
</table>
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.

Master of Science
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.

Master of Engineering
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. For a student with an accredited B.S. degree in chemical engineering, the program includes the following:

<table>
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<tr>
<th>Credit hours</th>
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<tbody>
<tr>
<td>CHME-6510 Advanced Fluid Mechanics I ..............................................................3</td>
</tr>
<tr>
<td>CHME-6570 Chemical and Phase Equilibria..........................................................3</td>
</tr>
<tr>
<td>CHME-6640 Advanced Chemical Reactor Design. ................................................3</td>
</tr>
<tr>
<td>Electives .......................................................................................................18</td>
</tr>
</tbody>
</table>

Of the electives, at least two must be chemical engineering courses and at least two must be nonchemical 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.

**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, 90 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

Chair: George F. List

Coordinator of Undergraduate Studies (Civil and Environmental Programs): Simeon Komisar

Coordinator of Graduate Studies (Civil Program): Jacob Fish

Coordinator of Graduate Studies (Environmental Program): James (Chip) Kilduff

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.

Civil and environmental engineers focus on the analysis, design, construction, maintenance, and operation of large-scale physical systems. 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
- 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
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 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 and Innovation 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 twenty 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.

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.

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 the development of automated finite element modeling techniques, adaptive analysis procedures, development of adaptive multiscale solution techniques, qualification and modeling of
engineering idealizations for analysis and design, design systems using knowledge-base techniques, prototype systems for applications including discrete crack propagation, forging simulations, multiple-scale modeling of composite materials and electronic packages, and unsteady aerodynamics.

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, and environmental chemistry of PAHs.

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.

Waste Treatment (Environmental)
Studies focus on aerobic and anaerobic biological treatment reactors for municipal and industrial wastes; high strength anaerobic waste treatment in fluidized bed bioreactors with energy recovery, nutrient removal systems, hazardous waste treatment reactors, biofilters.

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.

Environmental Systems (Environmental)
Under investigation are adaptive optimal control of treatment reactors, molecular modeling in environmental chemistry, and structure activity relationships.

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 a decade of successful operation, the facility has published results of some 500 earthquake-related model simulations, served as the basis for many MS and PD. 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 (Center for Earthquake Engineering Simulation), a School of Engineering Interdisciplinary Research Center (see Center for Earthquake Engineering Simulation).

The Rensselaer 1 g seismic shaking table, located in 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.
A major upgrade in lab equipment and space for environmental engineering research and teaching has occurred through the establishment of the Keck Water Quality Laboratory, the National Science Foundation Environmental Colloid and Particle Laboratory, and the refurbishment of the Environmental Engineering Teaching Laboratory suite. Analytical equipment in these labs provides the capability for analysis and investigation of a wide variety of industrial processes, treatment processes, and polluted environments. This equipment gives students experience and expertise in treatability and toxicity studies, design and operation of bench-scale treatment systems, and investigation of a wide range of environmental quality parameters. The fate of specific compounds in the environment and in treatment processes can be analyzed by UV-VIS spectrophotometry, high pressure liquid chromatography, gas-liquid and gas chromatography with a number of specific and sensitive detectors, including electron capture, flame ionization, thermal conductivity, and mass spectral. Metals analyses by atomic absorption spectrophotometry and elemental analyses are also available. A complete suite of water quality monitoring equipment, field sampling systems, and geographical information system tools are available. Computational capabilities are widely accessible not only throughout the campus, but also in research laboratories, as well.

**Faculty***

**Professors**

Dobry, R.—Sc.D. (Massachusetts Institute of Technology); geotechnical engineering, soil dynamics, earthquake engineering, seismic analysis.

Dvorak, G.J.—Ph.D. (Brown University); mechanics of solids, composite materials and structures, fracture and fatigue.

Fish, J.—Ph.D. (Northwestern University); computational mechanics, finite element methods, micromechanics, mathematical modeling.

List, G.F.—PE, Ph.D. (University of Pennsylvania); intelligent transportation systems, sensors, instrumentation and control, multiobjective.

O'Rourke, M.J.—PE, Ph.D. (Northwestern University); structures, lifeline earthquake engineering, snow loading on structures.

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.

**Associate Professors**

Holguín-Veras, J.—PE. Ph.D. (The University of Texas at Austin); intelligent transportation networks, intermodal transportation, transportation planning and modeling, transportation economics.

Kilduff, J.—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.

Symans, M.—Ph.D. (State University of New York at Buffalo); structural dynamics, earthquake engineering, seismic isolation and energy dissipation systems, structural vibration control.

* 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 2005 Board of Trustees meeting.
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
Abdoun, T.—Ph.D. (Rensselaer Polytechnic Institute); geotechnical engineering.
Han, Jong-In—Ph.D. (University of Michigan); microbial molecular biology, bioremediation, bioavailability of hydrophobic contaminants, microbial communication (quorum sensing).
Montoya, Lupita—Ph.D. (Stanford University); indoor air quality, biological aerosols, health effects of aerosols, human exposure to air pollutants, environmental justice.
Nyman, M.C.—Ph.D. (Purdue University); fate and transport of hydrophobic organic contaminants in natural systems, environmental chemistry.

Clinical Associate Professor
Komisar, S.J.—Ph.D. (University of Washington); wastewater treatment, biological processes, solid waste management.

Adjunct Faculty (Civil Program)
Dall, J.—M.S. (Rensselaer Polytechnic Institute); structural engineering.
Dunn, R.H.P.—M.S. (Rensselaer Polytechnic Institute); geotechnical engineering.
Floess, C.—Ph.D. (Rensselaer Polytechnic Institute); geotechnical engineering.
Kenneally, D.—B.S. (Rensselaer Polytechnic Institute); highway engineering.
O’Malley, D.—M.S. (Central Missouri State University); traffic engineering.
Griggs, F.—D.E. (Rensselaer Polytechnic Institute); structural engineering.
Reilly, J.—Ph.D. (Rensselaer Polytechnic Institute); transportation systems.

Adjunct Faculty (Environmental Program)
Hetling, L.—PE., Ph.D. (Rensselaer Polytechnic Institute) water resources.
Young, K.—J.D. (Harvard Law School) environmental law.

Emeritus Faculty
Clesceri, N.L.—Ph.D. (University of Wisconsin); advanced waste treatment, environmentally sound manufacturing, sediment decontamination.
Feeseer, L.J.—PE., Ph.D. (Carnegie Mellon University); structures, computer applications and computer graphics, computer-aided design, structural optimization.

Undergraduate Programs

Civil Engineering Curriculum

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 depending upon the student’s chosen field. In this regard, the Department of Civil and Environmental Engineering Department’s baccalaureate program in Civil Engineering will:

1. Prepare students to be involved, global citizens with a broad appreciation of the key civil engineering issues and challenges of the 21st Century.

2. Provide students with the technical background needed for the practice of civil engineering and to ensure their competence and literacy in both problem identification and problem solving, including design.
n Prepare students for leadership in the profession, including civil engineering practice, societal activities, research, licensing, and ethics.

n Provide students with a broad educational base, including a foundation in math, science, and engineering and exposure to the humanities and social sciences that prepares them for lifelong learning.

n Prepare students to thrive in the modern workplace and the public forums of civil engineering practice through the development of leadership, teamwork, and communication skills.

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 DSES.

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

#### Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>ENGR-1100</td>
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<tr>
<td>ENGR-1200</td>
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<tr>
<td>MATH-1010</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1300</td>
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</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
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#### Spring

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ENGR-1300</td>
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<tr>
<td>ENGR-1600 or CSCI-1100</td>
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<tr>
<td>MATH-1020</td>
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<td>Hum. or Soc. Sci. Elective</td>
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### Second Year

#### Fall

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>ENGR-2050</td>
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<td>MATH-2400</td>
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<td>PHYS-1200</td>
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#### Spring

<table>
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<th>Course</th>
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<tbody>
<tr>
<td>ENGR-2090</td>
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</tr>
<tr>
<td>ENGR-2250 or ENGR-4750</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2350 or ENGR-4300</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1190</td>
<td>1</td>
</tr>
</tbody>
</table>

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1 For these two courses, order does not matter. ENGR-1300 may be replaced with CIVL-2961.

2 Choose either ENGR-1600 or CSCI-1100.

3 For Multidisciplinary Elective I, choose either ENGR-2250 or ENGR-4750. For Multidisciplinary Elective II, choose either ENGR-2350 or ENGR-4300.

4 Can be satisfied with Computer Science I.
### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL-2030</td>
<td>Intro. to Transportation Eng. ......4</td>
<td>Multidisciplinary Elective II 1  .....4</td>
<td></td>
</tr>
<tr>
<td>CIVL-2630</td>
<td>Intro. to Geotechnical Eng. .........4</td>
<td>CE Design Elective 1 1 ..............3</td>
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<tr>
<td>CIVL-2670</td>
<td>Intro. to Structural Eng. .............4</td>
<td>Professional Elective 1 1 ............3</td>
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</table>
| ENGR-2600  | Modeling and Analysis  
of Uncertainty.................................3 | Math and Science Elective.................3-4 |

### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVE-2110</td>
<td>Intro. to Environ. Eng. ...............4</td>
<td>CIVL-4920</td>
<td>Civil Eng. Capstone Design.............3</td>
</tr>
<tr>
<td>CIVL-4120</td>
<td>CE Instrumentation and Sensors ......4</td>
<td>ENGR-4010</td>
<td>Professional Development III 7 ........1</td>
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<td></td>
<td>CE Design Elective 5 1 ...............3</td>
<td></td>
<td>CE Technical Elective 7 1 .............3</td>
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<tr>
<td></td>
<td>Free Elective ................................4</td>
<td></td>
<td>Hum. or Soc. Sci. Elective .................4</td>
</tr>
</tbody>
</table>

A minimum of 128 credit hours is required for this curriculum. 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 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 offered are listed in parentheses.

#### Construction Engineering

- CIVL-4070  Steel Design (Fall)
- CIVL-4080  Concrete Design (Spring)
- CIVL-4010  Foundation Engineering (Fall)
- CIVL-4150  Experimental Soil Mechanics (Spring)

#### Structural Engineering

- CIVL-4070  Steel Design (Fall)
- CIVL-4080  Concrete Design (Spring)
- CIVL-4960  Bridge Design (Spring)*

#### Environmental Engineering

- ENVE-4200  Solid and Hazardous Waste Science and Engineering (Spring)
- ENVE-4350  Biological Processes in Environmental Science and Engineering (Fall)

- ENVE-4310  Applied Hydrology and Hydraulics (Spring)
- ENVE-4340  Physiocochemical Processes in Environmental Engineering (Spring)

#### Geotechnical Engineering

- CIVL-4010  Foundation Engineering (Fall)
- CIVL-4140  Geoenvironmental Engineering (Fall)
- CIVL-4150  Experimental Soil Mechanics (Spring)

#### Transportation Engineering

- CIVL-4620  Mass Transit Systems (Spring)
- CIVL-4640  Transportation Facility Design and Planning (Spring)
- CIVL-4660  Traffic Engineering (Fall)
- CIVL-4670  Highway Engineering (Spring)

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1 For Multidisciplinary Elective I, choose either ENGR-2250 or ENGR-4750. For Multidisciplinary Elective II, choose either ENGR-2350 or ENGR-4300.

2 Text below lists the allowable courses.

3 This course will be fulfilled from a list published at the start of each semester.

4 Can be taken either semester of the senior year.

5 Special topics course.
Civil Engineering Technical Elective

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:

- CIVL-2040 Professional Practice
- CIVL-2130 Surveying
- CIVL-4240 Intro. to Finite Elements
- CIVL-4270 Construction Management
- CIVL-4440 Structural Analysis
- CIVL-4580 Infrastructure Engineering

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:

- ARCH-4510 Construction Industry Seminar
- ARCH-4530 Systems Building Seminar
- ARCH-4550 Building Economics
- ARCH-4750 Advanced Environmental Systems
- ENGR-4750 Engineering Economics and Project Management
- ENVE-4110 Aqueous Geochemistry
- ENVE-4200 Solid and Hazardous Waste Engineering
- ENVE-4200 Applied Hydrology and Hydraulics
- MATH-4800 Numerical Computing
- ERTH-2120 Structural Geology
- ERTH-2330 Earth Materials
- ERTH-4200 Surficial Geology
- ERTH-4710 Ground Water Hydrology

Humanities or Social Sciences Electives

In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Environmental Engineering Curriculum

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 depending upon the student’s chosen field. In this regard, the Civil and Environmental Engineering Department’s baccalaureate program in Environmental Engineering will:

- Prepare students to be involved global citizens with a broad appreciation of the key environmental issues and challenges of the 21st Century
- Provide students with a broad educational base, including a foundation in math, science, and engineering and exposure to the humanities and social sciences that will prepare them for life-long learning
- Provide students with the technical background needed for the practice of environmental engineering and to insure their competence and literacy in both problem identification and solving, including design.
- Prepare students for professional engineering practice, including professional licensing, with awareness of the importance of personal and professional ethics
- Prepare students to thrive in the modern workplace and the public forums of environmental engineering practice through the development of leadership, teamwork, and communication skills
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>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100 Intro. to Engineering Analysis</td>
<td>4</td>
<td>PHYS-1100 Physics I</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1010 Calculus I</td>
<td>4</td>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1300 Chemistry Principles for Engineers</td>
<td>4</td>
<td>ENGR-1600 Material Science for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1200 Engineering Graphics and CAD</td>
<td>1</td>
<td>ENGR-1300 Engineering Processes or</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>ENGR-1310 Intro to Eng. Electronics</td>
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### Second Year

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<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-1200 Physics II</td>
<td>4</td>
<td>ENGR-2600 Modeling and Analysis of</td>
<td>4</td>
</tr>
<tr>
<td>MATH-2400 Intro. to Differential Equations</td>
<td>4</td>
<td>ENGR-2050 Intro. to Engineering Design</td>
<td>2</td>
</tr>
<tr>
<td>ENVE-2110 Intro. Environmental Eng</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-2250 Intro. to Organic Chemistry</td>
<td>3</td>
<td>Free Elective I</td>
<td>4</td>
</tr>
</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHME-4010 Fluid Mech. and Heat Transfer</td>
<td>4</td>
<td>ENVE-4310 Applied Hydrology and Hydraulics</td>
<td>3</td>
</tr>
<tr>
<td>ENVE-4330 Atmospheric Pollution</td>
<td>3</td>
<td>ENVE-4320 Environmental Chemodynamics</td>
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<tr>
<td>Free Elective II</td>
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<td>ERTH-4180 Environmental Geology</td>
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<tr>
<td>Professional Development II</td>
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</table>

### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVE-4350 Biol. Proc. in Env. Eng.</td>
<td>4</td>
<td>ENVE-4340 Physicochem. Proc. in Env. Eng.</td>
<td>3</td>
</tr>
<tr>
<td>ENVE-4150 Environmental Eng. Lab</td>
<td>4</td>
<td>ENVE-4180 Technical Elective II</td>
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<tr>
<td>Hum. or Soc. Sci. Elective</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ENGR-4010 Professional Development III</td>
<td>1</td>
<td></td>
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</tr>
</tbody>
</table>

1 May be taken in any order in the first two semesters. ENGR-1300 or ENGR-1310 may be replaced with CIVL-2961.

2 Special section for environmental engineering students.

3 May be replaced by ENGR-2250.

4 Elective must be an engineering course with design content (e.g., ENVE-4200, ENVE-4240, ENVE-4210, ENVE-4110). Courses are selected in consultation with the program adviser. With adviser approval, courses from other disciplines may also be taken. These include Civil Engineering, Chemical Engineering, Earth and Environmental Sciences (for example, CIVL-2630, CIVL-4150, ERTH-4710 and others).

5 Multidisciplinary engineering elective: Must be an engineering course, chosen in consultation with the adviser (e.g., ENGR-4750, ENGR-4760, CIVL-2030, CIVL-2630, DSES-4260, ENGR-2530, ENGR-2830).

6 This course will be fulfilled from a published list at the start of each semester and can be taken either semester.
Minor Programs
The department offers minors in both civil and environmental engineering.

Civil Engineering
Students not majoring in civil engineering may receive a minor in this field by completing 15 credit hours selected from the following list (subject to consultation with a department program adviser):

- CIVL-2030 Intro. to Transportation Engineering
- CIVL-2630 Intro. to Geotechnical Engineering
- CIVL-2670 Intro. to Structural Engineering
- ENVE-2110 Intro. to Environmental Engineering
- CIVL-4010 Foundation Engineering
- CIVL-4150 Experimental Soil Mechanics
- CIVL-4070 Steel Design
- CIVL-4080 Concrete Design
- CIVL-4660 Traffic Engineering
- CIVL-4670 Highway Engineering

Students pursuing this minor must satisfy the prerequisites and/or corequisites for these courses, which may involve other course work. Courses in mechanics and structures taught by the School of Architecture may be substituted for certain core engineering, mathematics, and mechanics/materials courses (with instructor approval).

Environmental Engineering
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:

- ENVE-4260 Biological Processes in Environmental Engineering
- ENVE-4340 Physicochemical Process in Environmental Engineering
- ENVE-4310 Applied Hydrology and Hydraulics
- ENVE-4200 Solid and Hazardous Waste
- ENVE-4330 Atmospheric Pollution
- ENVE-4320 Environmental Chemodynamics

Professional Program
This program is intended primarily as a preparation for professional practice. After core engineering study, qualified undergraduates may enter this program, which leads to the B.S. and the M.Eng. degrees. Students follow a coherent program integrating advanced undergraduate and graduate study. An additional 30 credit hours are required beyond the B.S. degree.

Graduate Programs
Graduate programs leading to the M.Eng., M.S., D.Eng., and Ph.D. are available in both curricula. The selection of a graduate program and degree is based on student interest, area of graduate concentration, and satisfaction of prerequisites as indicated below.

Master’s Programs
Master of Science
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.

In the civil engineering discipline, 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.
M.S. candidates in the environmental engineering discipline must also provide documentation of an independent research-related effort. In addition to approval of this written work, they are also required to give an oral presentation of the thesis work.

Master of Engineering
This is a 30-credit structured program of advanced professional study aimed at preparing students for professional practice. Except for computational mechanics, 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.

Doctoral Programs
Advanced study and research are conducted under the guidance of an adviser. Usually 45 to 60 course credits beyond the bachelor’s degree are required in addition to the residence and thesis requirements. Each doctoral candidate must have at least 90 credits (course work plus thesis/project) beyond the bachelor’s degree. Environmental candidates are required to submit a draft of a journal article prior to graduation.

Doctor of Philosophy
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 dissertation can represent up to 30 credits of the student’s approved plan of study. 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 student’s second semester if student has a M.S. degree counting as a degree requirement or at the end of the student’s fourth semester if student does not have a 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.

Doctor of Engineering
This is a specialized program aimed at advanced engineering problem solving. The degree includes the preparation of a dissertation that poses a significant engineering problem and develops a solution. The dissertation for this degree can also represent up to 30 credits of the student’s approved plan of study. The examination requirements for both disciplines are the same as those noted under the Doctor of Philosophy.
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.

Decision Sciences and Engineering Systems

Chair: James M. Tien

Associate Chair and Director, Master’s Programs: Charles J. Malmborg

Director, Doctoral Program: Sunderesh Heragu

Director, Undergraduate Program: Mohamed Aboul Seoud

Department Home Page: http://www.dses.rpi.edu

The formation of the Decision Sciences and Engineering Department in 1987 is a prime example of Rensselaer’s ability to anticipate the changing needs of the engineering profession. The department was created to (1) prepare engineers to design, develop, and implement complex systems and (2) to conduct research that leads to better understanding of how information technology and quantitative analysis and modeling can support individuals, groups, and systems in problem solving and decision making. DSES achieves these objectives by extending and integrating knowledge from the disciplines of industrial engineering, information systems, operations research, mathematical statistics, computational intelligence, bioinformatics, and systems engineering.

The Department of Decision Sciences and Engineering Systems offers programs in industrial and management engineering, service and manufacturing systems engineering, and operations research and statistics. Curricula in management engineering and/or industrial engineering have been offered since 1933. The interdisciplinary graduate program in operations research and statistics (OR&S) at Rensselaer was established in response to the rapid increase in the use of mathematical models for characterizing systems, understanding operations, and making decisions. Both a master’s and a doctoral program were initiated in 1967. However, in 1988, the department replaced the OR&S Ph.D. with a unique Ph.D. degree in Decision Sciences and Engineering Systems, reflecting the focus of the new department. The program in Manufacturing Systems Engineering was inaugurated in the fall of 1992, and has been updated to the current degree program in Service and Manufacturing Systems Engineering. This program is designed to emphasize modeling, statistical, computer, and management skills as they relate to service operations and the process of manufacturing. A common theme throughout these programs is the use of mathematical, statistical, and computational/simulation models to better understand engineering, managerial, operational, and physical processes.

Research and Innovation Initiatives

Manufacturing Systems

Faculty have developed methodologies and procedures for infrastructure and operating systems (e.g., production planning and control, scheduling, and dispatching in flexible manufacturing systems), simulation of production facilities, manufacturing logistics, materials handling engineering, manufacturing facility design, information integration for design and manufacturing, control systems and agile manufacturing concepts for the electronics industry, and methodologies to integrate statistical quality control with computer graphics.
Service Systems
This area concentrates on the application of traditional and evolving industrial and systems engineering methodologies to the design and operation of service systems in both industry and the public sector. Areas of interest include simulation modeling and analysis, distribution and logistics, facilities design, work design, quality assurance, intelligent transportation systems, and engineering economic analysis. Also included is research in the deployment, allocation, and operation of urban service systems using computationally-intensive, real-time decision support approaches.

Information Systems
Information and decision support systems have been developed and extensively used for disaster preparedness and management of disasters (e.g., searches for ships lost at sea, earthquakes) and manufacturing enterprises (e.g., manufacturing-driven design and scalable adaptive integration of databases over wide area networks). New theory and methodologies for Internet-based information integration, e-commerce, data mining, and knowledge discovery are being developed. Decision support systems are being developed using a variety of knowledge engineering and computational intelligence tools. Also under development are methods, models, and technologies to aid in the planning and design of distributed information systems, information visualization, and user interfaces.

Mathematical Programming
Research topics include linear, nonlinear, integer, large-scale, multiple-objective, combinatorial, geometric, and stochastic programming. Of particular interest is research on the development and analysis of algorithms, computation, and the integration of uncertainty in optimization.

Statistics and Applied Probability
Research is conducted in the areas of real-time data fusion and analysis, data mining, knowledge discovery, and design of experiments—including optimality, efficiency, and robustness; nonlinear and robust estimation; statistical computing; probability; stochastic processes; queuing theory; reliability; quality control; and forecasting.

Facilitating these research programs are three research centers based directly within the Decision Sciences and Engineering Systems Department. Every department faculty member is involved in one or more of these research centers. In addition, several other faculty in the School of the Engineering, as well as in the other four schools, are also participating in activities conducted in the centers described below:

Electronics Agile Manufacturing Research Institute (EAMRI)
http://www.eamri.rpi.edu
The EAMRI grew out of a federally funded, five-year project focused on agile manufacturing information technologies as a strategy to help the electronics manufacturing industry achieve its goals. Agile manufacturing concepts employ network-based information for supply chain-oriented technologies and organizations, as well as improved communications to help solve design and manufacturing problems. The EAMRI provides a national focus for developing and sharing methods to enable the U.S. electronics industry to adopt agile manufacturing. Experts in electronics design and manufacturing, the EAMRI faculty possess engineering, computer science, and management backgrounds. The EAMRI’s initial information technology, known as the Virtual Design Environment, has recently received a patent from the U.S. Patent Office.

Center for Services Research and Education (CSRE)
http://www.dses.rpi.edu/research/csre.cfm
The goal of the CSRE is to enhance our understanding of the service sector and its function, and to educate students and managers seeking careers in the services industry, which accounts for more than three-quarters of the U.S. gross national product. CSRE faculty were one of the first groups to highlight the
duality between services and manufacturing; many manufacturing methods are applicable to service systems and can be employed to enhance productivity and competitiveness. The CSRE takes a holistic approach to the multifaceted service sector and brings together experts from engineering, marketing, psychology, economics, and management policy and organization, among others. Experts examine the common elements that characterize all aspects of the service sector and develop generic principles that apply across the wide spectrum of services, including the advancement of a focus in service systems engineering.

Rensselaer Statistical Consulting Center (RSCC)
http://www.dses.rpi.edu/research/rscc.cfm

The RSCC provides statistical planning and analysis services to Rensselaer researchers who require them. It also consults with companies and government agencies that require advice on state-of-the-art statistical and probabilistic methods and their applications. In addition, it allows graduate students to apply, in a supervised manner, established and new statistical and probabilistic approaches to real-world problems, and offers general and organization-specific short-term training programs and state-of-the-art courses in statistical methodologies and practices. The Center’s faculty represent a range of statistical expertise, and they have extensive research and consulting experience. These faculty members, together with talented graduate students, provide advice and guidance on the appropriate use of statistical and probabilistic methods, on a consulting or short course basis.

Faculty*

Professors

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.

Ecker, J.G.—(Mathematical Sciences) Ph.D. (University of Michigan); mathematical programming, multiobjective programming, geometric programming, mathematical programming applications, ellipsoid algorithms.

Heragu, S.S.—Ph.D. (University of Manitoba); artificial intelligence, cellular manufacturing, facilities design, intelligent manufacturing systems, materials handling, next-generation factory layout design, production and operations management, operations research, scheduling, storage and warehousing.

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.

Hughes, G.—(Economics) Ph.D. (Princeton University); global economics, economics of information technology; Clinical Professor.

List, G.E.—(Civil Engineering) P.E., Ph.D. (University of Pennsylvania); real-time control of transportation network operations; multiobjective routing, scheduling, and fleet sizing; operations planning; hazardous materials logistics.

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.

Mitchell, J.E.—(Mathematical Sciences) Ph.D. (Cornell University); mathematical programming integer programming, interior point methods, column generation methods, financial optimization, stochastic programming.

Pang, J.S.—(Mathematical Sciences) Ph.D. (Stanford University); Mathematics of Finance and Mathematical Statistics

* 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 2005 Board of Trustees meeting.
Raghavachari, M.—Ph.D. (University of California at Berkeley); statistical inference, quality control, multivariate methods, scheduling problems.

Tien, J.M.—NAE, Ph.D. (Massachusetts Institute of Technology) Yamada Corporation Professor (joint in Electrical, Computer, and Systems Engineering; IT); systems modeling, queuing theory, public policy and decision analysis, computer performance evaluation, and information and decision support systems, expert systems, computational cybernetics.

Wallace, W.A.—Ph.D. (Rensselaer Polytechnic Institute) (joint in Civil Engineering; Cognitive Sciences; IT); 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

Embrechts, M.J.—Ph.D. (Virginia Polytechnic Institute); application of neural networks and fuzzy logic for manufacturing and process control; image recognition and classification with the aid of neural networks; smart experiments; neural networks for trading and finance; neural networks, fractals, chaos, and wavelets for time-series analysis; data mining and computational intelligence.

Foley, W.J.—E., Ph.D. (Rensselaer Polytechnic Institute); engineering design, computer simulation modeling, health applications of operations research, health case policy analysis; Clinical Associate Professor.

Holguín-Veras, J.—(Civil and Environmental); Ph.D. (University of Texas/Austin); transportation modeling and transportation economics, information technology, information systems, optimization techniques.

Sullo, P.—Ph.D. (Florida State University); reliability, life testing, statistical quality control, quality management, biostatistics, industrial statistics.

Assistant Professors

Aboul-Seoud, M.—Ph.D. (University of Louisville); reliability engineering, quality control, operations research; Clinical Assistant Professor.

Carbone, M.J.—Ph.D. (Rensselaer Polytechnic Institute); modeling, manufacturing and service operations, queuing theory, Clinical Assistant Professor.

Gupta, A.—Ph.D. (Stanford University); behavioral aspects of optimization and application problems in finance, large-scale problems in decision making, simulation methods and tools for solving large-scale problems, simulation-based optimization.

Krishnamurthy, A.—Ph.D. (University of Wisconsin-Madison); queuing models and simulation based approaches for design and analysis of manufacturing systems, quick response manufacturing, queuing networks, analytical models in fabrication/assembly systems.

Adjunct Faculty

Bonnisone, P.—Ph.D. (University of California at Berkeley); approximate reasoning, soft computing, fuzzy logic, intelligent control.

Hahn, G.—Ph.D. (Rensselaer Polytechnic Institute); applied statistics, operations research.

Kupferschmid, M.—E., Ph.D. (Rensselaer Polytechnic Institute); mathematical programming, algorithm performance evaluation, engineering applications.

Osborn, B.E.—Ph.D. (Brown University);

Pavarini, C.—Ph.D. (Rensselaer Polytechnic Institute); Internet infrastructure, optical components, applications software markets.

Stephens, P.—M.S. (Rensselaer Polytechnic Institute); Statistics and Operations Research.

Tucker, W.—Ph.D. (Oklahoma State); applied statistics, operations research, quality control.
Affiliated Professors

Bennett, K.—(Mathematical Sciences) Ph.D. (University of Wisconsin); mathematical programming, operations research, artificial intelligence.

Bringsjord S.—(Cognitive Sciences) Ph.D. (Brown University); logic and artificial intelligence, foundations of artificial intelligence and cognitive science, computation creativity.

Desrochers, A.—(Electrical, Computer, and Systems Engineering) Ph.D. (Purdue University); performance modeling of automated manufacturing systems application to Petri nets, transfer lines, manufacturing architectures, database and network transactions, distributed systems.

Haddock, J.—(Lally School of Management); Ph.D. (Purdue University); mathematical and simulation modeling, just-in-time manufacturing, lean management techniques, corporate paradigms.

Kelly, L.J.—(Rensselaer at Hartford) Ph.D. (University of Connecticut); statistics, operations management.

Paulson, A.S.—(Lally School of Management and Technology) Ph.D. (Virginia Polytechnic Institute); risk management, financial models, multivariate statistics, time series and forecasting, survival data analysis.

Affiliated Associate Professors

Franklin, W.R.—(Electrical, Computer, and Systems Engineering) Ph.D. (Harvard University); computational geometry, graphics, CAD, cartography, parallel algorithms, large databases, expert system verification.

Goldenberg, D.H.—(Lally School of Management and Technology) Ph.D. (University of Florida); derivatives markets, stochastic modeling of prices, options in corporate finance.

Gutierrez-Miravete, E.—(Rensselaer at Hartford) Ph.D. (Massachusetts Institute of Technology); materials processing, transport phenomena, clean technologies, advanced mathematics for applications, numerical computing, mathematical modeling, computer simulation.

Maleyeff, J.—(Rensselaer at Hartford) Ph.D. (University of Massachusetts); statistical quality assurance in manufacturing, administration and health care; computer simulation of operating systems; development of effective teaching methodologies.

Ravichandran, T.—(Lally School of Management and Technology) Ph.D. (Southern Illinois University, Carbondale); management information systems.

Zaki, M.J.—(Computer Sciences) Ph.D. (University of Rochester); design of efficient, scalable, and parallel algorithms for various data mining techniques.

Affiliated Assistant Professor

Arnheiter, E.D.—(Rensselaer at Hartford) Ph.D. (University of Massachusetts); Monte Carlo simulation and probabilistic models in quality, modular consortiums, and automotive production models.

Martin, L.L.—(Chemical and Biological Engineering) Ph.D. (University of California at Los Angeles); process systems engineering, design for waste minimization and pollution prevention.

Yang, Y.—(Cognitive Science) Ph.D. (New York University); cognitive psychology, thinking, reasoning, decision-making, cognitive science.

Research Professors

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.

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.
Emeritus Faculty

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.

Wilkinson, J.—Ph.D. (University of North Carolina); regression modeling, statistical analysis.

Undergraduate Programs

http://www.dses.rpi.edu/programs/undergrad.cfm

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 ensuring that all graduates have specialized technical knowledge in their chosen field. In this regard, the Department of Decision Sciences and Engineering Systems baccalaureate program educates students in the fundamental theories, principles, methodologies, and practices of Industrial and Management Engineering while seeking to develop in its graduates:

- The ability to apply a total integrated systems perspective to the practice of industrial and management engineering.
- The ability to apply knowledge of manufacturing and service systems to the practice of industrial and management engineering.
- The ability to apply in-depth knowledge of computing to the practice of industrial and management engineering.
- The ability to manage people and systems.
- The ability to design innovative products, services, facilities, equipment, processes, and systems.
- The ability to identify, model, analyze, and solve challenging real-life problems.
- A solid foundation in math and science.
- Strong communication skills with emphasis on technical writing and interpersonal communication.
- The ability to perform effectively on diverse teams, both as leader and contributor.
- Informed citizens broadly educated in the humanities and social sciences.
- Preparation to practice engineering in a socially responsible and ethical manner.
- Motivation and preparation for continued growth and learning.

Baccalaureate Programs

The Department of Decision Sciences and Engineering offers a 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 and social sciences. These two years are oriented toward the quantitative (mathematical) approach. Computer-based technology, including simulation, 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 systems 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 both manufacturing and service systems, including information 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.
DSES 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 below.

### Industrial and Management Engineering

#### Undergraduate Degree

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGR-1100</td>
<td>Introduction to Engineering Analysis ..........................</td>
<td>ENGR-1200 Engineering Graphics &amp; CAD ........</td>
<td>1</td>
</tr>
<tr>
<td>ENGR-1300</td>
<td>Engineering Processes .........................................</td>
<td>MATH-1020 Calculus II ..................................</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I ........................................................</td>
<td>PHYS-1100 Physics I .....................................</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chem. Principles for Engineers ................................</td>
<td>Science Elective ..............................</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective .................................</td>
<td>Hum. or Soc. Sci. Elective ........................</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Second Year</strong></td>
<td>Credit hours</td>
<td>Spring</td>
<td>Credit hours</td>
</tr>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>ENGR-2050</td>
<td>Introduction to Engineering Design ................................</td>
<td>ENGR-2600 Modeling and Analysis of Uncertainty ........</td>
<td>3</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations ................................</td>
<td>CSCI-1190 C Programming ................................</td>
<td>1</td>
</tr>
<tr>
<td>PHYS-1200</td>
<td>Physics II ........................................................</td>
<td>DSES-2210 Multidisciplinary Engineering Elective .................................</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective ................................</td>
<td>Multidisciplinary Engineering Elective .................................</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Third Year</strong></td>
<td>Credit hours</td>
<td>Spring</td>
<td>Credit hours</td>
</tr>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSES-4140</td>
<td>Statistical Analysis ...........................................</td>
<td>DSES-4620 Operations Research II ................</td>
<td>3</td>
</tr>
<tr>
<td>DSES-4610</td>
<td>Operations Research I ..........................................</td>
<td>DSES-4230 Quality Control ........................</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Management Elective ...............................................</td>
<td>ENGR-4760 Eng. Economics ..........................</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective ................................</td>
<td>Hum. or Soc. Sci. Elective ........................</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Professional Development II ....................................</td>
<td>Free elective ...........................................</td>
<td>3-4</td>
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<tr>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

1. Students are encouraged to select a life science course such as BIOL-1010.

2. Students must select any two of the following approved multidisciplinary electives:

- ENGR-1600 Materials Science for Engineers
- ENGR-2090 Engineering Dynamics
- ENGR-2250 Thermal and Fluid Engineering I
- ENGR-2350 Embedded Control
- ENGR-2530 Strength of Materials
- ENGR-2710 General Manufacturing Processes
- ENGR-4050 Mod. & Control of Dynamic Systems
- ENGR-4300 Electronic Instrumentation

3. Students may select any one of the following courses to satisfy the management elective requirement:

- MGMT-1100 Introduction to Management
- MGMT-2320 Accounting for Decision Making
- MGMT-4430 Marketing Principles
- 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

4. This course can be fulfilled by taking a 2-credit course from a list of courses published at the start of each semester.
**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 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 and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

**Special Undergraduate Opportunities**

**Cooperative Education Program**

DSES 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 Career Development Center.

**Graduate Programs**

http://www.dses.rpi.edu/programs/masters.cfm

**Master’s Programs**

The Department of Decision Sciences and Engineering Systems offers two master’s level degrees, both of which can be earned within each of three curricula. These curricula and their individual requirements are described below.

**Industrial and Management Engineering (IME) Curricula**

Students can work toward either the M.S. degree, which requires a project or thesis, or the nonthesis M.Eng. degree. These IME degrees are also available through distance learning. Contact the Office of Professional and Distance Education for course scheduling information.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-4530</td>
<td>Information Systems</td>
<td>4</td>
</tr>
<tr>
<td>DSES-4962</td>
<td>Discrete Event Simulation</td>
<td>3</td>
</tr>
<tr>
<td>DSES-4963</td>
<td>Technical Elective</td>
<td>3</td>
</tr>
<tr>
<td>DSES-4964</td>
<td>Technical Elective</td>
<td>3</td>
</tr>
<tr>
<td>DSES-4965</td>
<td>Free Elective</td>
<td>3-4</td>
</tr>
<tr>
<td>DSES-4270</td>
<td>IME Design</td>
<td>3</td>
</tr>
<tr>
<td>ENGR-4100</td>
<td>Professional Development III</td>
<td>3</td>
</tr>
<tr>
<td>DSES-4961</td>
<td>Supply Chain Management</td>
<td>3</td>
</tr>
<tr>
<td>DSES-4260</td>
<td>Industrial Safety and Hygiene</td>
<td></td>
</tr>
<tr>
<td>DSES-4810</td>
<td>Computational Intelligence</td>
<td></td>
</tr>
<tr>
<td>DSES-4280</td>
<td>Dec. Focused Systems Engineering</td>
<td></td>
</tr>
</tbody>
</table>

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1. Students may select any three of the following courses to satisfy technical elective requirements:

   - DSES-4200 Design and Analysis of Work Systems
   - DSES-4240 Engineering Project Management
   - DSES-4250 Facilities Design & Industrial Logistics
   - DSES-4260 Industrial Safety and Hygiene
   - DSES-4810 Computational Intelligence
   - DSES-4280 Dec. Focused Systems Engineering

   Certain graduate level DSES courses can also serve as technical electives for eligible undergraduates with permission of the instructor and the adviser.

2. May be taken in either fall or spring semester.
In general, all applicants to the IME master’s programs must take the Graduate Record Exam (GRE). This requirement is especially important for those requesting financial aid, due to the large number of aid requests. However, for students applying to the M.Eng. program, the GRE may sometimes be waived. In special situations, and with departmental approval, the GMAT may be substituted for the GRE.

All students seeking either of the IME master’s degrees must have completed the following two courses in their undergraduate program at Rensselaer or have had the equivalent courses elsewhere:

- Applied Operations Research (equivalent to DSES-6610 Systems Modeling and Decision Sciences)
- Introduction to Applied Statistics (equivalent to DSES-6110)

Both IME master’s degrees require a minimum of 30 credit hours.

In addition to the above prerequisite courses, a student’s core course work must include:

- For students seeking the M.S. degree, three to nine of the 30 credit hours must be in DSES-6990 (Master’s Thesis) or DSES-6980 (Master’s Project). The thesis or project credits can also count toward the nine-credit-hour (three-course) concentration that the program requires.

While the remainder of the program may be tailored to the student’s interest, the plan of study must include a concentration area. The concentration is a set of three or more courses (or nine credit hours) that reflects a logical progression for developing a base of expertise in an area of study. Concentrations will usually, but not always, include at least one of the core courses listed above. Listed below are several concentration areas and the courses that are within each area.

**Applied Operations Research Concentration**

- DSES-4770 Mathematical Models of Operations Research
- DSES-4780 Computational Optimization
- DSES-6050 Stochastic Processes
- DSES-6200 Models in Facilities Planning and Materials Handling
- DSES-6210 Theory of Production Scheduling
- DSES-6630 Continuous Simulation and Financial Mathematics
- DSES-6760 Combinatorial Optimization and Integer Programming
- DSES-6670 Linear Programming
- DSES-6780 Nonlinear Programming
- DSES-6820 Queuing Systems and Applications
- DSES-6830 Large-Scale Systems: Case Studies and Analyses
- DSES-6840 Modeling Large-Scale Systems
- DSES-6860 Evaluation Methods for Decision Making
- DSES-6890 Multiple Criteria Decision Making
### Applied Probability and Statistics and Quality Control Concentration

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>DSES-4750</td>
<td>Probability Theory and Applications</td>
</tr>
<tr>
<td>DSES-4760</td>
<td>Mathematical Statistics</td>
</tr>
<tr>
<td>DSES-6010</td>
<td>Applied Regression Analysis</td>
</tr>
<tr>
<td>DSES-6020</td>
<td>Design of Experiments</td>
</tr>
<tr>
<td>DSES-6030</td>
<td>Sampling Methods</td>
</tr>
<tr>
<td>DSES-6040</td>
<td>Nonparametric Methods</td>
</tr>
<tr>
<td>DSES-6050</td>
<td>Stochastic Processes</td>
</tr>
<tr>
<td>DSES-6060</td>
<td>Applied Multivariate Analysis</td>
</tr>
<tr>
<td>DSES-6070</td>
<td>Statistical Methods for Reliability Engineering</td>
</tr>
<tr>
<td>DSES-6090</td>
<td>Decision Analysis</td>
</tr>
<tr>
<td>DSES-6100</td>
<td>Time Series Analysis</td>
</tr>
<tr>
<td>DSES-6140</td>
<td>Exploratory Data Analysis</td>
</tr>
<tr>
<td>DSES-6150</td>
<td>Advanced Probability for Statistical Inference</td>
</tr>
<tr>
<td>DSES-6170</td>
<td>Management of Quality Processes and Reliability</td>
</tr>
<tr>
<td>DSES-6180</td>
<td>Introduction to Knowledge Discovery with Data Mining</td>
</tr>
<tr>
<td>DSES-6230</td>
<td>Quality Control and Reliability</td>
</tr>
</tbody>
</table>

### Information Systems Concentration

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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>DSES-4810</td>
<td>Computational Intelligence</td>
</tr>
<tr>
<td>DSES-6220</td>
<td>Concurrent Engineering</td>
</tr>
<tr>
<td>DSES-6500</td>
<td>Information and Decision Technologies for Industrial and Service Systems</td>
</tr>
<tr>
<td>DSES-6520</td>
<td>Enterprise Database Systems</td>
</tr>
<tr>
<td>DSES-6530</td>
<td>Decision Support and Expert Systems</td>
</tr>
<tr>
<td>DSES-6550</td>
<td>Information Systems Analysis and Design</td>
</tr>
<tr>
<td>DSES-6560</td>
<td>Information Technology and Systems for Enterprise Engineering</td>
</tr>
<tr>
<td>DSES-6570</td>
<td>Information Technology and Systems for E-Business</td>
</tr>
<tr>
<td>DSES-6870</td>
<td>Introduction to Neural Networks</td>
</tr>
</tbody>
</table>

### Management of Technology Concentration

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>MGMT-6690</td>
<td>Supply Chain Mgmt. for E-Business</td>
</tr>
<tr>
<td>MGMT-6960</td>
<td>Knowledge Based Operations Management</td>
</tr>
<tr>
<td>MGMT-6240</td>
<td>Financial Trading and Investment</td>
</tr>
<tr>
<td>MGMT-6490</td>
<td>Competitive Advantage and Operations Strategy</td>
</tr>
<tr>
<td>DSES-6470</td>
<td>Global Strategic Management of Technological Innovation</td>
</tr>
<tr>
<td>DSES-6480</td>
<td>Service Operations Management</td>
</tr>
<tr>
<td>DSES-6830</td>
<td>Large-Scale Systems: Case Studies and Analyses</td>
</tr>
<tr>
<td>DSES-6860</td>
<td>Evaluation Methods for Decision Making</td>
</tr>
</tbody>
</table>

### Manufacturing Systems Concentration

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>DSES-4200</td>
<td>Design and Analysis of Work Systems</td>
</tr>
<tr>
<td>DSES-4250</td>
<td>Facilities Design and Industrial Logistics</td>
</tr>
<tr>
<td>DSES-6200</td>
<td>Models in Facilities Planning and Materials Handling</td>
</tr>
<tr>
<td>DSES-6210</td>
<td>Theory of Production Scheduling</td>
</tr>
<tr>
<td>DSES-6220</td>
<td>Concurrent Engineering</td>
</tr>
<tr>
<td>DSES-6230</td>
<td>Quality Control and Reliability</td>
</tr>
<tr>
<td>DSES-6560</td>
<td>Information Technology and Systems for Enterprise Engineering</td>
</tr>
<tr>
<td>DSES-6600</td>
<td>Models for Production Control and Service Logistics</td>
</tr>
<tr>
<td>DSES-6960</td>
<td>Management of Manufacturing Supply Chains</td>
</tr>
</tbody>
</table>

### Service Systems Concentration

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-6480</td>
<td>Service Operations Management and at least two courses from the list below:</td>
</tr>
<tr>
<td>MGMT-4370</td>
<td>Risk Management</td>
</tr>
<tr>
<td>DSES-6170</td>
<td>Management of Quality Processes and Reliability</td>
</tr>
<tr>
<td>DSES-6860</td>
<td>Evaluation Methods for Decision Making</td>
</tr>
<tr>
<td>DSES-6980</td>
<td>Master’s Project in Service Systems</td>
</tr>
</tbody>
</table>
Service and Manufacturing Systems Engineering Curricula

The Department of Decision Sciences and Engineering Systems offers the Master of Engineering and Master of Science degrees in Service and Manufacturing Systems Engineering. This program combines modeling, statistical, computer, design and management skills focused on the operations of service and manufacturing systems. The program core provides a skill base in operations engineering with a balance of applications in services and manufacturing. Course work concentrations allow specialization in Service Operations or Manufacturing Processes.

All applicants are encouraged to take the Graduate Record Exam (GRE). GRE completion is especially important for those requesting financial aid, due to the large number of aid requests. The GMAT may be substituted for the GRE for students applying to the Master of Engineering program.

All students seeking the Master of Engineering or Master of Science degree in Service and Manufacturing Systems Engineering must complete the following course in their undergraduate program while at Rensselaer or have had the equivalent course work elsewhere:

DSES-6110 Introduction to Applied Statistics

The Master of Engineering and Master of Science degrees in service and manufacturing systems engineering are 30-credit-hour programs of study. The prerequisite course may be counted toward the 30 credit hour total if taken at Rensselaer and included in the Master’s Plan of Study.

In addition to the above prerequisite courses, a student’s core course work will include:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
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<tbody>
<tr>
<td>DSES-6570</td>
<td>Information Technology and Systems for E-Business</td>
</tr>
<tr>
<td>DSES-6610</td>
<td>Systems Modeling and Decision Sciences</td>
</tr>
<tr>
<td>DSES-6620</td>
<td>Discrete Event Simulation</td>
</tr>
<tr>
<td>DSES-6820</td>
<td>Queuing Systems and Applications</td>
</tr>
<tr>
<td>MGMT-6960</td>
<td>Knowledge Based Operations Management</td>
</tr>
</tbody>
</table>

Concentrations

Students must select the remaining 4 to 5 courses in the Plan of Study from either the Service Operations or Manufacturing Processes concentrations. These concentrations are summarized below:

Service Operations Concentration

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
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</thead>
<tbody>
<tr>
<td>DSES-6140</td>
<td>Exploratory Data Analysis</td>
</tr>
<tr>
<td>DSES-6180</td>
<td>Knowledge Discovery with Data Mining</td>
</tr>
<tr>
<td>DSES-6470/MGMT-6610</td>
<td>Global Strategic Management of Technological Innovation</td>
</tr>
<tr>
<td>DSES-6480/MGMT-6480</td>
<td>Service Operations Management</td>
</tr>
<tr>
<td>DSES-6630</td>
<td>Continuous Simulation and Financial Mathematics</td>
</tr>
<tr>
<td>DSES-6860</td>
<td>Evaluation Methods for Decision Making</td>
</tr>
<tr>
<td>DSES-6870</td>
<td>Introduction to Neural Networks</td>
</tr>
<tr>
<td>DSES-6990/6980</td>
<td>Master’s Project in Service Systems</td>
</tr>
<tr>
<td>MATH-4740</td>
<td>Mathematics of Finance</td>
</tr>
<tr>
<td>MGMT-6240</td>
<td>Financial Trading and Investing</td>
</tr>
<tr>
<td>MGMT-6690</td>
<td>Supply Chain Management for E-Business</td>
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</tbody>
</table>
Manufacturing Processes Concentration

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-6070</td>
<td>Statistical Methods for Reliability Engineering</td>
<td>DSES-6600</td>
<td>Models for Production Control &amp; Service Logistics</td>
</tr>
<tr>
<td>DSES-6100</td>
<td>Time Series Analysis</td>
<td>DSES-6960</td>
<td>Management of Manufacturing Supply Chains</td>
</tr>
<tr>
<td>DSES-6170/</td>
<td>Management of Quality Processes and Reliability</td>
<td>DSES-6990/</td>
<td>Master’s Project in Manufacturing Systems</td>
</tr>
<tr>
<td>MGMT-6470</td>
<td></td>
<td>6980</td>
<td></td>
</tr>
<tr>
<td>DSES-6200</td>
<td>Models for Materials Handling and Facility Design</td>
<td>MANE-6800</td>
<td>Manufacturing Systems Integration</td>
</tr>
<tr>
<td>DSES-6210</td>
<td>Theory of Production Scheduling</td>
<td>MGMT-6490</td>
<td>Competitive Advantage and Operations Strategy</td>
</tr>
<tr>
<td>DSES-6220</td>
<td>Concurrent Engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSES-6230</td>
<td>Quality Control and Reliability</td>
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</tbody>
</table>

For students seeking the Master of Science degree, three to nine of the 30-credit-hour program must be taken under DSES-6990 (Master’s Thesis in Service Systems or Master’s Thesis in Manufacturing Systems) or DSES-6980 (Master’s Project in Service Systems or Master’s Project in Manufacturing Systems).

Operations Research and Statistics Curricula

In this curriculum, DSES offers M.S. and M.Eng. degree programs that combine course work in applied probability and statistics, optimization, modeling, and decision sciences in the scientific application of quantitative tools to support decision making. The scope of the programs includes the formulation, solution, and implementation of mathematical models of decision problems to measure, evaluate, and optimize system performance. Most students can complete either program in 30 credit hours. Any student planning to enroll in the DSES doctoral program should consult with the faculty adviser prior to making course selections.

The diversity of this curriculum’s faculty enables these programs to encompass varied research topics. A student may work simultaneously on a master’s degree in this program and on a degree in computer science, business administration, mathematics, computer and systems engineering, or another related area.

Most students participating in this curriculum hold a bachelor’s or master’s degree in engineering, mathematics, the physical sciences, business administration, or management. Students with training in other disciplines such as economics and the social sciences are also encouraged to apply if their quantitative backgrounds include the equivalent of at least three semesters of calculus and linear algebra.

All applicants are required to take the Graduate Record Examination (GRE) except under extenuating circumstances.

For the master’s programs in operations research and statistics, no prerequisites are required. However, the following courses or their equivalents are required.
### School of Engineering

While the remainder of the program may be tailored to the student’s interest, the Plan of Study must include a concentration area. The concentration is a set of three or more courses (or nine credit hours) that reflects a logical progression for developing a base of expertise in an area of study. Concentrations will usually, but not always, include at least one of the core courses listed above. Listed below are several concentration areas and the courses that are within each area.

#### Quality and Reliability Concentration
- DSES-6020 Design of Experiments
- DSES-6050 Stochastic Processes
- DSES-6070 Statistical Methods for Reliability Engineering
- DSES-6150 Advanced Probability for Statistical Inference
- DSES-6170 Management of Quality Processes and Reliability
- DSES-6230 Quality Control and Reliability

#### Forecasting Concentration
- ECON-6570 Econometrics
- DSES-6010 Applied Regression Analysis
- DSES-6060 Applied Multivariate Analysis
- DSES-6100 Time Series Analysis
- DSES-6130 Statistical Computing
- DSES-6140 Exploratory Data Analysis
- DSES-6150 Advanced Probability for Statistical Inference
- DSES-6870 Introduction to Neural Networks

#### Decision Analysis Concentration
- DSES-4750 Probability Theory and Applications
- DSES-6090 Decision Analysis
- DSES-6500 Information and Decision Technologies for Industrial and Service Systems
- DSES-6530 Decision Support and Expert Systems
- DSES-6830 Large-Scale Systems: Case Studies and Analyses

#### Modeling/Optimization Concentration
- DSES-4640 Operations Research I
- DSES-4750 Probability Theory & Applications
- DSES-4760 Mathematical Statistics
- DSES-6050 Stochastic Processes
- DSES-6150 Advanced Probability for Statistical Inference
- DSES-6640 Queuing Systems & Applications
- DSES-6620 Discrete-Event Simulation
- DSES-6060 Applied Multivariate Analysis
- DSES-6140 Exploratory Data Analyses
- DSES-6820 Queuing Systems and Applications

* Any course listed under the Modeling/Optimization Concentration except DSES-4770.

#### Credit hours

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-4640 Operations Research I</td>
<td>4</td>
</tr>
<tr>
<td>DSES-4750 Probability Theory &amp; Applications</td>
<td>4</td>
</tr>
<tr>
<td>DSES-4760 Mathematical Statistics</td>
<td>4</td>
</tr>
<tr>
<td>DSES-6050 Stochastic Processes</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6150 Advanced Probability for Statistical Inference</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6820 Queuing Systems &amp; Applications</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6620 Discrete-Event Simulation</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6060 Applied Multivariate Analysis</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6140 Exploratory Data Analyses</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6640 Queuing Systems &amp; Applications</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Simulation Concentration
- DSES-6630 Continuous Simulation and Financial Mathematics
- DSES-6020 Design of Experiments
- DSES-6050 Stochastic Processes
- DSES-6100 Time Series Analysis
- DSES-6150 Advanced Probability for Statistical Inference
- DSES-6820 Queuing Systems and Applications
- DSES-6870 Introduction to Neural Networks
### Data Mining Concentration
- DSES-4810 Computational Intelligence
- DSES-6010 Applied Regression Analysis
- DSES-6020 Design of Experiments
- DSES-6030 Sampling Methods
- DSES-6040 Nonparametric Methods
- DSES-6060 Applied Multivariate Analysis
- DSES-6100 Time Series Analysis
- DSES-6130 Statistical Computing
- DSES-6140 Exploratory Data Analysis
- DSES-6180 Introduction to Knowledge Discovery with Data Mining
- DSES-6870 Introduction to Neural Networks

### Financial Engineering Concentration
- MATH-4200 Mathematical Analysis I
- MGMT-4370 Risk Management
- MATH-4740 Mathematics of Finance
- DSES-6630 Continuous Simulation and Financial Mathematics
- MGMT-6240 Financial Trading and Investment
- DSES-6010 Applied Regression Analysis
- DSES-6060 Applied Multivariate Analysis
- DSES-6100 Time Series Analysis
- DSES-6130 Statistical Computing

### Information Systems Concentration
- DSES-4810 Computational Intelligence
- DSES-6500 Information and Decision Technologies for Industrial and Service Systems
- DSES-6520 Enterprise Database Systems
- DSES-6530 Decision Support and Expert Systems
- DSES-6560 Information Technology and Systems for Enterprise Engineering
- DSES-6620 Discrete-Event Simulation
- DSES-6870 Introduction to Neural Networks

### Marketing Research Concentration
- DSES-6010 Applied Regression Analysis
- DSES-6060 Applied Multivariate Analysis
- DSES-6130 Statistical Computing
- DSES-6520 Enterprise Database Systems

### Doctoral Programs

**http://www.dses.rpi.edu/programs/doctoral.cfm**

Students working toward the Ph.D. in DSES may choose to major in industrial engineering, information systems, service and manufacturing systems engineering, operations research, or statistics. Advanced research and a dissertation in the chosen field are required in the doctoral program. In addition, Ph.D. students must complete the following:

- Institution requirements established by the Office of Graduate Education.
- Seminar in DSES research: Doctoral students must complete DSES-6900 during the fall semester of the first academic year of residency. This course is intended to introduce the student to the research environment at Rensselaer and to provide background on the process of doctoral research in DSES. Another intent of the course is to develop the student’s communication skills.
- Doctoral qualifying examination: The doctoral qualifying exam consists of two components — a written exam component and a research component. The written exam covers the core areas of DSES and the basis for this examination, including DSES-4530, DSES-4750, DSES-4760, DSES-4770, and DSES-6500 or their equivalents. A more detailed description of this and other required examinations is available from the DSES doctoral program director.
- Doctoral area requirement: Doctoral students must register for and complete course work in a selected major area. See the DSES doctoral program director for detailed documentation of DSES doctoral area requirements.
Doctoral candidacy examination: Each student must take an oral candidacy examination after passing the DSES area requirement but before completing 75 credit hours of graduate work. 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 DSES research, doctoral area course requirements, and equivalent course material for the doctoral qualifying examination, 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 course work, as well as supervised research. A plan of study is required, which must be approved by the thesis adviser and the DSES doctoral program director. Representative programs of study are available from the DSES doctoral program director.

Course Descriptions
Courses directly related to all Decision Sciences and Engineering Systems curricula are described in the Course Description section of this catalog under the department code DSES.

Electrical, Computer, and Systems Engineering
Chair: Kenneth A. Connor
Director of Master’s Programs: Yannick L. LeCoz
Director of Doctoral Programs: Alan A. Desrochers
Department Home Page: http://www.ecse.rpi.edu/

Electrical, computer, and systems engineers have long been at the forefront of new discoveries and their integration into advanced design and engineering methodologies. 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 work.

As a broad-based department, Electrical, Computer, and Systems Engineering (ECSE) offers several advantages for undergraduate and graduate study. One is the ability to attack the many facets of modern problems that cut across disciplinary lines. Another is the flexibility for students to embark on individually tailored programs and for the department to launch new areas of research.

The department offers programs of study leading to bachelors, master’s, and doctoral degrees in electric power engineering, electrical engineering, and computer and systems engineering. Each curriculum is sufficiently flexible to accommodate a wide range of interests. The curriculum the student selects is determined by his or her specific interests and, in some cases, by directions within a field of interest.
Research and Innovation Initiatives

Communications, Information, and Signal Processing

Advanced study and research in this field deals with the encoding, transmission, retrieval, and interpretation of information. Students may pursue programs of study strong in mathematical foundations, or oriented more toward hardware and practical implementation, or a combination of both.

Communications research focuses on the transmission of information over wireless, optical, and wire channels. Link level concerns, such as modulation and coding, as well as local and wide area networks are considered. Two of the fundamental subdisciplines emphasized are statistical communications and telecommunications. The former considers special types of systems in different environments, typified by random signals in random channels, as in space communication. The latter includes the hardware and societal demands of telephone, wireless communications, cable television, communications networks (including ATM and ISDN), and other systems.

The area of information processing is concerned primarily with the theory and engineering design associated with interpreting and manipulating received data, primarily in discrete form. Major research topics include information theory, including rate distortion theory, along with the coding and compression of speech, image, and video signals. A quantitative understanding of the nature and meaning of information provides a theoretical foundation. A special research emphasis at Rensselaer is the application of image transmission and interpretation techniques to pattern recognition, image processing, digital video, and speech recognition.

Signal processing considers the application of digital processing techniques to problems encountered in many areas, including biomedical instrumentation, control systems, and audio processing.

Special laboratories are available for speech processing, video and image processing, networking and communications.

Computer Networks

Research focal areas in computer networking include network management, traffic management, congestion control, traffic engineering, quality-of-service (QoS) architectures, multimedia networking, network modeling, measurement, and performance analysis. The application areas include wired, wireless, ad-hoc, satellite networks, and pervasive computing. The networking group also participates in interdisciplinary research in control theory, economics, scalable simulation technologies, and video compression.

As world networks get increasingly complex, the need for automated network management and sophisticated traffic management capabilities becomes more urgent. The theoretical foundations for these areas are of immense interest. Moreover, the structure of the Internet in terms of thousands of ISPs demands new economic models and mechanisms to ensure continued investment and growth of Internet services. Network heterogeneity—especially in terms of wired, wireless, ad-hoc, and satellite—demands fundamental research for seamless interconnection. Rensselaer's modeling subgroup serves all areas in terms of self-similar and advanced stochastic models. Finally, newer applications with QoS capabilities need to be deployed on the Internet and co-exist with the current applications. The computer network group works on all these areas with a mix of analysis, simulation, and experimental tools.

Computer Vision, Image Processing, Geometry, and Digital Media

Research in image processing covers a range of technologies and applications. This activity occurs at the Center for Image Processing Research (CIPR), the Center for Subsurface Sensing and Imaging Systems (CenSSIS), and the Center for Next Generation Video (CNGV), as well as the Document Analysis
Laboratory (DocLab), Advanced Imaging Systems Laboratory, Computer Vision and Robotics Laboratory, and Intelligent Systems Laboratory.

Research areas include pattern recognition, computer vision, multidimensional and multimodality image analysis, image compression, biotech assay automation, eye tracking, optical scanning systems, artificial intelligence, graphics, computational geometry, and Internet image analysis services.

Application areas include computer-assisted surgery, radiation treatment planning, medical image reconstruction, document image analysis, geographic data analysis, and image analysis aids to neurobiology. Additional application areas are bioinformatics, human fatigue monitoring, human computer interaction, video imagery activity interpretation, decision making under uncertainty, robot localization, robotic devices for automated scoring of assays for the biotechnology industry, and biological multidimensional microscopy.

The work of digital media includes such topics as image processing algorithms and architectures for digital cinema, advanced image compression and decompression algorithms, and methods for indexing video by content. Multimedia work also includes graphics courseware development for the World Wide Web using HTML, Java, PHP, mySQL, and VRML.

Computer Hardware, Architecture, VLSI and Mixed Signal Design
The design, implementation, layout, and testing of hardware systems constitute a vital component of computer engineering research. Research areas include multichip packaging concepts, high-frequency package characterization, thermal management, optical interconnections, and packaging reliability. Other topics include advanced concepts in fault tolerant computing, wafer-scale integration, high-speed GaAs RISC engines architectures for VLSI signal processing, and computer-aided design of VLSI for CMOS, bipolar, BiCMOS, and GaAs MESFET circuits. Fabrication and testing facilities are available in the Center for Integrated Electronics.

Control, Robotics, and Automation
Current research projects address both the theory and application of control. Faculty interest in control theory includes adaptive control, large-scale systems, optimization, multivariable control, robust control, nonlinear control, model reduction, and discrete event systems. Design results are applied to robotics, advanced automation systems, flexible manufacturing, human physiology, large space structures, power systems, semiconductor systems, and material processing systems.

In robotics research, the focus is on intelligent robotic systems. Such systems represent a class of autonomous machines that can perform human-like functions with or without human interaction. They are fundamental for activities too hazardous for humans or too distant or complex for remote telemanipulation. This research is instrumental in advancing the theory of intelligent control with applications to systems of robotic arms. A robotic transporter with two-arm manipulative capabilities, stereo vision, and tactile sensing, connected to a Sun workstation network has been developed.

The design of controllers of large-scale systems is highly complex. Research is being performed on the design of low-order, structurally constrained robust controllers using iterative methods and convex programming techniques. Emphasis is also being given to linear and nonlinear model reduction methods. Applications to power systems, aircraft engines, and flexible structures are being considered, together with the development of control-aided design software.

Today, low-cost, highly reliable microcomputers and workstations that can be used for both control systems design and control system synthesis are widely available. As a result, increased emphasis has been placed on the design of implementable digital adaptive control logic that can be used for maintaining
uniform qualities in an aircraft or other systems, despite large variations in the parameters that define the system dynamic equations. Such adaptive control algorithms have been developed and applied to a wide range of applications, including robotics, blood pressure control, large flexible systems, and flight control systems.

Discrete event systems theory is an emerging discipline relevant to communication protocols and parallel computing as well as manufacturing control. Petri net and formal language theory are being developed to model, design, analyze, evaluate performance, and control such interconnected systems. Important issues are deadlock avoidance, synchronization, concurrency, resource allocation, and random events. Applications under study are manufacturing automation and integration, and task coordination for cooperating robotic systems.

All dynamic systems are fundamentally nonlinear. The nonlinearity can be either treated as a perturbation of a nominally linear system or directly taken into account in a nonlinear control design. In the first approach, linear control designs have been developed under various performance and robustness specifications. In the second approach, various nonlinear control strategies have been developed based on the Lyapunov theory, optimal control, and predictive control. There are currently various research projects applying these tools to a wide range of applications including vehicles, smart structures with piezoelectric actuators and sensors and shape memory alloy wires, robot position and force control, extrusion, and welding.

Research areas in robotics include sensor fusion, assembly sequence planning, dexterous manipulation, teleoperated and variably autonomous systems, distributed control architectures, and their applications to inspection, maintenance, and servicing operations in hazardous environments. Extensive experimental and computational facilities are available in the New York State Center for Automation Technologies.

In computer-aided design, research is focused on the front end of the manufacturing process, namely product development. The goal is to understand and develop computer-based systems to support initial conceptual design, feature-based design, geometric modeling, and rapid prototyping.

**Electric Power and Power Electronics**

Current research is concentrated in five principal areas: electric and magnetic field computation, electrical transients and switching technology, dielectrics and insulation systems, power system analysis and optimization, and semiconductor power electronics.

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. Projects are under way in the magnetic fields area to better understand the mechanism of electrical losses in rotating machinery and power transformers, with the ultimate goal of reducing these losses.

Of current interest are electric transients initiated by the switching of power plant auxiliaries and capacitor banks, especially by vacuum switching devices. The modeling of transients in transformer structures could also provide insight into the problems of both design and operation. The techniques being developed are finding application in new areas such as superconducting magnetic energy storage (SMES) and fault current limiting devices. This area of endeavor also includes the fundamental processes of switching large currents and the attendant system interactions.
An electrical insulation system, be it solid, liquid, gaseous, or a combination of these, 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. This involves experimentation and computer modeling in the areas of discharge physics, electrostatic phenomena, and high-voltage technology.

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 using the department’s system simulator and Electromagnetic Transient Program (EMTP) studies.

With the development of innovative energy sources such as advanced electric machines, fuel cells, and solar photovoltaics, power electronic systems are playing an ever-increasing role at both the source and the load. Issues of power quality and electromagnetic interference (EMI) need to be addressed through careful circuit design, circuit board layout, and EMI resistant communications. Rensselaer has identified this growing area of interest and is currently investigating future solutions to these challenging problems.

With the continual improvement of power semiconductor devices over the last thirty years, it is now possible to convert electrical energy from one form to another efficiently and accurately. Work in this multidisciplinary field requires an understanding of semiconductor devices, circuit theory, signal analysis, analog and digital control, magnetics, and heat transfer. At Rensselaer, these fields are applied to electronic energy conversion and motion control for the electric power and industrial automation industries. Current interests include propulsion systems for electric vehicles, generation systems for wind turbines, the use of artificial intelligence (fuzzy logic, genetic algorithms, and neural networks) in the design and control of electric power conversion and electric machines, and the adaptive control of electric machines.

Microelectronics and Photonics Technology

Advanced study and research includes semiconductor devices for power and high-frequency applications, fabrication of novel semiconductor materials and device structures, and the use and development of computer tools for microelectronics design. Research in association with the Center for Advanced Interconnect Sciences and Technology (CAIST) focuses on overcoming the strong limits interconnects pose for future developments in VLSI technology.

An extensive clean room in the Center for Integrated Electronics (CIE) is equipped for fabricating silicon-based devices, integrated circuits, and a full complement of equipment for compound semiconductor device processing. Activities in this area have been focused on novel device technology and process development, advanced interconnect processing, and the fabrication of micromechanical structures.

The microelectronics group has several specialized laboratories 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-epitaxy growth, and cold wall epitaxial reactors for the growth of single crystal III-V and II-VI semiconductors. Diagnostic equipment available includes a scanning electron microscope with energy dispersive X-ray analysis, a double crystal X-ray diffractometer, a Fourier transform IR spectrometer, a photoluminescence system with visible and UV excitation, a spectroscopic ellipsometer, and a Hall-effect measurement system.

The high-voltage power device laboratory has equipment that can measure semiconductor power devices in wafer and package form up to 5000 V and 25 A. The equipment includes a Sony/Tektronix 370A curve...
tracer, an HP 4155 parameter analyzer with a high power module, a Velonex High Power Pulse Generator Model 350, a custom high-voltage rectifier and IGBT switching circuits, a 500 MHz digitizing oscilloscope, a Delta 9023 furnace, and a manual probe station with a high-temperature controller and chuck for device testing.

The semiconductor device characterization laboratories are equipped for carrying out comprehensive electrical characterization of semiconductor devices. Automated measurement systems are available for CV and IV measurements and deep level transient spectroscopy. Facilities are available for cryogenic measurements of semiconductor and superconducting devices at liquid nitrogen and helium temperatures. Additional specialized instrumentation has been developed for analyzing the quantum efficiency and spectral response of solar cells and photoconductive materials, and automated reflectance, electroreflectance, and photoreflectance for the characterization of semiconductor surfaces and quantum layers. Also available is a wide-band 35 GHz microwave setup for contactless measurement of electric resistivity, mobility, and excess carrier lifetime in epitaxial layers or bulk wafers. A full complement of microwave equipment is available for high frequency testing, including HP 8510 and 8410 network analyzers, frequency counters, probe stations, and an automated multiprobe system for on-wafer time-domain measurements.

Within the ECSE Department and the Center for Integrated Electronics are numerous Sun workstations with a variety of commercial design and simulation software, presently including Cadence, Mentor, TMA, and Hewlett-Packard software suites. Research programs developing supplemental design tools for modeling integrated circuits, devices, processes, and interconnects have provided unique supplemental capabilities.

**Plasma Engineering and Electromagnetics**

Plasma engineering and electromagnetics have played fundamental roles in electrical engineering throughout the history of this discipline. Research at Rensselaer in recent years has centered on two general areas—analysis of electromagnetic fields and characterization of plasma media. Project areas include diagnostics for fusion plasmas based on the interaction between energetic particle beams and plasmas, the application of finite element methods to microwave heating of a variety of materials, antenna design, low temperature plasma modification of materials, magnetic levitation, and electric vehicles. Additional microwave projects are described in the section above.

High-temperature plasma research is crucial to the development of a controlled thermonuclear fusion energy source. Rensselaer’s Plasma Dynamics Laboratory has a very active research program on the development of particle beam diagnostic systems for magnetically confined plasma experiments. Specific diagnostic techniques are developed and tested on relatively small-scale experiments in the on-campus laboratory. Techniques are then scaled up and applied on major confinement experiments located at other U.S. universities (e.g., the Universities of Texas and Wisconsin), at U.S. national laboratories (e.g., Oak Ridge National Lab and Lawrence Livermore National Lab), and foreign institutions (e.g., the Japanese National Institute for Fusion Science).

Electromagnetics remains one of the richest sources of problems and opportunities for electrical engineers. In recent years, the availability of powerful analysis tools, such as those based on finite element methods, has greatly enhanced the ability to exploit electromagnetic phenomena for the greater good of society. Issues associated with high power microwave antenna design, material properties assessment for microwave heating applications, noise in electric vehicle design, and processing of waste materials have been addressed.
Faculty*

Professors

Bhat, I.—Ph.D. (Rensselaer Polytechnic Institute); solid state, electronic materials.

Chow, J.H.—P.E., 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.

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.

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.

Gutmann, R.J.—Ph.D. (Rensselaer Polytechnic Institute); solid-state devices, microwave techniques, and interconnection technology.

McDonald, J.F.—Ph.D. (Yale University); communication theory, coding and switching theory, computer architecture, integrated circuit design, high frequency packaging, digital signal processing.

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.

Roysam, B.—D.Sc. (Washington University); intelligent imaging at low SNR, parallel computation, biomedical applications.

Salon, S.J.—P.E., 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.

Schubert, E.F.—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.

Tien, J.M.—Ph.D. (Massachusetts Institute of Technology); systems modeling, queuing theory, public policy and decision analysis, computer performance evaluation, information systems, expert systems, computational cybernetics.

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.

Zhang, X.C.—Ph.D. (Brown University); ultrashort optical pulse spectroscopy, terahertz lasers.

* 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 2005 Board of Trustees meeting.
Associate Professors

Franklin, W.R.—Ph.D. (Harvard University); computational geometry, graphics and CAD applications, large geometric databases, geographic information systems, terrain visibility and compression.

Ji, Q.—Ph.D. (University of Washington); computer vision, image processing, pattern recognition, robotics.

Kalyanaraman, S.—Ph.D. (Ohio State University); ATM and Internet traffic management, multimedia networking, IP telephony, performance analysis, Internet pricing.

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.

Saulnier, G.J.—Ph.D. (Rensselaer Polytechnic Institute); circuits and electronics, communication systems, digital signal processing.

Schoch, P.M.—Ph.D. (Rensselaer Polytechnic Institute); plasma diagnostics, instrumentation, engineering education.

Sun, J.—Ph.D. (University of Paderborn); power electronics and energy systems.

Xiang, N.—Ph.D. (Ruhr-University Bochum); signal processing, acoustic sensing, and architectural acoustics.

Assistant Professors

Abouzeid, A.A.—Ph.D. (University of Washington); packet networks.

Arcak, M.—Ph.D. (University of California, Santa Barbara); design and analysis of nonlinear control systems, adaptive control, applications to mechanical systems.

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.

Hella, M.—Ph.D. (Ohio State University) RF and mixed signal VLSI circuits for wireless/optical transceivers; analog/RFIC design for bio-medical applications.

Huang, W.—Ph.D. (Carnegie Mellon University); robotic manipulation, mobile robotics.

Huang, Z.R.—Ph.D. (Georgia Institute of Technology) optoelectronic device/microsystem design, fabrication and packaging.

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.

Mercado, A.V.—Ph.D. (University of Maryland); wireless communication.

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.

Sikdar, B.—Ph.D. (Rensselaer Polytechnic Institute); computer networks.

Yazici, B.—Ph.D. (Purdue University); inverse problems in biomedical imaging, tomography, diffuse optical tomography, biomedical optics, free space optical communications, ultrasونics, statistical pattern recognition theory and application.

Zhang, T.—Ph.D. (University of Minnesota); VLSI signal processing, error-correcting coding.

Clinical Professors

Murtuza, S.—Ph.D. (Purdue University); engineering education.

Research Associate Professors

Lu, J.—Ph.D. (Technical University of Munich); electronic materials.

Millard, D.L.—Ph.D. (Rensselaer Polytechnic Institute); microelectronics design and manufacturing, nondestructive testing and evaluation, instrumentation systems, multimedia development.
Research Assistant Professors

Azimi-Sadjadi, B.—Ph.D. (University of Maryland); stochastic systems, control, communication.

Demers, D.—Ph.D. (Rensselaer Polytechnic Institute); fusion plasmas, plasma diagnostics.

Gessmann, T.—Ph.D. (University of Stuttgart); condensed matter, wide bandgap semiconductors.

Adjunct Faculty


Bonissone, P.P.—Ph.D. (University of California, Berkeley); theory of fuzzy sets.

Bonner, S.J.—Ph.D. (Rensselaer Polytechnic Institute); robotics.

Caola, R.J.—M.E. (Rensselaer Polytechnic Institute); protective relaying.

Citriniti, T.D.—M.S. (Rensselaer Polytechnic Institute); computer graphics and visualization.

Hershey, J.E.—Ph.D. (Oklahoma State University); communication systems, cryptography, intellectual property management.

Kraft, R.P.—Ph.D. (Rensselaer Polytechnic Institute); digital control and manufacturing systems.

Marwali, M.K.—Ph.D. (Illinois Institute of Technology); power transmission and generators.

Prabhakara, E.S.—Ph.D. (Purdue University); power systems.

Sivasubramanian, K.—Ph.D. (Rensselaer Polytechnic Institute); electromagnetics, machines.

Thomenius, K.D.—Ph.D. (Rutgers University); imaging science.

Torrey, D.A.—P.E., Ph.D. (Massachusetts Institute of Technology); semiconductor power electronics, electric machinery.

Yuksel, M.—Ph.D. (Rensselaer Polytechnic Institute); computer networks, Internet pricing, routing in wireless networks, large-scale network simulation.

Emeritus Faculty

Borrego, J.M.—P.E., Sc.D. (Massachusetts Institute of Technology); semiconductor device physics and characterization, solar cells, application of microwaves.

Carlson, A.B.—Ph.D. (Stanford University); communication systems, circuits and electronics, educational methods, social context of engineering.

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.

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.

Greenwood, A.N.—Ph.D. (University of Leeds); electrical transients, interrupting devices.

Hickok, R.L., Jr.—Ph.D. (Rensselaer Polytechnic Institute); gaseous electronics, plasmas, energy conversion.

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.


Rose, K.—Ph.D. (University of Illinois); semiconductor and superconductor materials and processing, VLSI design and testing.
**Undergraduate Programs**

**Objectives of the Undergraduate Curriculum**
Graduates of the programs within Electrical, Computer, and Systems Engineering will be prepared to:

- Obtain entry-level engineering positions in industry and/or admission to graduate study programs in their areas of interest.
- Establish themselves as problem-solvers and innovators, having a solid foundation in electrical, computer and systems, or electric power engineering and the ability to apply this background to solve real-world problems.
- Function effectively in a professional environment, having the necessary communication and leadership skills and the ability to view their own work in a broader context.
- Continue to develop professionally through life-long learning.

**Baccalaureate Programs**
Within this department, students may obtain the Bachelor of Science degree in three disciplines, electrical engineering, computer and systems engineering, or electric power engineering. The department also encourages students to consider graduate study in any of these three curricula. A professional program option, which leads to both the B.S. and M.Eng. degree, is also open to qualified students.

Engineering design is introduced and developed in the required courses ENGR-2050, ENGR-2350, and ECSE-2610, and in various electives. These courses set the stage for capstone design experience in the design elective, a writing-intensive course that satisfies the Institute writing requirements.

The following program descriptions indicate course schedules for students who select any of the three ECSE disciplines as their chosen field of study. 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.

All three of the ECSE curricula require completion of a minimum of 128 credit hours. Within all of these program areas, 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 Curriculum

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 and electromagnetics to circuits and electronics, and to large-scale 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>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100</td>
<td>Intro. to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1310</td>
<td>Intro. to Eng. Electronics</td>
<td>1</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
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</table>

**Spring**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1200</td>
<td>Eng. Graphics and CAD</td>
<td>1</td>
</tr>
<tr>
<td>MATH-1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1100</td>
<td>Physics I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
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</table>

## Second Year

**Fall**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2050</td>
<td>Intro. to Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1200</td>
<td>Physics II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
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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>ENGR-2350</td>
<td>Embedded Control</td>
<td>4</td>
</tr>
<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></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</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>ECSE-2050</td>
<td>Analog Electronics</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2060</td>
<td>Digital Electronics</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2410</td>
<td>Signals and Systems</td>
<td>4</td>
</tr>
<tr>
<td>MATH-2010</td>
<td>Multivar. Calc. and Matrix Alg.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
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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>ECSE-2100</td>
<td>Fields and Waves I</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2210</td>
<td>Microelectronics Technology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Free Elective 1,4</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Multidisciplinary Elective</td>
<td>4</td>
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</tbody>
</table>

## Fourth Year

**Credit hours**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-4500</td>
<td>Probability for Engineering</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Applications</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-4010</td>
<td>Professional Development II</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Professional Development III</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Laboratory Elective</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Design Elective</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Restricted Elective</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Free Electives (2 or 3)</td>
<td>8-9</td>
</tr>
<tr>
<td></td>
<td>Concentration Electives</td>
<td>6</td>
</tr>
</tbody>
</table>

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1. May be taken either term.
2. May be replaced by ENGR-1300.
3. Students entering this program in the fourth term should take CSCI-1100 in the spring, deferring ECSE-2610.
4. The free electives must total at least 12 credits.
5. This course will be fulfilled from a list published at the start of each semester.
6. May be taken in the third year.
7. Students are encouraged to select a life science course, such as BIOL-1010.
Humanities or 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 and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Restricted Elective
Any course with the designation EPOW, ECSE, or ENGR-4xxx.

<table>
<thead>
<tr>
<th>Laboratory Electives</th>
<th>Multidisciplinary Electives</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-4710 Advanced Manufacturing Laboratory I (Fall)</td>
<td>ECSE-4770 Computer Hardware Design (Fall)</td>
</tr>
<tr>
<td>EPOW-4030 Electric Power Engineering Laboratory (Spring)</td>
<td>ENGR-1600 Materials Science for Engineers</td>
</tr>
<tr>
<td>ECSE-4220 VLSI Design (Fall)</td>
<td>ENGR-2090 Engineering Dynamics</td>
</tr>
<tr>
<td>ECSE-4690 Experimental Networking (Fall)</td>
<td>ENGR-2250 Thermal and Fluids Engineering I</td>
</tr>
<tr>
<td>ECSE-4760 Computer Applications Laboratory (Spring)</td>
<td>ENGR-2530 Strength of Materials</td>
</tr>
</tbody>
</table>

Design Electives
Design electives can be described as “multidisciplinary” (ECSE-4900) or “depth of understanding.” Students should visit the ECSE homepage for help with design elective selection.

<table>
<thead>
<tr>
<th>ECSE-4900</th>
<th>ECSE-4120</th>
<th>ECSE-4260</th>
<th>ECSE-4460</th>
<th>ECSE-4560</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE Design (Fall and Spring)</td>
<td>Electronic Circuits Design (Spring)</td>
<td>Physical Design of Microelectronics (Spring)</td>
<td>Control Systems Design (Spring)</td>
<td>Signal Processing Design (Spring)</td>
</tr>
<tr>
<td>ECSE-4780</td>
<td>Advanced Computer Hardware Design (Spring)</td>
<td>ECSE-4790 Microprocessor Systems Design (Fall)</td>
<td>ENGR-4060 Inventor’s Studio (Fall or Spring)</td>
<td>EPOW-4850 EPE Design (Spring)</td>
</tr>
</tbody>
</table>

Concentration Electives
Two courses in one of the concentration areas. See the ECSE homepage for areas and courses.
## Computer and Systems Engineering Curriculum

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 digital computer as a system in itself, as a tool for modeling and design, and as an online element within a real-time system. There is the flexibility to study in depth automatic control, communications, or information processing, in addition to computer software, systems, and hardware.

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>ENGR-1200</td>
<td>1</td>
<td>MATH-2800</td>
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</tr>
<tr>
<td>ENGR-1100</td>
<td>4</td>
<td>ENGR-1310</td>
<td>1</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>4</td>
<td>MATH-1020</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1100</td>
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<td>CSCI-1200</td>
<td>4</td>
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<tr>
<td>Hum. or Soc. Sci. Elective</td>
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<td>Hum. or Soc. Sci. Elective</td>
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<tr>
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<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>ENGR-2350</td>
<td>4</td>
<td>ECSE-2660</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2610</td>
<td></td>
<td>MATH-2400</td>
<td>4</td>
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<td>CSCI-2300</td>
<td>4</td>
<td>PHYS-1200</td>
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</tr>
<tr>
<td>PHYS-1100</td>
<td>4</td>
<td>CHEM-1300</td>
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### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2050</td>
<td>4</td>
<td>ECSE-2410</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2010</td>
<td>4</td>
<td>Software Engineering Elective</td>
<td>3–4</td>
</tr>
<tr>
<td>Multidisciplinary Elective</td>
<td>4</td>
<td>Free Elective 1,4,7</td>
<td>3–4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Fourth Year

<table>
<thead>
<tr>
<th></th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>Professional Development II</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-4500</td>
<td></td>
</tr>
<tr>
<td>Probability for Engineering</td>
<td></td>
</tr>
<tr>
<td>Applications 1</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-4010</td>
<td></td>
</tr>
<tr>
<td>Professional Development III</td>
<td>1</td>
</tr>
<tr>
<td>Design Elective</td>
<td></td>
</tr>
<tr>
<td>Restricted Elective</td>
<td>3–4</td>
</tr>
<tr>
<td>Free Electives (2 or 3)</td>
<td>8–9</td>
</tr>
<tr>
<td>Concentration Electives</td>
<td>6–8</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
</tr>
</tbody>
</table>

1 May be taken either term

2 May be replaced by ENGR-1300

3 Students entering this program in the fourth term should take CSCI-1100 and ENGR-2350 in the spring deferring ECSE-2610, ECSE-2660, CSCI-1200, and CSCI-2300.

4 The free electives must total at least 12 credits.

5 This course will be fulfilled from a list published at the start of each semester.

6 May be taken in the third year.

7 Students are encouraged to select a life science course, such as BIOL-1010.
Humanities or 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 and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Restricted Elective
Any course with the designation ECSE, CSCI, or ENGR-4xxx.

Software Engineering Electives
ECSE-4690 Experimental Networking (Fall)
ECSE-4750 Computer Graphics (Fall or Spring)
ECSE-6770 Software Engineering I (Fall)
CSCI-4380 Database Systems (Fall or Spring)
CSCI-4440 Software Design and Documentation (Fall or Spring)
CSCI-4600 The Human-Computer Interface

Design Electives
Design electives can be described as “multidisciplinary” (ECSE-4900) or “depth of understanding.” Students should visit the ECSE homepage for help with design elective selection.

ECSE-4900 ECSE Design (Fall and Spring) ECSE-4780 Advanced Computer Hardware Design (Spring)
ECSE-4120 Electronic Circuits Design (Spring) ECSE-4790 Microprocessor Systems Design (Fall)
ECSE-4260 Physical Design of Microelectronics (Spring) ECSE-4980 Senior Design Project (Fall or Spring)
ECSE-4460 Control Systems Design (Spring) ENGR-4060 Inventor’s Studio (Fall and Spring)
ECSE-4560 Signal Processing Design (Spring) EPOW-4850 EPE Design (Spring)

Concentration Electives
Two courses in one of the concentration areas. See the ECSE homepage for areas and courses.

Electric Power Engineering Curriculum
The traditional place for electric power studies in a university is in the electrical engineering program, where the power option is offered as one of several concentrations. At Rensselaer, electric power is a separate degree program with its own faculty. It maintains strong ties to industry and is dedicated to preparing students for careers in power generation, delivery, or equipment; power electronics applied to drives and power conditioning; or at the intersection of electric power, economics, and management.

The vital role that energy plays in our lives has become increasingly evident in recent years. Society as we know it cannot function without an abundant supply of energy. It turns the wheels of industry and agriculture, it provides transportation, it supplies many of our domestic and recreational needs. There is continuing controversy over the primary source of the energy, but there is widespread agreement that electrical energy, because of its ease of transformation to and from other energy forms and its ease of transmission, distribution, and utilization, is vital. It is expected that electrical energy will constitute an increasing portion of the total energy used.

To keep pace with expanding needs through the development of ever more sophisticated systems requires the technical talent, scientific knowledge, mature judgment, and visionary innovation of the best
engineering minds of this generation. The electric power engineering program at Rensselaer is dedicated to meeting this need in generation, delivery, and utilization in an increasingly competitive environment. Study at Rensselaer is supported by the power industry, which the program serves. In particular, the ECSE Department operates a Grainger Scholar program under the auspices of the Grainger Foundation for well-qualified U.S. students.

**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-2400</td>
<td>Calculus I ........................................4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers .......4</td>
</tr>
<tr>
<td>ENGR-1100</td>
<td>Intro. to Engineering Analysis ............4</td>
</tr>
<tr>
<td>ENGR-1200</td>
<td>Eng. Graphics and CAD 1 ..................1</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective 1 .........4</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1020</td>
<td>Calculus II ........................................4</td>
</tr>
<tr>
<td>ENGR-1600</td>
<td>Materials Science for Engineers ...........4</td>
</tr>
<tr>
<td>PHYS-1160</td>
<td>Physics I ............................................4</td>
</tr>
<tr>
<td>ENGR-1300</td>
<td>Engineering Processes 2 1 ....................4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective 1 ..........4</td>
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**Second Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations ..........4</td>
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<tr>
<td>PHYS-1200</td>
<td>Physics II ...........................................4</td>
</tr>
<tr>
<td>ENGR-2050</td>
<td>Intro. to Engineering Design .............4</td>
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<td>Hum. or Soc. Sci. Elective 1 ..........4</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2010</td>
<td>Electric Circuits ................................4</td>
</tr>
<tr>
<td>ENGR-4050</td>
<td>Modeling and Control of Dynamic Systems ..4</td>
</tr>
<tr>
<td>ENGR-2600</td>
<td>Modeling and Analysis of Uncertainty .......3</td>
</tr>
<tr>
<td>CSCI-1190</td>
<td>Beginning C Programming for Engineers .......1</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective 1 ..........4</td>
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**Third Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>ENGR-4300</td>
<td>Electronic Instrumentation ...............4</td>
</tr>
<tr>
<td>ECSE-2100</td>
<td>Fields and Waves I ................................4</td>
</tr>
<tr>
<td>ENGR-2250</td>
<td>Thermal and Fluids Engineering I ..........4</td>
</tr>
<tr>
<td>EPOW-4010</td>
<td>Power Engineering Fundamentals ..........4</td>
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</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2410</td>
<td>Signals and Systems ................................4</td>
</tr>
<tr>
<td>EPOW-4020</td>
<td>Electromechanics ..................................3</td>
</tr>
<tr>
<td>ENGR-2350</td>
<td>Embedded Control ....................................4</td>
</tr>
<tr>
<td>Elective 3 .............................................4</td>
<td></td>
</tr>
<tr>
<td>Professional Development II 4 ...........2</td>
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</table>

**Fourth Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>EPOW-4080</td>
<td>Semiconductor Power Electronics ..........3</td>
</tr>
<tr>
<td>Technical Elective 4 ................................3</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective 4 ................4</td>
<td></td>
</tr>
<tr>
<td>Elective .............................................4</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPOW-4850</td>
<td>Electric Power Eng. Design ..................3</td>
</tr>
<tr>
<td>EPOW-4030</td>
<td>EPE Laboratory .....................................4</td>
</tr>
<tr>
<td>Elective .............................................4</td>
<td></td>
</tr>
<tr>
<td>Technical Elective 4 ................................3</td>
<td></td>
</tr>
<tr>
<td>ENGR-4010</td>
<td>Professional Development III 5 ............1</td>
</tr>
</tbody>
</table>

1 There should be a total of 20 credit hours of H&SS electives.
2 These required courses may be taken in any order.
3 May be replaced by ENGR-1310.
4 Any course in engineering or science that is at the 2000 level or higher.
5 Can be taken in either semester during senior year.
6 This course will be fulfilled from a list published at the start of each semester.
7 Students are encouraged to select a life science course, such as BIOL-1010.
Humanities or 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 and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Concentration in Power Electronics Systems
The concentration in Power Electronics Systems is open to all students in Electric Power Engineering. Fulfillment of the concentration will be recognized by the department and consists of both the following courses:

- EPOW-4080 Semiconductor Power Electronics Systems
- EPOW-4850 Electric Power Engineering Design (with Power Electronics emphasis)

and one of the following:

- ECSE-4250 Integrated Circuit Processes and Design
- ECSE-4290 Electronic Packaging
- MANE-4490 Mechatronics
- MANE-4250 Mechatronic System Design

Minor Programs
Minors in any of the three ECSE curricula are open to undergraduates not majoring in any of these disciplines. The corresponding curriculum chair must approve all minors.

In Electrical Engineering, the minor consists of:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2010 Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2410 Signals and Systems</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2610 Computer Components and Operations</td>
<td>4</td>
</tr>
<tr>
<td>Approved ECSE elective</td>
<td>3–4</td>
</tr>
</tbody>
</table>

In Electric Power Engineering, the minor consists of:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2010 Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2050 Analog Electronics or EPOW-4080 Semiconductor Power Electronics</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-4300 Electronic Instrumentation</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2100 Fields and Waves</td>
<td>4</td>
</tr>
<tr>
<td>EPOW-4020 Electromechanics</td>
<td>4</td>
</tr>
<tr>
<td>EPOW-4010 Power Engineering Fundamentals or EPOW-4080 Semiconductor Power Electronics</td>
<td>4</td>
</tr>
<tr>
<td>EPOW-4080 Semiconductor Power Electronics</td>
<td>4</td>
</tr>
</tbody>
</table>

In Computer and Systems Engineering, the minor consists of:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2010 Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2610 Computer Components and Operations</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2660 Computer Architecture, Networks, and Operating Systems</td>
<td>4</td>
</tr>
<tr>
<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
- Electrical engineering and electric power engineering
- Computer and systems engineering and computer science

See the ECSE web page for detailed information about these programs.
Professional Programs
ECSE students following the Electric Power Engineering Program may follow this option to complete both the B.S. and M.S. degrees. In this case, the fourth year follows closely the outline for the last year of the baccalaureate program. However, in choosing electives the student should bear in mind that the following courses must be taken at some time prior to or during the professional program:

ENGR-4760 Engineering Economics
Mathematics elective at 4000 level or higher

The following 4000-level courses (or their equivalents) can be used to satisfy the degree’s mathematics course requirement:
MATH-4600 Advanced Calculus
MATH-4300 Intro. to Complex Variables: Theory and Applications
MATH-4500 Methods of Partial Differential Equations of Mathematical Physics
MATH-4700 Foundations of Applied Mathematics

The typical curricula for the remainder of the program is as follows:

Fifth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPOW-6810 Power Engineering Analysis ..............3</td>
<td>EPOW-6870 Mechanical Aspects of Electric Power Apparatus ....................3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selected Power Courses 1 ..................... 3</td>
<td>Selected Power Courses 1 ..................... 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electives ..........................................6</td>
<td>Electives ..........................................6</td>
<td></td>
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</tr>
</tbody>
</table>

A student wishing to qualify for a B.S. degree by the end of the first year of professional school studies must complete the humanities and social sciences core requirement during the first year of the professional program.

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.

1 At least two courses should be selected from the following:

EPOW-6820 Power Quality (Spring)
EPOW-6880 Utility as a Business (Spring or Summer)
EPOW-6830 Protective Relaying (Fall; offered on availability of instructor)
EPOW-6840 Power Generation Operation and Control (Spring)

EPOW-6960 Topics in Electric Power Engineering (Spring or Summer)
EPOW-6860 Surge Phenomena in Electric Power Engineering (Fall)
ENVE-4400 Nuclear Power Systems Engineering (Spring)
The Grainger Scholar program
This program is for well-qualified U.S. students in electric power engineering. Through this program, the power industry, under the auspices of the Grainger Foundation, supports study at Rensselaer.

Graduate Programs
The department offers graduate programs leading to the Master of Engineering, Master of Science, Doctor of Philosophy, and Doctor of Engineering in all three 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, it 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. or D.Eng. 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.

In the electric power engineering curricula, most study and research is of an applied nature, which is recognized in the awarding of the D.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 Ph.D. 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.

**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, DSES, ECSE, ENVE, EPOW, ITEC, MATH, MATP, MTLE, and PHYS.

**Materials Science and Engineering**

**Chair:** David J. Duquette  
**Undergraduate Advising:** Pawel Keblinski  
**Graduate Recruiting:** Roger N. Wright  
**Graduate Advising:** Christoph Steinbruchel  
**Department Home Page:** [http://www.eng.rpi.edu/dept/materials/](http://www.eng.rpi.edu/dept/materials/)

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 research in 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. New 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 concentrates on materials problems associated with the interconnections between integrated circuit elements. Included are the growth of thin films of metals and both polymer and ceramic dielectric materials, the patterning and etching processes necessary for the fabrication of multilayer devices, and the planarization processes necessary for successful device fabrication. Of special note is the program in microelectronics packaging, which addresses the mechanical, electronic, and thermal aspects of device design and fabrication.

**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.

**High-Performance Composite Materials**

These materials are used in industrial and consumer products due to their exceptional stiffness and strength-to-weight ratios. Applications of composites in the construction industry, such as steel bridge repairs using graphite-epoxy composites, are growing rapidly. Meanwhile, next generation conceptual
plans for hybrid electric vehicles are using ceramic composite components for gas turbine engines and thermal recuperators. Composites research activities at Rensselaer include ceramic, metallic, and polymer matrix composites; micromechanics and modeling of both fabrication processes and materials properties; design with new materials; synthesis of new matrix materials; and all aspects of the fabrication and characterization of composites and composite structures. Of special note is the sailplane program, in which students have designed, fabricated, and tested an all-composite glider, which has now been flying for over seven years. A new project, the composite hybrid electric vehicle, has also been initiated and offers numerous opportunities for both graduate and undergraduate participation.

**Faculty**

**Professors**

Ajayan, P.M.—Ph.D. (Northwestern University); synthesis, structure, and properties of carbon-based nanostructures and nanocomposites; phase transitions in nanoscale materials; electron microscopy.

Duquette, D.J.—Ph.D. (Massachusetts Institute of Technology); environmental and surface effects on the mechanical behavior of metals, corrosion, stress corrosion fatigue (Department Head).

Glicksman, M.E.—Ph.D. (Rensselaer Polytechnic Institute); melting and solidification, transport properties of liquid metals, phase transformation kinetics, metallurgy of superconductors (John Tod Horton Professor of Materials Engineering).

Messler, R.W., Jr.—Ph.D. (Rensselaer Polytechnic Institute); materials in manufacturing, welding.

Nalamasu, O.—Ph.D. (University of British Columbia); electronic and photonic polymers, nanopatterning, micro- and nanofabrication, electronic and photonic devices.

Rajan, K.—Sc.D. (Massachusetts Institute of Technology); electron microscopy, electronic materials, thin films and superlattices.

Schadler, L.S.—Ph.D. (University of Pennsylvania); polymer and glass matrix composites, micromechanical behavior, strains and interface properties, micro-Raman spectroscopy, environmental effects.

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).

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).

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.

**Associate Professors**

Keblinski, P.—Ph.D. (Pennsylvania State University); atomic mesoscopic-level computational modeling of interfacial processes; structure-property correlations; interfaces in silicon, diamond and metals; thin film growth; phase separation.

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.

* 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 2005 Board of Trustees meeting.
Steinbruchel, C.—Ph.D. (University of Minnesota); thin films, electronic materials, plasma processing, ion beam and ultra-high vacuum techniques.

Assistant Professors

Gall, D.—Ph.D. (University of Illinois, Urbana-Champaign); physical properties of thin films and nanostructures; combined theory, modeling and experimentation in thin film technology as applied to electronic structures and properties, transition-metal nitride film growth and characterization.

Ozisik, R.—Ph.D. (The University of Akron, Ohio); multiscale simulations of polymers, surface and interface properties of nanoparticles; development and characterization of fuel cells.

Shima, M.—Ph.D. (University of Maryland); thin film deposition; nano-patterning, structural and magnetic characterization.

Research Professors

Doremus, R.H.—Ph.D. (University of Cambridge), Ph.D. (University of Illinois); glass science, sintering of ceramics, bone implant materials, reactions in fused salts, crystallization, diffusion, optical properties of metals (New York State Science and Technology Foundation Professor of Glass and Ceramics Science).

Eisman, G.—Ph.D. (Northeastern University); fuel cells, ceramic powder synthesis, electrochemical engineering, chloralkali technology.

Hillig, W.B.—Ph.D. (University of Michigan); ceramic and polymer matrix composites, strength of glass, crystal growth.

Research Associate Professors

Lupulescu, A.—Ph.D. (Rensselaer Polytechnic Institute); diffusion, crystal growth

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.

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); Ph.D. (University of Agra); 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).

Stoloff, N.S.—Ph.D. (Columbia University); mechanical behavior of crystals, order-disorder reactions, fracture, stress corrosion.

Manager of Electron Microscopy Facilities

Dove, R.

Manager of Instruction Laboratories

Van Steele, D.

Manager of Metallographic Facilities

Planty, R.
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. In this regard, the Department of Materials Science and Engineering’s baccalaureate program produces students who will:

- Exhibit general knowledge in all major classes of materials and specialized knowledge in several classes, such as metals, ceramics and glasses, polymers, composites and electronic materials.
- Recognize the interdependence of the structure, properties, processing, and performance of materials and be able to integrate fundamental materials science with analysis of experimental data, laboratory synthesis and processing as well as quantitative modeling.
- Integrate meaningful design experiences within Materials Engineering and in relationship to other engineering disciplines.
- Exhibit a thorough grounding in fundamental mathematics and science and the ability to apply this knowledge in identifying, formulating, and solving real-life engineering problems.
- Be able to put engineering problems, their solutions, and consequences into a societal context.
- Effectively communicate and work in teams.
- Maintain a desire for life-long learning.

Baccalaureate Program
The sample curriculum shown below, which results in the B.S. degree in Materials Engineering, requires a minimum of 128 credit hours and completion of the required elective courses that follow.

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100 Intro. to Engineering Analysis ..........4</td>
<td>ENGR-1300 Eng. Processes.........................1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH-1010 Calculus I .........................................4</td>
<td>ENGR-1600 Materials Science for Engineers ..........4</td>
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<tr>
<td>CHEM-1300 Chemistry Principles for Engineers ...4</td>
<td>MATH-1020 Calculus II .......................................4</td>
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<tr>
<td>Hum. or Soc. Sci. Elective ..........4</td>
<td>PHYS-1100 Physics I ...........................................4</td>
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<tr>
<td>ENGR-1200 Engineering Graphics and CAD .........1</td>
<td>Hum or Soc. Sci. Elective ..........4</td>
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Second Year

<table>
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<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
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</tr>
</thead>
<tbody>
<tr>
<td>PHYS-1200 Physics II.................................4</td>
<td>MTLE-2100</td>
<td>Science Elective 1 ..................................4</td>
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</tr>
<tr>
<td>MATH-2400 Intro. to Differential Equations ......4</td>
<td>ENGR-2050 Intro. to Engineering Design.................4</td>
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<tr>
<td>ENGR-2250 Therm./Fluid I .......................4</td>
<td>MTLE-4250 Prop. of Eng. Materials II ...............4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGR-1200 Engineering Graphics and CAD ......1</td>
<td>Hum. or Soc. Sci. Elective ..........4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Restricted Elective ........................4 |

Free Elective I ..................................4 |

1 Students are encouraged to select a life science course, such as BIOL-1010.
2 This course will be fulfilled from a list published at the start of each semester.
Electives
The following is a list of courses from which the electives indicated above should be selected.

Restricted Elective Options
- ENGR-2530 Strength of Materials
- ENGR-2350 Embedded Control
- ENGR-2090 Engineering Dynamics
- ECSE-2010 Electric Circuits
- ENGR-4300 Electronics Instrumentation

Materials Electives
- MTLE-4030 Glass Science
- MTLE-4050 Intro. to Polymers
- MTLE-4160 Semiconducting Materials
- MTLE-4290 Electronic Packaging
- MTLE-4410 Welding Processes and Metallurgy
- MTLE-4420 Joining of Advanced Materials
- MTLE-4630 Composites Laboratory

Minor Programs
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.

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 the M.Eng. require completion of a minimum of 30 credit hours.

Master of Science
For the M.S., students must complete 24 credits of course work, with at least 18 credits in materials courses. Three credits each are required in the areas of thermodynamics and kinetics, structure, and mechanical properties. Students who have not taken courses equivalent to undergraduate work at Rensselaer in X-ray diffraction, thermodynamics, mechanical properties, and their area of specialization must take graduate courses in these areas. Six credits of research work leading to an M.S. thesis are also required.

Master of Engineering
At least 21 credits of course work toward the M.Eng. degree must be materials courses. These must include one course each in structure and defects, thermodynamics and kinetics, and mechanical properties. A capstone independent study project is also required.

Doctoral Programs
A minimum of 45 credits in course work is required for the Ph.D. degree in materials engineering. In addition to the course requirements for the M.S. degree, a minor of nine credits in a subject area outside

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This course can be taken in either semester of senior year.
the materials department is required. The student must pass an oral preliminary examination and an oral candidacy examination, as well as the final examination on the Ph.D. thesis.

Course Descriptions
Courses offered by the Department of Materials Science & Engineering are described in the Course Description section of this catalog under the department code MTLE.

Mechanical, Aerospace, and Nuclear Engineering
Chair: John A. Tichy
Director, Mechanical Engineering and Aerospace Engineering Programs: John A. Tichy
Director, Nuclear Engineering and Engineering Physics Program: Don Steiner
Associate Chair for Graduate Studies: Antoinette Maniatty
Associate Chair for Undergraduate Studies: Henrik J. Hagerup
Department Home Page: www.rpi.edu/dept/mane

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 a branch of mechanical engineering with associated technologies that apply not only to aircraft and spacecraft, but to other vehicular systems such as submarines and hydrofoils as well. Nuclear engineering and engineering physics focus on the methods, devices, and systems required for the peaceful use of nuclear technology. While nuclear engineering’s particular emphasis is on nuclear power generation, engineering physics emphasizes the radiation aspect of this technological area.

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 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 fluid dynamics laboratory and 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.

Facilities include the gas turbine laboratory; the energy systems laboratory; subsonic, transonic, and supersonic wind tunnels; shock tubes and the hypersonic shock tunnel; the heat transfer laboratory; and the laboratory for fouling research. Additional equipment includes various two-phase flow loops and associated instrumentation, laser Doppler anemometer, optical void probes, and the resources of the Center for Multiphase Research.

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 thermal fluids laboratory; subsonic, transonic, and supersonic wind tunnels; and the heat transfer laboratory. Additional equipment includes various two-phase flow loops and associated instrumentation, laser Doppler anemometer, etc.

**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, the robotics and mechanisms laboratory, and the mechatronics 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 supersonic wind tunnels, the shock tube, and crystal growth laboratories.

**Faculty**

**Professors**
- **Craig, K.C.**—Ph.D. (Columbia University); design, tribology, mechanics, controls (Chair, Engineering Science, and Director, Core Engineering).
- **Drew, D.A.**—Ph.D. (Rensselaer Polytechnic Institute); applied mathematics, fluid mechanics (joint appointment, Mathematics home department).
- **Dvorak, G.J.**—NAE, Ph.D. (Brown University); mechanics of solids, composite materials and structures, fracture and fatigue (William Howard Hart Professor of Mechanics).
- **Fish, J.**—Ph.D. (Northwestern University); computational mechanics, finite element methods, micromechanics, mathematical modeling (joint appointment, Civil Engineering home department).
- **Gabriele, G.A.**—Ph.D. (Purdue University); design automation, design optimization.
- **Hajela, P.**—Ph.D. (Stanford University); optimum design, structural dynamics, aeroelasticity (Vice Provost for Administration, Dean of Undergraduate Education).
- **Jensen, M.K.**—Ph.D., P.E. (Iowa State University); heat transfer, fluid mechanics, energy systems.
- **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 (jointly with the Chemical Engineering Department; Edward W. Hood Jr. Professor).
- **Li, C.J.**—Ph.D. (University of Wisconsin-Madison); control of manufacturing process and equipment, machine condition monitoring, nonlinear system identification.
- **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); continuum mechanics, mechanics of materials (Clare Boothe Luce Associate Professor).
- **Messac, A.**—Ph.D. (Massachusetts Institute of Technology); optimal design, physical programming, design methodology, structural dynamics.
- **Ostrogorsky, A.G.**—Sc.D. (Massachusetts Institute of Technology); heat transfer and fluid mechanics, solidification, crystal growth (jointly with Materials Science and Engineering Department).
- **Peterson, G.P. “Bud”**—Ph.D. (Texas A&M University); two phase heat transfer (Provost).
- **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 aerodynamics, fluid mechanics.
- **Smith, R.N.**—Ph.D. (University of California, Berkeley); energy systems (Associate Dean, Academic and Students Affairs).
- **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).
- **Spilker, R.L.**—Ph.D. (Massachusetts Institute of Technology); biomechanics, finite element methods (joint appointment, Biomedical Engineering home department).
- **Steiner, D.**—Ph.D. (Massachusetts Institute of Technology); nuclear fusion systems, plasma

*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 2005 Board of Trustees meeting.
engineering, radiation effects on materials (Institute Professor of Nuclear Engineering).

**Tichy, J.A.**—Ph.D. (University of Michigan); tribology, non-Newtonian fluid mechanics, rheology (Department Chair).

**Tiersten, H.F.**—Ph.D., P.E. (Columbia University); continuum mechanics, continuum physics, electro-mechanical devices, structures.

**Wen, J.T.**—Ph.D. (Rensselaer Polytechnic Institute); nonlinear control, robot control, flexible structures control, deformation processes control (joint appointment, Electrical, Computer, and Systems Engineering home department).

**Associate Professors**

**Anderson, K.S.**—Ph.D. (Stanford University); multibody dynamics, parallel computing, vehicle dynamics.

**Blanchet, T.A.**—Ph.D. (Dartmouth College); tribology, solid lubrication, surface science, contact mechanics.

**Castillo, L.**—Ph.D. (State University of New York at Buffalo); fluid mechanics, turbulent boundary layers.

**Derby, S.J.**—Ph.D. (Rensselaer Polytechnic Institute); automation, mechanisms, robotics, design.

**Embrechts, M.J.**—Ph.D. (Virginia Polytechnic Institute); fusion engineering, applied chaos theory, neural networks (joint appointment, Decision Sciences and Engineering Systems home department).

**Hagerup, H.J.**—Ph.D. (Princeton University); viscous flow.

**Hirsa, A.**—Ph.D. (University of Michigan); fluid mechanics, experimental gas dynamics (jointly with the Chemical and Biological Engineering Department).

**Huang, H.**—Ph.D. (University of California, Los Angeles); nanomechanics of materials, thin film deposition, radiation damage, multiscale materials modeling.

**Jansen, K.**—Ph.D. (Stanford University); computational mechanics, parallel computing, computational fluid dynamics.

**Kaminski, D.A.**—Ph.D. (Rensselaer Polytechnic Institute); heat transfer, computational fluid mechanics, thermal radiation.

**Myrabo, L.N.**—Ph.D. (University of California, San Diego); energy systems, space technology.

**Picu, C.R.**—Ph.D. (Dartmouth College); mechanics of solids, micro- and nano-mechanics of crystalline defects, atomistic simulations.

**Scarton, H.A.**—Ph.D. (Carnegie Mellon University); biomechanics, wave phenomena, acoustics, noise control.

**Walczyk, D.F.**—Ph.D., P.E. (Massachusetts Institute of Technology); rapid tooling, environmentally conscious design, machine design.

**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).

**Clinical Associate Professor**

**Alben, R.**—Ph.D. (Harvard University); electronic materials, engineering education, engineering management, entrepreneurship, manufacturing and service operations.

**Steiner, M.W.**—Ph.D. (Rensselaer Polytechnic Institute); multidisciplinary design, product architecture, advanced design methods.

**Assistant Professors**

**Amitay, M.**—D.Sc. (Technion-Israel Institute of Technology); aerodynamics flow control, mini-and micro-unmanned aerial vehicles and two-phase flows with applications in medical engineering.
Borca-Tasciuc, T.—Ph.D. (University of California, Los Angeles); heat transfer and energy conversion, nanotechnology, MEMS.

Danon, Y.—Ph.D. (Rensselaer Polytechnic Institute); nuclear instrumentation and data, accelerator technology and radiation applications, nondestructive testing, neural networks applications.

De, S.—Sc.D. (Massachusetts Institute of Technology); numerical methods in engineering, multimodal virtual environments, fast computational techniques of MEMS.

Koratkar, N.A.—Ph.D. (University of Maryland at College Park); smart materials and structures, rotorcraft, unsteady aerodynamics.

Peles, Y.—Ph.D. (Technion-Israel Institute of Technology); MEMS fabrication, design and device testing, design and manufacturing of electronic packaging.

Research Assistant Professors

Antal, S.—Ph.D. (Rensselaer Polytechnic Institute); computational fluid dynamics, numerical methods in multiphase flows, heat transfer.

Senior Lecturer

Swersey, B.L.—B.S. (Cornell University); creativity in design, design methodology.

Adjunct Faculty

Anderson, T.—Ph.D. (New York University); plasma physics, fluid dynamics, reactor physics and radwaste management, environmental engineering.

Borton, D.N.—Ph.D. (Rensselaer Polytechnic Institute); solar energy.

Caracappa, P.—M.S. (Rensselaer Polytechnic Institute); radiation safety, health physics.

DeLorey, T.F.—Ph.D. (Massachusetts Institute of Technology); reactor physics, computational physics, software engineering.

Feitelberg, A.S.—Ph.D. (Massachusetts Institute of Technology); combustion.

Francis, N.—Ph.D. (University of Rochester); reactor physics.

Haley, T.—Ph.D. (Rensselaer Polytechnic Institute); nuclear fuel management, mathematical modeling, reactor design.

Trumbull, T.H.—M.Eng. (Rensselaer Polytechnic Institute); research reactor experimental operations.

Witter, J.K.—Ph.D. (Massachusetts Institute of Technology); reactor physics, plant operations, thermal hydraulics, reactor for space applications.

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.

Ettles, C.M.—Ph.D. (Imperial College), D.Sc. (University of London); mechanical design, machine dynamics, tribology.

Harris, D.R.—Ph.D. (Rensselaer Polytechnic Institute); reactor physics, fusion technology, shielding, reactor noise analysis.

Krempl, E.—Dr.Ing. (Technical University of Munich); continuum mechanics; mechanics of materials; creep, fatigue, inelastic analysis (Rosalind and John J. Redfern Jr. Professor of Engineering).

Lee, D.—Sc.D. (Massachusetts Institute of Technology); mechanics of materials, computer-aided manufacturing.

Nagamatsu, H.T.—Ph.D. (California Institute of Technology); hypersonics, transonsics, plasma dynamics, aeroacoustics, heat transfer.
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. In this regard, graduates of the Department of Mechanical, Aerospace, and Nuclear Engineering's baccalaureate program will:

- Be able to apply skills in science and mathematics to the practice of engineering.
- Through a broad education in the humanities and social sciences, be able to identify and treat problems of interest to society.
- Have the ability to analyze real-world problems and to design products and systems for their solution.
- Develop strong communication skills both oral and written.
- Exhibit teamwork skills and leadership ability, working both within specialized and multidisciplinary settings, and form an awareness and appreciation of ethical and societal implications and the impact of engineering solutions in a global context.
- Have a broad foundation in mechanical systems, thermal and fluids engineering, and electronics and controls; be able to apply their knowledge to the design of mechanical and thermal/fluids systems and devices; gain additional technical depth in one or more areas of concentration, such as aeronautics, applied energy systems, design optimization, dynamics, heat transfer and fluid mechanics, manufacturing, mechatronics, and mechanics of materials; and be familiar with basic laboratory techniques in mechanical and in thermal/fluids engineering; or
- Have a broad foundation in aerodynamics, aircraft structures, propulsion, and flight mechanics; be able to design and conduct experiments; and be familiar with basic numerical methods for engineering problems and the use of high-level computer software; or
- Develop and demonstrate the ability to apply relevant atomic and nuclear phenomena to nuclear and radiological systems and processes, conduct experimental investigations, and work on design projects so as to be prepared to work professionally in one or more of the nuclear or radiological fields of specialization identified by the nuclear engineering program; or
- Have a broad foundation in the application of engineering to physical systems and additional depth in one or more areas of concentration such as multiphase science, radiation technology, microelectronics, and applied mathematics; conduct experimental and analytical investigations and design projects; and develop the ability to work professionally in one or more of the areas of specialization identified by the engineering physics program.
Be motivated for continued intellectual growth and improvement in engineering skill beyond graduation.

Students may achieve these objectives through completion of the B.S. degree in mechanical engineering, aerospace engineering, nuclear engineering, or engineering physics. A variety of options are available to those pursuing the B.S., depending upon the specific degree program. These options, which include concentrations, minors, and/or dual majors are delineated within the following individual descriptions of each baccalaureate curriculum.

**Baccalaureate Programs**

Freshmen or sophomores who have identified mechanical, aerospace, nuclear engineering, or engineering physics as their major may follow the baccalaureate program below in lieu of the general core engineering program presented earlier. The total number of credit hours required to complete any of these curricula is 128. Dual major programs which lead to a single baccalaureate degree embracing two fields are also available and are described in more detail below.

**Mechanical Engineering Curriculum**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
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<td>4</td>
</tr>
</tbody>
</table>

| Second Year                              | Credit hours | Spring                              | Credit hours |
|------------------------------------------|--------------|                                     |              |
| **Fall**                                 |              |                                     |              |
| ENGR-2530 Strength of Materials           | 4            | ENGR-2050 Intro. to Engineering Design | 4            |
| MATH-2400 Intro. to Differential Equations| 4            | ENGR-2090 Engineering Dynamics       | 4            |
| PHYS-1200 Physics II                     | 4            | ENGR-2250 Thermal and Fluids Engineering I | 4        |
| Hum. or Soc. Sci. Elective               | 4            | Hum. or Soc. Sci. Elective           | 4            |
| CSCI-1190 Beginning C Programming for     |              |                                      |              |
| Engineers                                |              |                                      |              |

| Third Year                               | Credit hours | Spring                              | Credit hours |
|------------------------------------------|--------------|                                     |              |
| **Fall**                                 |              |                                     |              |
| ENGR-2600 Modeling and Analysis of       | 3            | ENGR-2350 Embedded Control           | 4            |
| Uncertainty                              |              | MANE-4050 Modeling and Control of    |              |
| ENGR-4300 Electronic Instrumentation     | 4            | Dynamic Systems                      | 4            |
| Mechanical Engineering Core Module       | 6            | Mechanical Engineering Core Module   | 6            |
| Hum. or Soc. Sci. Elective               | 4            | Professional Development II          | 2            |

1 These required courses may be taken in any order.
2 Alternative: ENGR-1310
3 Choice of Mechanical Design Module and Thermal and Fluids Module. Both modules are required for graduation; each module may be taken in either semester. The Mechanical Design Module consists of MANE-4030 and MANE-4040, taken concurrently. The Thermal and Fluids Module consists of MANE-4010 and MANE-4020, taken concurrently. Other third year courses may be taken in either semester.
4 This course will be fulfilled from a list published at the start of each semester. It must be completed before MANE-4260.
5 Course may be taken either semester.
Fourth Year

Credit hours

MANE-4260 Design of Mechanical Engineering Systems ............................................3
ENGR-4010 Professional Development III 6 ............1
Concentration Elective (Restricted) ........................................4
Concentration Elective (Restricted) ........................................4
Concentration Elective ........................................4
Concentration Elective ........................................4
Concentration Elective ........................................4
Free Elective 7 ......................................4
Free Elective ........................................4
Free Elective ........................................4

Concentrations
The mechanical engineering curriculum offers the following six concentration options.

Aeronautics
The focus is on the analysis, design, development, and operation of flight vehicles, which is fundamental for students interested in aeronautical engineering. This concentration provides a strong engineering and scientific foundation in fluid mechanics, thermodynamics, structural dynamics, vehicular mechanics, and control systems analysis. Student projects in recent years have involved spin preventions in fighter aircraft, trailing vortex dissipation, and helicopter maneuverability.

Applied Mechanics
This concentration provides the opportunity for fundamental study in fluid mechanics and solid mechanics. The objective is to develop broad analytical abilities and encourage critical inquiry. Programs in this area usually continue through the master’s level. Topics have included cellular heat convection, locally separated flow, and inelastic fatigue analysis and fracture. Biomechanics, especially the mechanics of musculoskeletal systems, is part of this concentration.

Design
The concern here is with design methodology in general and mechanical design techniques in particular, and is intended for mechanical engineering students interested in the design of machinery and mechanical systems. A student interested in the design of specialized mechanical equipment can develop a suitable program from courses in this and other mechanical engineering concentrations.

Energy Systems
This concentration is intended for those interested in energy conversion and the development of mechanical power. Students concerned with the design of equipment in this field should consider this concentration together with the design concentration. Those interested in the fundamentals should consider this concentration together with the applied mechanics concentration.

Manufacturing Concentration
This area is intended for the mechanical engineering student who is interested in manufacturing and is planning a career designing manufacturing equipment, developing new manufacturing techniques, or operating manufacturing facilities.

6 Can be taken either semester senior year.
7 Students are encouraged to select a life science course, such as BIOL-1010.
Space Technology
This is an inherently multidisciplinary area that is offered for students interested in the analysis, design, development, and operations required for space exploration and utilization. Current areas of particular emphasis include the space environment, propulsion, orbital and structural dynamics, structures and control.

Concentration Electives Criteria
Students wishing to obtain any one of these concentrations must adhere to strict concentration electives criteria as follows. The first two courses within the four-course concentration are highly restricted. The first of these should be selected from the courses listed below. These courses define the concentration areas available within mechanical engineering and are thus termed “concentration-defining” electives.

Applied Mechanics
- MANE-4670 Mechanical Behavior of Materials I
- MANE-4170 Machine Dynamics
- MANE-4610 Vibrations

Aeronautics
- MANE-4070 Aerodynamics I
- MANE-4060 Aerospace Structural Analysis

Design
- MANE-4280 Design Optimization
- MANE-4180 Mechanisms

Energy Systems
- MANE-4710 Advanced Heat Transfer
- MANE-4720 Design and Analysis of Energy Systems
- MANE-4800 Boundary Layers and Heat Transfer

Manufacturing
- MANE-4550 Analysis of Manufacturing Processes
- ENGR-4710 Advanced Manufacturing Laboratory I

Mechatronics
- MANE-4490 Mechatronics

The second of the restricted concentration elective courses may be chosen from either:

- A list of courses associated with the originally defined concentration area. Such courses will be termed “concentration-completing” electives. Through them, a student clearly identifies a concentration within the mechanical engineering major.

- The original short list of concentration-defining electives. Through these, a student obtains greater breadth within mechanical engineering.

Any student wishing to satisfy these restricted concentration elective requirements in another way may first consult with the adviser and then propose a plan to the associate chair in undergraduate studies for approval. Students are reminded to consult the catalog and the Class Hour Schedule for the availability of a particular course in any given semester.

The second two courses of the four-course concentration are to be selected from any upper-level (4000 or above) course in science, engineering, or mathematics. One of these may be an independent study course, such as a design project or an undergraduate research project. The second course should not normally be a project. However, the associate chair for undergraduate studies may grant approval for an exception based on a particularly valuable research experience.

Humanities or Social Sciences Electives
In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities 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 Product Design and Innovation (STS), and others. Further information is available in the departmental office.

## Aerospace Engineering Curriculum

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### Humanities or 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 and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences should consult the respective departments for specific course requirements.

1 These required courses may be taken in any order.
2 Alternative: ENGR-1310.
3 This course will be fulfilled from a list published at the start of each semester.
4 Can be taken either semester.
5 Choice of: MANE-4090, MANE-4100, or MANE-4200.
6 Choice of: MANE-4230, MANE-4850, or MANE-4860.
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. These students would choose ENGR-1600, ENGR-2350, ENGR-4300, and MANE-4040 as free electives. General requirements and procedures for dual degrees are described within the Academic Information and Regulations section of this catalog.

**Nuclear Engineering Curriculum**

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1 May be taken in any order in the first two semesters.

2 Students are encouraged to select a life science course, such as BIOL-1010.

3 Includes Professional Development I.

4 Any course in engineering or science at 4000 level or higher.

5 Can be taken either semester senior year.

6 MANE-4350 may be substituted for this course.
Concentrations
For more information on any of these concentrations, students should consult with their program adviser.

Reactor Physics
This area of concentration is intended for students who wish to develop expertise in the physics of nuclear power reactor cores. Topics such as reactor physics design, nuclear fuel management, and reactor startup physics tests are included.

Reactor Engineering
This area of concentration is intended for students who wish to develop a broad understanding of nuclear technology. Topics such as reactor thermal-hydraulics, reliability, safety and licensing, radioactive waste management, structural dynamics, and materials problems are included.

Health Physics
This area of concentration is intended for students who wish to develop expertise in the radiation safety aspects of nuclear power plant operations and the associated nuclear fuel cycle.

Nuclear Thermal Hydraulics
This area of concentration is intended for students who wish to develop an extended knowledge and the ability to apply principles of fluid mechanics and heat transfer in single-phase and multiphase gas-liquid systems to reactor engineering.

Nuclear Plant Operations and Management
This area of concentration is intended for students who wish to specialize in the operation and management of nuclear power plants. This concentration is directed toward students interested in careers with nuclear electric utility organizations.

Fusion Reactor Engineering
This area of concentration is intended for students who desire to develop expertise in the analysis, assessment, and design of fusion reactor power systems.

Humanities or Social Sciences Electives
In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities 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 and in Nuclear Engineering and Engineering Physics are available to students who follow prescribed programs that can be completed in eight semesters. Further information is available in the departmental office.

Minor Programs
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.
## Engineering Physics Curriculum

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### Concentrations

#### Radiation Applications

This area of concentration is intended for students who wish to develop expertise in various industrial and other applications of radiation, including radiation damage or enhancement of materials, nondestructive testing, etc.

1. May be taken in any order in the first two semesters.
2. Science Elective: ENGR-1600 or CSCI-1100 (C Programming not necessary after Computer Science I).
3. Students are encouraged to select a life science course, such as BIOL-1010.
4. Includes Professional Development I.
5. Any course in engineering or science at 4000 level or higher.
6. Can be taken either semester senior year.
7. MANE-4350 may be substituted for this course.
Radiation Effects on Electronics
This area of concentration is intended for students interested in using radiation techniques to create advanced solid-state electronic circuitry and/or those interested in understanding how optical/electronic devices respond to radiation.

Multiphase Science and Technology
This area of concentration is concerned with applications of fluid mechanics and heat transfer technology to the interactions between mixtures of gases, liquids, and solids.

Fusion Applications
This area of concentration deals with the development and engineering applications of plasmas and the analysis of advanced magnetic confinement and laser-driven fusion power systems.

Humanities or Social Sciences Electives
In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities 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 program in Engineering Physics and Nuclear Engineering is available to students who follow a prescribed program that can be completed in eight semesters. Further information is available in the departmental office.

Minor Programs
Students not majoring in engineering physics may receive a minor in this discipline by completing 15–16 credit hours of courses selected in consultation with the program adviser.

Special Undergraduate Opportunities
Program for Graduates of U.S. Navy Nuclear Power Training School
Rensselaer’s School of Engineering and its Department of Mechanical, Aerospace, and Nuclear Engineering, in cooperation with the Education for Working Professionals Office and the U.S. Navy, have developed undergraduate degree programs in nuclear engineering and engineering physics for graduates of the U.S. Navy Nuclear Power Training School. Currently, Rensselaer offers programs to personnel stationed at the Kesselring Site in West Milton, New York. These academic programs and resulting degrees are the same as those offered to on-campus students studying this discipline.

Designed to meet the needs of Navy personnel, this program delivers courses and degree programs at a time and place that is convenient to them. Student services are flexible and designed to accommodate the needs of working professionals. Services such as undergraduate admissions and registration are handled entirely by mail, phone, fax, or e-mail. Programs and classes are delivered to Rensselaer’s Malta Commons campus, just 20 minutes from the Kesselring Site. The course schedule developed for the program is coordinated with the shift work schedule of the Navy personnel.

The total number of credit hours required for the B.S. degree in either engineering science or nuclear engineering is 128. The curriculum is comprised of 104 engineering and science credits and four professional development credits. Navy students receive up to 31 credit hours of transfer credits for their Navy Nuclear Power Training School course work, leaving 97 credit hours to be completed at Rensselaer.
Courses from other accredited universities may also be considered for transfer. The following is a list of credit transfer courses for graduates of the U.S. Navy Nuclear Power Training School.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Transfer Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1300</td>
<td>Engineering Processes</td>
<td>1</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>USNA-1010</td>
<td>Military and Its Place in Society</td>
<td>1</td>
</tr>
<tr>
<td>USNA-2040</td>
<td>Naval Ship Systems</td>
<td>3</td>
</tr>
<tr>
<td>ENGR-2050</td>
<td>Intro. to Eng. Design with Prof. Development I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2940</td>
<td>Engineering Project</td>
<td>3</td>
</tr>
<tr>
<td>ENGR-2960</td>
<td>Topics in Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ENGR-4300</td>
<td>Electronic Instrumentation</td>
<td>4</td>
</tr>
<tr>
<td>MANE-4440</td>
<td>Critical Reactor Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>ENGR-4010</td>
<td>Professional Development III</td>
<td>1</td>
</tr>
<tr>
<td>MANE-2400</td>
<td>Fundamentals of Nuclear Engineering</td>
<td>4</td>
</tr>
</tbody>
</table>

The program has been divided into three trimesters (fall, spring, and summer) each calendar year. Students normally take three courses or 12 credit hours per trimester. Each trimester consists of approximately 15 weeks and averages a two-week break between any two consecutive trimesters. The total of 97 credits can usually be completed in two years plus seven to eight months.

Students with prior credits from other academic institutions may be eligible to transfer them to the present program. Rensselaer’s designated academic units are responsible for reviewing and approving such transfers. In addition, students may take a validation exam in selected subjects in place of some regular courses. Academic advisers provide advice and assistance in this regard.

Students must be in residence (i.e., enrolled as full-time students with a minimum of 12 credits per semester) for at least four semesters of their curriculum.

The academic director of this program is Michael Z. Podowski, and the program is administered through the Education for Working Professionals Office.

### 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 webpage, [http://www.rpi.edu/dept/mane/deptweb/index.html](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 courses from MANE (or courses that are cross-listed with MANE courses), and a minimum of 15 credits overall must be from MANE (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, 90 credits in addition to the bachelor’s or 60 credits in addition to the master’s degree are required. Usually, this means that 16 to 20 courses beyond the bachelor’s are needed, as specified by the adviser and the doctoral committee, in addition to residence and thesis requirements. 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

Program Coordinator: Ernesto Gutierrez-Miravete (ernesto@rh.edu)

Rensselaer at Hartford offers engineering curricula designed to accommodate the evolving needs of the practicing engineer. The 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 being awarded:

n Master of Engineering in Computer and Systems Engineering
n Master of Engineering in Electrical Engineering
n Master of Engineering in Engineering Science
n Master of Engineering in Mechanical Engineering
n Master of Science in Electrical Engineering
n Master of Science in Engineering Science
n Master of Science in Mechanical Engineering

Candidates for the master’s degree must complete an adviser approved plan of study consisting of:

n At least 30 credit hours beyond the bachelor’s degree with satisfactory grades.

n At least 18 of the total credit hours presented toward the degree must have the suffix numbers 6000–6990 or 7000–7990.

n At least 21 of the total credit hours presented towards the degree must be from courses taken within the discipline.

Students must prepare their plan of study together with their adviser and have it reviewed and approved by the adviser and the Program Coordinator 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. It may be fulfilled by any of the following:

n 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.

n 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.
General Engineering Requirements
Students entering the engineering programs are expected to hold a Bachelor of Science degree. Students not holding a degree in one of the traditional engineering disciplines must have evidence of course work 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 any of the engineering programs.

The Bachelor of Engineering Technology (BET) degree is not generally considered appropriate preparation for admission to master’s degrees and courses in engineering. Applicants with this degree may be required to do significant background repair and/or submit scores from the Graduate Record Examination Engineering test, along with the standard admissions credentials. Application forms for this test may be obtained from the Office of Admissions.

All students entering the engineering programs at Rensselaer at Hartford are expected to be familiar with one of the major higher level programming languages (FORTRAN, C, Pascal, Symbolic Manipulators, etc.).

A limited number of elective courses outside a specific engineering discipline may be taken and credited toward an engineering degree. The student’s faculty adviser must approve these elective courses.

Please contact Professor Ernesto Gutierrez-Miravete at ernesto@rh.edu if you have any general questions about the engineering programs.

Electrical Engineering
The Master’s Program in Electrical Engineering allows students to increase their competence in a number of Electrical Engineering subjects, particularly in Digital Communications and Digital Signal Processing, Control Systems, and Communication Networks.

Admission Requirements
Requirements for admission include an undergraduate degree in Electrical Engineering or a closely associated discipline from an accredited institution, a GPA in the upper quartile, and some work experience in a high-technology environment. Additional information on admissions may be found on the Engineering Programs Overview page and on the General Admissions page.

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
Specific background requirements for Electrical Engineering include:

- Advanced Mathematics (i.e., Complex Variables, Laplace Transforms, Fourier Analysis, Probability) (1 term)
- Electric Circuits (1 term)
Electronic Circuits (2 terms)
Signals and Systems (1 term)
Digital Logic (1 term)
Technical Design Elective (e.g., Communications Systems, Control Systems Engineering, Computer Networks) (1 term)

Students lacking any of the above courses must consult with their adviser to devise a plan for corrective action.

M.Eng. in Electrical Engineering Program Requirements
The Master’s degree is awarded on successful completion of the following:

Required Core (15 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-4500</td>
<td>Probability for Engineering Applications</td>
<td></td>
</tr>
<tr>
<td>ECSE-6400</td>
<td>Systems Analysis Techniques</td>
<td></td>
</tr>
<tr>
<td>ECSE-6560</td>
<td>Digital Communications Engineering</td>
<td></td>
</tr>
<tr>
<td>ECSE-6620</td>
<td>Digital Signal Processing</td>
<td></td>
</tr>
<tr>
<td>ECSE-6980</td>
<td>Engineering Project</td>
<td></td>
</tr>
</tbody>
</table>

Electives (15 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH-6230</td>
<td>Network Management</td>
<td></td>
</tr>
<tr>
<td>ECSE-4440</td>
<td>Control Systems Engineering</td>
<td></td>
</tr>
<tr>
<td>ECSE-4490</td>
<td>Fundamentals of Robotics</td>
<td></td>
</tr>
<tr>
<td>ECSE-4670</td>
<td>Computer Communication Networks</td>
<td></td>
</tr>
<tr>
<td>ECSE-6410</td>
<td>Robotics and Automation Systems</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-6630</td>
<td>Digital Image and Video Processing</td>
<td></td>
</tr>
<tr>
<td>ECSE-6660</td>
<td>Broadband and Optical Networking</td>
<td></td>
</tr>
<tr>
<td>ECSE-6960</td>
<td>Topics in E.E: Wireless Communications and Networks</td>
<td></td>
</tr>
<tr>
<td>ECSE-6960</td>
<td>Topics in E.E: LANs, MANs and Internetworking</td>
<td></td>
</tr>
<tr>
<td>ECSE-6960</td>
<td>Topics in E.E: Embedded Digital Control Systems</td>
<td></td>
</tr>
<tr>
<td>ECSE-6960</td>
<td>Topics in Electrical Engineering, Cryptography, and Network Security</td>
<td></td>
</tr>
<tr>
<td>ECSE-6960</td>
<td>Topics in Mechanical Engineering, Sensors and Actuators in Mechatronics</td>
<td></td>
</tr>
<tr>
<td>ECSE-6960</td>
<td>Topics in E.E: LANs, MANs and Internetworking</td>
<td></td>
</tr>
<tr>
<td>ECSE-7010</td>
<td>Real-Time Programming and Applications</td>
<td></td>
</tr>
<tr>
<td>MANE-6960</td>
<td>Topics in Mechanical Engineering, Sensors and Actuators in Mechatronics</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Specializations
From the elective courses currently available at Hartford, a three-course specialization can be constructed in any of the following areas:

- Digital Communications and Signal Processing
- Control Systems
- Communication Networks

M.S. in Electrical Engineering Program Requirements
The M.S. requirements are the same as those for the M.Eng. in Electrical Engineering, except for the substitution of a 6-credit-hour thesis (ECSE-6990) in place of one elective and the three-credit-hour project.

The student may propose other areas, but they are subject to adviser's approval.

Please contact Professor Farooque Mesiya at mesiya@rh.edu if you have any questions about the electrical engineering program.
Computer and Systems Engineering

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.

Admission Requirements

Students should have received a B.S. degree in Electrical Engineering, Computer Engineering, or Computer Science. Students with a B.S. degree in another engineering discipline, Mathematics or Physics, are subject to the condition that the following essential prerequisites (or their equivalents) for their chosen area of specialization have been completed:

Digital Communications and Signal Processing

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2010</td>
<td>Electrical Circuits</td>
</tr>
<tr>
<td>ECSE-2410</td>
<td>Signals and Systems</td>
</tr>
<tr>
<td>ECSE-2610</td>
<td>Computer Components and Operations</td>
</tr>
</tbody>
</table>

Computer Communications Networks

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2010</td>
<td>Electrical Circuits</td>
</tr>
<tr>
<td>ECSE-2410</td>
<td>Signals and Systems</td>
</tr>
<tr>
<td>ECSE-2610</td>
<td>Computer Components and Operations</td>
</tr>
</tbody>
</table>

Computer and Systems Engineering Program Requirements

The Master's degree is awarded on successful completion of the following:

Required Core (15 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-4500</td>
<td>Probability for Engineering Applications</td>
</tr>
<tr>
<td>ECSE-4670</td>
<td>Computer Communication Networks</td>
</tr>
<tr>
<td>ECSE-4440</td>
<td>Control Systems Engineering OR CSCI-4210 Operating Systems</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
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<tbody>
<tr>
<td>ECSE-4440</td>
<td>Control Systems Engineering</td>
</tr>
<tr>
<td>ECSE-4490</td>
<td>Fundamentals of Robotics</td>
</tr>
<tr>
<td>ECSE-4670</td>
<td>Computer Communication Networks</td>
</tr>
<tr>
<td>ECSE-6400</td>
<td>System Analysis Techniques</td>
</tr>
<tr>
<td>ECSE-6410</td>
<td>Robotics and Automation Systems</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 Engineering</td>
</tr>
<tr>
<td>ECSE-6630</td>
<td>Digital Image and Video Processing</td>
</tr>
<tr>
<td>ECSE-6660</td>
<td>Broadband and Optical Networking</td>
</tr>
<tr>
<td>ECSE-6770</td>
<td>Software Engineering I</td>
</tr>
<tr>
<td>ECSE-6780</td>
<td>Software Engineering II</td>
</tr>
</tbody>
</table>

Electives (15 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-6960</td>
<td>Topics in E.E.: Wireless Communications and Networks</td>
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<td>ECSE-6960</td>
<td>Topics in E.E. Embedded Digital Control Systems</td>
</tr>
<tr>
<td>ECSE-6960</td>
<td>Topics in E.E.: Cryptography and Network Security</td>
</tr>
<tr>
<td>ECSE-7010</td>
<td>Optical Fiber Communications</td>
</tr>
<tr>
<td>ECSE-7100</td>
<td>Real-Time Programming and Applications</td>
</tr>
<tr>
<td>MANE-6960</td>
<td>Topics in Mechanical Engineering Sensors and Activators</td>
</tr>
</tbody>
</table>
Specializations
From the courses currently available at Hartford, a three-course specialization can be constructed in any of the following areas.

- Digital Communications and Signal Processing
- Computer Communication Networks
- Robotics and Automation Systems
- Software Engineering

The student may propose other areas, but they are subject to adviser's approval.

Preparatory courses do not apply toward the minimum 30 credit hours required for the Master of Engineering degree.

Please contact Professor Farooque Mesiya at mesiya@rh.edu if you have any questions about the computer and systems engineering program.

Engineering Science
The Engineering Science curriculum serves students whose educational needs do not correspond to the standard professional engineering curricula. It allows students to tailor courses 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 have fulfilled the General Engineering Requirements noted above.

Please contact Professor Ernesto Gutierrez-Miravete at ernesto@rh.edu if you have any questions about the engineering science program.

Mechanical Engineering
The Master of Science in Mechanical Engineering allows 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.

Requirements for admission include an undergraduate degree in Mechanical Engineering or a closely associated discipline from an accredited institution, a GPA in the upper quartile and some work experience in a high technology environment. Detailed admission policies are also available on the internet at: www.rh.edu/engr/eng_admission.html.

Students with a B.S. degree in another engineering discipline, mathematics, or physics may be admitted subject to fulfillment of the following Mechanical Engineering Background Requirements

Mechanical Engineering Background Requirements

- Chemistry (One additional term)
- Statics (One term)
- Dynamics (One term)
- Strength of Materials (One term)
- Fluid Mechanics (One term)
Students lacking any of the above courses must work closely with their adviser to devise plans for corrective action.

**Mechanical Engineering Program Requirements**

The Master’s degree is awarded on successful completion of the following:

**Required Core (15 credits)**

- MANE-5000 Advanced Engineering Math I
- MANE-7000 Advanced Engineering Math II
- MANE-5100 Mechanical Engineering Foundations I (Thermo-Fluids)
- MANE-7100 Mechanical Engineering Foundations II (Solids-Materials)
- MANE-6980 Engineering Project

Electives from any of four Concentration Areas (15 credits)

**SOLIDS**

- MANE-4240 Introduction to Finite Elements
- MANE-4610 Vibrations
- MANE-4650 Fracture Mechanics
- MANE-6180 Mechanics of Composite Materials
- MANE-6200 Plates and Shells
- MANE-6960 Advanced Topics in Finite Element Analysis

**THERMAL SYSTEMS**

- MANE-6540 Advanced Thermodynamics
- MANE-6630 Conduction Heat Transfer
- MANE-6640 Radiation Heat Transfer
- MANE-6650 Convection Heat Transfer
- MANE-6840 An Intro to Multiphase Flow and Heat Transfer
- MANE-6830 Combustion

**FLUIDS**

- MANE-4800 Boundary Layers and Heat Transfer
- MANE-5060 Introduction to Compressible Flow
- MANE-5080 Turbo machinery
- MANE-6530 Turbulence
- MANE-6530 Theory of Compressible Flow
- MANE-6720 Computational Fluid Dynamics

**MANUFACTURING AND MATERIALS**

- MTLE-4260 High Temperature Alloys
- DSES-6110 Introduction to Applied Statistics
- MTLE-6960 High Temperature Coatings Engineering
- MTLE-7061 Casting and Joining Processes

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 emesto@rh.edu if you have any questions about the mechanical engineering program.
Graduate Certificate in Control Systems

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 offers a Certificate of Advanced Studies 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.

The Certificate of Advanced Graduate Studies in Control Systems is awarded on successful completion of the following courses:

Core Courses (6 credits):
- ECSE-4440 Control Systems Engineering
- ECSE-6400 Systems Analysis Techniques

Elective Courses (Any two, 6 credits)
- ECSE-4490 Fundamentals of Robotics
- ECSE-6420 Nonlinear Control Systems
- ECSE-6440 Optimal Control Theory
- ECSE-6460 Multivariable Control Systems
- MANE-6960 Sensors and Actuators in Mechatronics
- ECSE-6960 Special Topics in Electrical Engineering, Embedded Digital Control Systems
- ECSE-6480 Adaptive Systems

Academic credit earned from these courses can then be applied towards a Master's degree.

Please contact Professor Farooque Mesiya at mesiya@rh.edu if you have any questions about the Control Systems Certificate Program.

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 offers a Certificate of Advanced Graduate Studies 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.

The Certificate of Advanced Graduate Studies in High-Temperature Materials is awarded on successful completion of the following courses:

MTLE-4260 High-Temperature Alloys
MTLE-6960 High-Temperature Coatings Engineering
MTLE-7061 Casting and Joining Processes

Academic credit earned from these courses can then be applied towards a Master's degree.

Please contact Professor Ernesto Gutierrez-Miravete at ernesto@rh.edu if you have any questions about the High-Temperature Materials Certificate Program.
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 below, 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.

Engineering Science

Chair: Richard N. Smith (Interim)

Rensselaer’s graduate Engineering Science program serves students whose educational desires do not correspond to the standard professional engineering curricula. Although no B.S. degree is offered in Engineering Science, 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 who are pursuing their program of study through the Education for Working Professionals core enterprise (either Distance Learning or 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 and social sciences. The general requirements for the Ph.D. in Engineering Science may be found in the Catalog chapter 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.
Product Design and Innovation

**Chair:** Mark W. Steiner (Interim)

**Chair:** Sharon Anderson-Gold (Interim)

This dual major program, which the Schools of Engineering and Humanities and Social Sciences offer jointly, satisfies the requirements for the Bachelor of Science programs in both Mechanical Engineering and Science, Technology, and Society (STS). Product Design and Innovation (PDI) prepares students to become innovative designers who will develop and design the advanced products and technologies needed in the future. Built around a design studio every semester, PDI combines the technical sophistication of Rensselaer’s engineering curriculum with the insight and vision of the humanities and social science disciplines in the STS curriculum.

The design studio that students take every semester is the PDI core, which gives them a hands-on opportunity to bring together the two major curricula. The engineering curriculum provides a fundamental education in engineering science through basic courses in engineering mechanics, engineering electronics, energy, materials, and manufacturing. The STS curriculum provides a fundamental education in the economic, ethical, cultural, and political dimensions of product development and innovation, including numerous case studies of successes and failures that help students learn what it takes to be effective leaders of design teams. Through the design studios, students explore and develop their creativity while building a portfolio of design experiences continuously throughout all four years.

The design experiences range from larger systemic problems to smaller focused problems, so that students have broad exposure to different applications of design practice. Some fall and spring semester studios are taught as a sequence to give students experience with the design process from beginning to 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.

PDI graduates are thus uniquely prepared to put their creativity to work as leaders of design and innovation, whether in a multinational business at the cutting-edge of the global market or in a smaller business that creates an unusual solution to a local problem. They are able to function effectively in the new situations and unfamiliar environments of a multicultural global society, to collaborate with diverse constituencies to analyze and formulate problems of varying complexities, and to work individually and in teams to develop truly innovative and powerful solutions to challenges affecting this country’s continued prosperity and social well-being. Programs corresponding to PDI are described in the School of Architecture and the Humanities and Social Sciences STS Department sections of this catalog.
# Product Design and Innovation Curriculum

## First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-2200 Design Studio I</td>
<td>4</td>
</tr>
<tr>
<td>STSH-1110 Introduction to STS (First-Year Studies)</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1011 Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1500 Chemistry of Materials I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1200 Engineering Graphics and CAD</td>
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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2020 PDI Studio II</td>
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</tr>
<tr>
<td>ENGR-1100 Introduction to Engineering Anal.</td>
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</tr>
<tr>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1300 Engineering Processes</td>
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<tr>
<td>STSS-2960 Design Culture and Society</td>
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## Second Year

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>IHSS-2500 Design Studio III</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1600 Materials Science for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>MATH-2400 Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1100 Physics I for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1190 Programming</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2050 Intro. to Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2530 Strength of Materials</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2090 Engineering Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1200 Physics II for Engineers</td>
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</table>

## Third Year

<table>
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<th>Fall</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>ARCH-4960 Design Studio V</td>
<td>4</td>
</tr>
<tr>
<td>STSS-4xxx STS Advanced Option</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2710 General Manufacturing Processes</td>
<td>3</td>
</tr>
<tr>
<td>ENGR-2350 Embedded Control</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2600 Modeling and Analysis of Uncertainty</td>
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<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>ENGR-4960 Design Studio VI</td>
<td>4</td>
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<tr>
<td>STSS-4xxx STS Advanced Option</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-4050 Modeling and Control</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2550 Thermo/Fluids Engineering I</td>
<td>4</td>
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</table>

## Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANE-4260 Design of Mechanical Systems</td>
<td>3</td>
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<tr>
<td>MANE-4030 Elements of Mechanical Design</td>
<td>4</td>
</tr>
<tr>
<td>MANE-4040 Mechanical Systems Lab</td>
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<tr>
<td>MANE-4908 STS Senior Project</td>
<td>4</td>
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<tr>
<td>STSS-4800 Public Service Internship</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>MANE-4980 PDI Capstone Project</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-4300 Electronic Instrumentation</td>
<td>4</td>
</tr>
<tr>
<td>MANE-4010 Thermo Fluids Engr. II</td>
<td>4</td>
</tr>
<tr>
<td>MANE-4020 Thermo Fluids II Lab</td>
<td>2</td>
</tr>
<tr>
<td>ENGR-4010 Professional Development III</td>
<td>1</td>
</tr>
</tbody>
</table>

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1. These courses may be taken in any order.
2. PDI II, V, VI, and GMP satisfy the mechanical engineering requirement for the concentration electives in Product Design and Innovation.
3. For PDI students, IHSS-2500 can be used as a substitute for the second-year requirement in the STS area option.
4. PDI II, V, VI, and GMP satisfy the mechanical engineering requirement for the concentration electives in Product Design and Innovation.
5. Candidate courses include STSS-4350; STSS-4960; STSS-4960; STSS-4230; STSS-4110; STSS-4250; STSS-4310; STSS-4560; and STSS-4650.
6. This course satisfies the requirement for Professional Development II.
7. The STS Senior Project can be combined with the PDI Capstone Design Studio to make an 8-credit capstone studio project. Coordination should be done with your PDI adviser.
Interdisciplinary Research Centers

Center for Earthquake Engineering Simulation

**Director:** Ricardo Dobry  
**Associate Director:** Tarek Abdoun  
**Assistant Director for Training and Outreach:** Thomas Zimmie

The Center for Earthquake Engineering Simulation is part of NEES (Network for Earthquake Engineering Simulation), an 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. Between 2000–04, the National Science Foundation (NSF) invested more than $80 million to construct the Collaboratory. Today it includes 15 experimental sites or "nodes" plus the UC San Diego Supercomputer Center and the NEES Consortium located in Davis, CA. Rensselaer is a node in NEES network and a partner in the node at Cornell University. As a result of Rensselaer’s designation as a node, the campus-based 150 g-ton geotechnical centrifuge facility was upgraded and expanded. The facility is now home to tele-participation tools including state-of-the-art telecontrol and teleconference rooms enabling researchers to conduct real-time experiments between Rensselaer and other NEES experimental and computational facilities via high-speed internet connections. The Center for Earthquake Engineering Simulation is also home to a 1 g seismic shaking table, 1.6 m x 2.6 m in plan, that is primarily utilized for structural engineering research.

As part of a 10-year initiative started in October of 2004, NEES facilities will be used in innovative earthquake research, including use of the CEES by Rensselaer faculty and outside researchers working on campus, or via tele-participation tools. To date, Rensselaer, in partnership with Cornell, has already received one of the coveted 10 initial NEES research grants. This grant is supporting a 4-year project on buried pipelines subject to permanent ground deformation, such as at fault crossing locations. In addition, a number of other currently supported research projects focus on:

- the development of wireless sensors and sensor networks to measure ground accelerations and deformations in both lab and field,
- the seismic response of pile foundations to liquefaction,
- the effect of blasting on earth embankments,
- the numerical modeling of soil compaction using micro mechanics, and
- the development of additional tools for existing in-flight centrifuge robot
- the numerical modeling and analysis of metal buildings subjected to seismic loads.

**Affiliated Faculty**
T. Abdoun, A. Abouzeid, S. Derby, R. Dobry, M. O’Rourke, M. Symans, M. Zeghal, T. Zimmie
Flexible Manufacturing Center

Co-Directors: Stephen J. Derby, Raymond H. Puffer, Jr.

FMC Home Page: http://www.fmc.rpi.edu

The mission of the Flexible Manufacturing Center (FMC) is to conduct research and education related to modular, flexible manufacturing systems and processes. An increasingly competitive global environment has led to ever shorter product life cycles. Flexible manufacturing systems and processes are necessary to cost effectively produce under these conditions. Flexibility during process operation accommodates a broad product mix, while flexibility in overall system design will accommodate product and process reconfiguration and redeployment. The FMC has also been involved with many projects dealing with materials that are themselves flexible.

The objectives of the FMC are to: develop solutions for manufacturing research problems using a team of interdisciplinary scientists and engineers; provide both graduate and undergraduate students with a unique educational opportunity to conduct R&D and gain experience solving industrially relevant problems and prepare them to “hit the ground running” in key technical positions in industry; advance state-of-the-art in flexible, energy efficient & environmentally friendly manufacturing processes; develop underpinning technologies required to support manufacturing a flexible product mix with short cycle times; serve as a model for industry/university/government partnership to solve societal problems; and build long-term relationships with clients of all sizes to become their “manufacturing and process R&D lab.”

Current research projects include; manufacturing processes and systems for high temperature proton exchange membrane fuel cell components; automation of pattern assembly for investment casting; automated handling of contact lenses during manufacture and inspection; vision based inspection of contact lenses; material handling of limp and viscous materials; laser processing of flexible materials; and peak load management systems development. FMC researchers have also conducted numerous short term projects for manufacturers in collaboration with the NASA Space Technology Outreach Program (SATOP).

Affiliated Faculty/Staff:

Center for Image Processing Research

Director: William A. Pearlman

Associate Director: John W. Woods

CIPR Home Page: http://www.cipr.rpi.edu

The Center for Image Processing Research (CIPR) conducts a range of research and academic programs in image and video processing. Faculty participants represent a number of academic disciplines and, together with their students, provide the nucleus for ongoing activities within CIPR. In addition to providing an intellectual focus for image-processing activities at Rensselaer, the objectives are to provide a positive impact on graduate and undergraduate programs, to support ongoing activities with a world-class infrastructure, and to enhance its reputation as one of the world’s premier image-processing research centers. Current CIPR research areas include image modeling, computer vision and image analysis, document analysis and processing, image and video enhancement and reconstruction, biomedical image
processing, computer graphics, computational geometry, image and video compression and transmission, virtual video synthesis, visualization and display techniques, and multimedia systems. The CIPR has administrative authority over and shares infrastructure with the NSF Industry/University Center for Next Generation Video (CNGV) and the NSF Engineering Research Center for Subsurface Sensing and Imaging System (CenSSIS) at Rensselaer. These centers have some joint research programs with CIPR, but otherwise operate independently of CIPR.

**Affiliated Faculty**

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**Center for Infrastructure and Transportation Studies**

**Director:** George F. List  
**Director of Research:** William A. Wallace  
**Senior Research Associate:** Donald N. Geoffroy  
**CITS Home Page:** [http://www.rpi.edu/dept/cits](http://www.rpi.edu/dept/cits)

The Center for Infrastructure and Transportation Studies (CITS) provides a focal point for campus research addressing the world’s infrastructure and transportation needs. CITS also assists in coordinating all related pedagogical initiatives. About 15 faculty across the Institute participate.

The Center’s research program focuses on five themes: intelligent transportation systems, information technology, deployment, and application, network analysis and control, asset management, and advanced materials. Each aspect of the life cycle for infrastructure and transportation systems is of interest—planning, analysis, design, maintenance, operation, preservation, restoration, and renewal. Common infrastructure focal points are roadways, bridges, and power distribution networks.

Projects currently under way include wireless ATIS systems, incident management systems, critical infrastructure interdependencies, investment planning for multimodal freight networks, capacity analyses for highway facilities, multilayer network modeling, and advanced concrete technologies. The pedagogical activities include course material development in the areas of intelligent transportation systems and asset management.

**Affiliated Faculty**

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**Center for Multiphase Research**

**Director:** Michael Z. Podowski  
**CMR Home Page:** [http://www.ne.rpi.edu/cmr](http://www.ne.rpi.edu/cmr)

In this country, Rensselaer’s interdisciplinary Center for Multiphase Research (CMR) is the premier research center of its kind. The CMR has assembled a large and dynamic group of scientists and engineers dedicated to exploring and exploiting new developments in every conceivable aspect of multiphase flow
and heat transfer technology. The CMR coordinates the diverse activities of these researchers and facilitates the cross-disciplinary exchange of information as well as technology transfer to industry.

Multiphase flow occurs in any physical process or industrial system involving more than one phase (solids, liquids, and vapors). Multiphase flow and related heat transfer technology are the keys to increasing the productivity and efficiency of many American industries. Indeed, this technology underlies our understanding of crystal growth, foundry casting, high-power density electronic cooling, chemical processing, petroleum refining, and slurry and pneumatic transport. Multiphase technology also has basic applications to aircraft wing icing, deep-sea mining, aseptic food processing, pharmaceutical manufacturing, refrigeration and air conditioning, chemical and nuclear reactor safety, foam production, aerosols, particulate erosion, combustion, processing and propulsion in outer space, enhanced petroleum recovery and bioreactors. Moreover, there are many important defense applications for this technology.

Historically, multiphase flows have been analyzed empirically. As a result, these analyses necessarily included many uncertainties and inaccuracies. Thus, the design and operation of phase change equipment had to include large margins. Recent developments in supercomputing, symbolic manipulator algorithms, diagnostic instrumentation, and applied mathematics have driven revolutionary changes in scientists’ ability to understand and predict multiphase flow phenomena.

The research activities of the CMR involve faculty, staff, and graduate students of many backgrounds who work synergistically on relevant multiphase research. Some typical research projects are:

- Conducting crystal growth experiments in outer space.
- Developing state-of-the-art laser optical diagnostic system for measuring multidimensional phenomena.
- Developing CFD models of multiphase flows.
- Predicting critical heat flux (CHF) using first principle models.
- Understanding instability phenomena in various phase change systems.
- Investigating laser materials processing, thin film behavior, and ultrahigh boiling heat fluxes.
- Imaging interfacial structures in gas/liquid flows.
- Assessing the consequences of hypothetical nuclear reactor accidents.

The members of the center represent a broad spectrum of science and engineering disciplines and have access to a wide variety of equipment and computational power.

**Affiliated Faculty**

**Center for Subsurface Sensing and Imaging Systems**

**Director:** Badrinath Roysam

**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**

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School of Humanities and Social Sciences

Dean: John P. Harrington

Associate Dean of Undergraduate Programs and Curriculum Initiatives: C.L. Odell

Associate Dean of Graduate Programs and Research Initiatives: (vacant)

Director of Student Services: Elizabeth Large

Director of Program Development: Dean Button

Director of External Communication: Donald Moore

School of Humanities and Social Sciences Home Page: http://www.hss.rpi.edu

In an historic technological institution, the Rensselaer School of Humanities and Social Sciences (H&SS) 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 H&SS offer unique opportunities for study of the technological world, its impact on society, and its potential contributions to social, cultural, and artistic goals. All H&SS 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.

H&SS 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); Minds and Machines; Product Design and Innovation (PDI); and Ecological Economics, Values, and Policy (EEVP).


**Degrees Offered and Associated Departments**

Communication

Communication and Rhetoric

Ecological Economics

Ecological Economics, Values, and Policy

Economics

Electronic Arts

Electronic Media, Arts, and Communication

Minds and Machines

Philosophy

Product Design and Innovation

Psychology

Science, Technology, and Society

Science and Technology Studies

Technical Communication

Language, Literature, and Communication

Economics

Interdisciplinary

Arts

Interdisciplinary

Cognitive Science

Interdisciplinary

Science and Technology Studies

Language, Literature, and Communication

Overview of Undergraduate Programs

Individual departments in the School of Humanities 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. H&SS 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 H&SS section of this catalog.

- **Electronic Media, Arts, and Communication (EMAC)** – The departments of Arts and of Language, Literature, and Communication (LL&C) offer this B.S. degree, which combines theory and practice through electronic media arts studio and theory courses.

- **Ecological Economics, Values, and Policy (EEVP)** – The departments of Economics and of Science and Technology Studies (STS) offer this B.S. degree. It combines ecological economics, environmental policy studies, and social and cultural theory and practice.

- **Minds and Machines (M&M)** – This B.S. degree based in the department of Cognitive Science includes substantial hands-on and research-based work in artificial intelligence, psychology, cognitive science, logic, and philosophy.

- **Product Design and Innovation (PDI)** – This innovative design program offers a dual major with three possibilities, Mechanical Engineering and STS, Engineering Science and STS, or Building Sciences and STS. This program combines engineering or architectural disciplines, STS courses, and design studios.
In all curriculum areas, H&SS 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.

**H&SS Core Program**

As part of their B.S. degree program, all Rensselaer undergraduates take a selection of H&SS courses referred to as the H&SS 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 H&SS 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>Code</th>
<th>Social Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANG</td>
<td>Economics</td>
</tr>
<tr>
<td>LITR</td>
<td>Science and Technology Studies, Social Science</td>
</tr>
<tr>
<td>COMM</td>
<td>Psychology</td>
</tr>
<tr>
<td>WRIT</td>
<td>Interdisciplinary Studies</td>
</tr>
<tr>
<td>ARTS</td>
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<tr>
<td>PHIL</td>
<td></td>
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<tr>
<td>STSH</td>
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<tr>
<td>IHSS</td>
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</tbody>
</table>

H&SS interdisciplinary courses may be substituted for courses in either category.

To ensure depth in the H&SS 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 H&SS courses may be applied toward the H&SS 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 H&SS courses (up to eight credit hours) toward their H&SS 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 H&SS curriculum adviser.

Transfer students entering Rensselaer at the sophomore level or above are not limited in the number of courses they may transfer for H&SS core credit. All others must take at least 16 credit hours of their H&SS core at Rensselaer.

Enrolled Rensselaer students wishing to take an H&SS 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 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 H&SS, 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, H&SS 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 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.
The Arts

Chair: Kathy High

Director of Graduate Studies: Tomie Hahn

Director of iEAR Studios: Branda Miller

Department Home Page: http://www.arts.rpi.edu/

The Department of the Arts offers a B.S. in Electronic Arts and a graduate program leading to an M.F.A. in Electronic Arts. Also offered jointly with the Department of Language, Literature, and Communication is a B.S. in Electronic Media, Arts, and Communication.

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 build the 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, and acting, the department offers courses in electronic media including digital video, computer imaging and animation, interactivity, virtual reality, multimedia installation, and computer music.

Rensselaer’s Master of Fine Arts offers a unique emphasis on integrating a variety of electronic arts disciplines into a single curriculum. Building upon undergraduate backgrounds in music composition or the visual arts, this program provides professional-level training in a technologically sophisticated artistic environment. The 60-credit degree emphasizes developing creative skills in digital video, computer music, imaging, animation, interactive media, performance, and installation art.

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 whose works are represented internationally in museums, galleries, and performances.

Arts students 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. program may use elective credits to explore Rensselaer’s extensive technological resources. Numerous opportunities to engage in creative or research projects with students or faculty from other departments or schools within the Institute are also available.

Faculty*

Professors

Canier, C.—M.F.A. (Boston University); painting, drawing.

Century, M.—M.A. (University of California, Berkeley); musicology, music composition, improvisation, and performance.

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.

* 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 2005 Board of Trustees meeting.
Rolnick, N.—Ph.D. (University of California, Berkeley); music composition, electronic and computer
music, electronic arts.

Distinguished Research Professor of Music
Oliveros, P.—Honorary Dr. of Music (University of Maryland, Baltimore County); music composition,
electronic music, improvisation.

Associate Professors
Bahn, C.—Ph.D. (Princeton University); computer music and interactive performance.
Hahn, T.—Ph.D. (Wesleyan University); ethnomusicology, Japanese & contemporary music and dance,
choreography.
High, K.—M.A.H. (SUNY-Buffalo, Center for Media Study): video, film, photography/production
and theory.
Ruiz, K.—M.A. (New York University); interactive simulation, game studies, digital photography, and
emerging multidisciplinary genres.
Staniszewski, M.—Ph.D. (Graduate School and University Center, City University of New York);
art history and critical theory.
Vamos, I.—M.F.A. (University of California at San Diego); video, film production and theory.

Assistant Professors
Bustamante, N.—M.F.A. (San Francisco Art Institute); new genres, performance art, video, installation.
Lawson, S.—M.F.A. (School of the Art Institute of Chicago); animation, virtual reality, interactive
installation.
Thornton, K.D.—M.F.A. (School of the Art Institute of Chicago); art and technology, installation/new
media/sculpture.

Clinical Professors
Gibson, D.—M.M. (Yale School of Music); music history and theory, orchestra performance, cello.
Shur, P.—Ph.D. (St. Petersburg Institute of Theatre, Music and Film); theatre.

Undergraduate Programs
At Rensselaer, the Department of the Arts offers bachelor's degree programs in Electronic Arts, Information
Technology-Arts, and Electronic Media, Arts, and Communication (EMAC). Information and
requirements specific to each program are described below.

Baccalaureate Programs
As explained in the Humanities 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, and CSCI-1100 Computer
Science or CSCI-1010 Introduction to Computer Programming. MATH-1010 Calculus I and MATH-
1020 Calculus II may be substituted for MATH-1500 and MATH-1620, respectively. To ensure depth in
their science core, students must take at least two four-credit courses within a single area other than
mathematics. One-credit courses that are graded satisfactory/unsatisfactory do not satisfy science
requirements. For more information, see a departmental adviser.

Electronic Arts Curriculum
The B.S. degree in Electronic Arts allows students to pursue an arts degree that particularly emphasizes
the use of technology and an interdisciplinary approach to electronic arts, including computer music,
interactivity, video, computer imaging, animation, net art, multimedia installation, and performance art. The
degree is designed for students who aspire to be artists and are also strong in math, science, and technology.
The program prepares students for careers in which technology is used in producing works of art and music. It also prepares students for graduate studies in the electronic arts. The program integrates an intensive curriculum of studio and theory courses in electronic and traditional arts and music with Rensselaer’s rigorous core requirements in math and science. Situated within the context of a technological university, Rensselaer’s arts program offers a unique creative environment in which to develop and realize electronic art.

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 an applicant’s best work in any medium, such as drawings, paintings, photographs, slides, CD-ROMS, DVDs, video and audio recordings, music scores, and digital images.

Once accepted into the program, an undergraduate electronic arts student can expect to follow a program of courses similar to the following.

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>ARTS-1010</td>
<td>Media Studio: Video/Audio^1 4</td>
<td>ARTS-1020</td>
<td>Media Studio/Imaging 4</td>
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<tr>
<td>ARTS-1200</td>
<td>Basic Drawing 4</td>
<td>MATH-1620</td>
<td>Contemporary Ideas in Math 4</td>
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<td>or</td>
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<td>H&amp;SS Elective 4</td>
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<tr>
<td>ARTS-2220</td>
<td>Fundamentals of 2-D Design 4</td>
<td>ARTS-1400</td>
<td>Music Fundamentals 4</td>
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<td>IHSS-196x</td>
<td>Humanities Elective/First Year Studies 4</td>
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<tr>
<td>MATH-1500</td>
<td>Calc. I for H&amp;SS 4</td>
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### Second Year

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<th>Credit hours</th>
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<tr>
<td>ARTS-2010</td>
<td>Intermediate Video^1 4</td>
<td>ARTS-2020</td>
<td>Computer Music 4</td>
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<tr>
<td>ARTS-2540</td>
<td>The Multimedia Century^1 4</td>
<td>ARTS-2030</td>
<td>Net Art 4</td>
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<tr>
<td>ARTS-2040</td>
<td>Intermediate Digital Imaging^1 4</td>
<td></td>
<td>Math/Science Elective 4</td>
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<tr>
<td>CSCI-1100</td>
<td>Computer Science 4</td>
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<td>Humanities Elective 4</td>
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<tr>
<td>(or CSCI-1010 Intro. to Computer Programming)</td>
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### Third Year

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<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Professional History/Theory Elective 4</td>
<td>ARTS-4710</td>
<td>Technical Production and Documentation 4</td>
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<tr>
<td>Professional Elective in Studio 4</td>
<td></td>
<td>Professional Elective in Studio 4</td>
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<td>Humanities/Social Science Elective 4</td>
<td></td>
<td>Social Science Elective 4</td>
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<tr>
<td>Math/Science Elective 4</td>
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<td>Math/Science Elective 4</td>
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### Fourth Year

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<th>Spring</th>
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<tr>
<td>ARTS-xxxx</td>
<td>Senior Capstone 4</td>
<td>Senior Capstone 4</td>
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<tr>
<td>Professional History/Theory Elective 4</td>
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<td>Free Elective 4</td>
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<tr>
<td>Free Elective 4</td>
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<td>Free Elective 4</td>
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</tbody>
</table>

^1 These courses may be taken in any order.

^2 These courses may be taken in reverse order.
Information Technology—Arts Curriculum
The Information Technology 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.

Electronic Media, Arts, and Communication (EMAC) Curriculum
This joint B.S. degree is earned from both the Department of the Arts and the Department of Language, Literature, and Communication. As such, it is interdisciplinary in nature and is therefore described in detail under the heading Interdisciplinary Programs and Research at the end of the Humanities and Social Sciences section of this catalog.

Minor Programs
Music
A music minor consists of 16 credits from the music curriculum. All music minors must take ARTS-2400 Music Theory I. The remaining credits may be filled by courses in music history, theory, jazz, computer music, world music, and performance ensembles. Up to eight ensemble credits may be applied toward the music minor.

Studio Arts
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.

Professional Electives in History/Theory (eight credit hours required)
ARTS-2220 Fundamentals of 2-D Design
ARTS-2400 Music Theory I
ARTS-2500 History of Western Music
ARTS-2510 History of Jazz
ARTS-2560 The American Musical
ARTS-4100 Electronic Art Theory Seminar (various topics)
ARTS-4400 Music Theory II
Additional, appropriate History/Theory offering from other departments will be determined each semester.

Professional Electives in Studio (eight credit hours required)
ARTS-2210 Sculpture I
ARTS-2600 Acting I
ARTS-4010 Interactive Arts Programming
ARTS-4020 Advanced Digital 3-D Projects
ARTS-4060 Animation I
ARTS-4070 Animation II
ARTS-4200 Advanced Drawing
ARTS-4210 Sculpture II
ARTS-4220 Painting
ARTS-4620 Theatre Performance
ARTS-496x Performance Art
Electronic Arts
An electronic arts minor consists of 16 credits from the electronic arts curriculum. These should include at least one or two Media Studio courses (ARTS-1010 or ARTS-1020), one art history or theory course, and one or two 2000-level or 4000-level electronic arts studio courses.

Special Undergraduate Opportunities
Visiting Artists Series
The Department of the Arts supports the iEAR Presents! series which brings leading composers, performers, 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 Troy area.

Ensembles
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. The department offers one-credit ensembles that may be applied toward the music minor: Rensselaer Orchestra, Rensselaer Concert Choir, Jazz Ensemble, Percussion Ensemble, and Ghanaian Drumming Ensemble.

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. In addition to the standard transcripts, recommendations, and statement of background and goals, prospective students submit a portfolio of creative work. 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 form of this creative work may include musical compositions and performances, videotapes and installations, multimedia presentations, performance art, and computer-generated or mediated images. 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 degree¹, including:

- at least 30 credit hours in 6000-level courses
- three history or theory courses at the 4000 or 6000 level, one of which must be:²
  - ARTS-6110 Electronic Arts Overview
- a demonstration of competency in interdisciplinary electronic arts³
- four credits of artistic residency through Arts Practicum (ARTS-4050)
- enrollment in Electronic Arts Practice or Thesis every semester of residency⁴
- one to nine credits of Master’s Thesis
- required public presentation and participation in critiques at the end of each semester

**Course Descriptions**

Courses related to all Arts curricula are described in the Course Descriptions section of this catalog under the department code ARTS.

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¹ Individual requirements can be waived, in exceptional circumstances, by the department without decreasing the total number of credits for the degree. It is also possible to reduce the total number of credits required by transferring up to six credits of previous graduate work or by waiving up to 12 credits of which can be graduate transfer credit.

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 by enrolling in Thesis supervision credits rather than Arts-6080.

⁴ All levels of Arts-6080 and Thesis supervision meet together in a weekly three hour seminar format, which is required of all students in residence. When enrolled for 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. The maximum number of thesis credits in which a student can enroll is nine.
Cognitive Science

Chair: Selmer Bringsjord

Director, Minds and Machines Program: Rensselaer’s Undergraduate Program in Cognitive Science: Bram van Heuveln

Director, Graduate Program in Cognitive Science: Wayne D. Gray

Director, Undergraduate Advising, Philosophy: Michael J. Zenzen

Director, Undergraduate Advising, Psychology: Brett R. Fajen

Department Home Page http://www.cogsci.rpi.edu

Cognitive Science is broadly defined as the study of the mind/brain, how it is structured, how it functions, and how it can be represented and simulated. It is theoretically grounded in cognitive psychology, neuroscience, logic, and philosophy of knowledge and mind. Its practical applications include artificial intelligence, cognitive engineering and human factors, cognitive modeling, perception and action, and psychopharmacology.

At the graduate level, the department is committed to the concept of integrated cognitive systems. Specifically, research and teaching falls into areas that together cover low- to high-level cognition, whether in minds or machines:

- Reasoning (Human and Machine)
- Computational Cognitive Modeling
- Cognitive Engineering
- Perception and Action

Modern research facilities, including the CogWorks Laboratory, Interactive and Distance Education Assessment (IDEA) Laboratory, Rensselaer Artificial Intelligence and Reasoning Laboratory (RAIR Lab), Vision and Action Lab, and dedicated space in the Institute’s new Social and Behavioral Research Laboratory, provide a new expression of the Department’s interests in cognitive science that integrates the diverse research activities of the faculty in the Department. At the graduate level, our goal is to prepare our doctoral graduates for careers as researchers in four related areas within cognitive science: computational cognitive modeling, reasoning and decision-making, perception and action, and cognitive engineering.

Our new Ph.D. in Cognitive Science was approved by the State of New York in 2003. For information and guidance about applying to this new Ph.D., please contact Betty Osganian, Student Services Administrator at the undergraduate and graduate levels at osgane@rpi.edu or Paul Bauer, Director of Graduate Enrollment Programs, Enrollment Management, Admissions, at bauerp@rpi.edu.

At the undergraduate level, the Department has maintained separate programs in philosophy and psychology leading to the Bachelor of Science degree in each discipline, respectively. An important goal of the undergraduate program, particularly for those enrolled in the Minds and Machines Program, the department’s undergraduate program in cognitive science, is to prepare students for careers in the rapidly growing “Information Economy.”
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.

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 the Rensselaer Reasoning Group, which works out of the Rensselaer AI & Reasoning (RAIR) Lab. For information, contact Selmer Bringsjord via selmer@rpi.edu.

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.

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.

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
Baron, R.A.—Ph.D. (University of Iowa); industrial/organizational psychology, social psychology.
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.
Koller, J.M.—Ph.D. (University of Hawaii); Asian and comparative thought, social philosophy, philosophy of religion.
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.

* 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 2005 Board of Trustees meeting.
Sun, Ron—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, visualisation and modeling.

Watt, J.—Ph.D. (University of Wisconsin-Madison); survey research via the internet; marketing communication; media and web cognitive processes; mathematical models of communication processes.

Zenzen, M.J., Jr.—Ph.D. (Rensselaer Polytechnic Institute); philosophy of science, philosophy of religion, aesthetics.

Associate Professors

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.

Assistant Professors

Cassimatis, Nicholas L.—Ph.D. (Massachusetts Institute of Technology); integrated cognitive models, human-level artificial intelligence, physical reasoning, natural language understanding.

Fajen, Brett R.—Ph.D. (University of Connecticut); visual perception, perception and action, ecological psychology, dynamical systems modeling; virtual reality.

Yang, Yingrui—Ph.D. (New York University); cognitive psychology, thinking, reasoning and decision-making, and cognitive science.

Research Assistant Professors

Schoelles, M.—Ph.D. (George Mason University); computational cognitive modeling, interactive behavior, natural language processing.

Clinical Assistant Professors

Destefano, M.—M.S. (Rensselaer Polytechnic Institute); games design, psychology of play, system dynamics.

Fahey, J.T.—Ph.D. (University at Albany); philosophy of science, metaphysics, epistemology, philosophy of artificial intelligence.

Francis, Sonja—Ph.D. (University of Toronto); cognitive developmental aspects of children’s graphic composition and college instructional strategies.

Hubbell, C.L.—Ph.D. (University at Albany); behavioral neuroscience; psycho-pharmacology, learning.

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); philosophy of mind, artificial intelligence, logic, computation, reasoning, and cognition.

VerWys, C.—Ph.D. (University at Albany); social psychology, forensic psychology.

Adjunct Faculty

Anderson, K.—Ph.D. (University of Georgia); counseling/clinical psychology.

Thero, D.—Ph.D. (University at Albany); history of ideas, ethics, environmental philosophy, philosophy of biology.

Van Orman, K.—M.A. (Kent State University); ABD (University at Albany); philosophy of science, philosophy of mind, philosophy of psychology, reasoning and cognition.
Undergraduate Programs

Baccalaureate Programs

Cognitive Science Program
The Cognitive Science Department’s undergraduate program is the Minds and Machines program. See the “Minds and Machines program” in the Interdisciplinary Programs and Research section of this catalog.

Philosophy Curriculum
Philosophy is a search for understanding and wisdom through inquiry into fundamental questions of existence and reflection on the underlying assumptions of knowledge and action. Through inquiry and reflection, humans seek to answer the “big” questions: What is the nature of human consciousness or of reality or of human experience? What is the meaning of life? Of what does the good life consist? How are right and wrong determined?

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 experience, values, and goals. This development of a coherent and critical personal perspective provides the foundation for a full and satisfying life, for the practice of responsible citizenship, and for leadership.

Whether working toward bachelor’s degree in philosophy alone or toward a dual degree, students must complete at least 32 credit hours of work in philosophy. Each student will develop a plan of study in consultation with a departmental adviser. In their senior year, all philosophy majors must write a thesis. Preparing this thesis will give students some research experience and early training in thesis writing in the event that they pursue further study. Students will write the thesis under the guidance of a professor of their choosing or selected based on familiarity with the research topic.

Psychology Curriculum
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 three basic psychology courses (PSYC-1200 General Psychology, PSYC-2310 Experimental Methods and Statistics, and PSYC-4990 Undergraduate Thesis) and the completion of at least 18 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-2310 Experimental Methods and Statistics and PSYC-4990 Undergraduate Thesis in the third or 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.

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<tr>
<th>First Year</th>
<th>Credit hours</th>
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1 The science sequence may be selected, with the assistance of the student's adviser, from among 1000-level introductory sequences in biology, chemistry, computer science, geology, or physics, including ERTH-1030, ERTH-1040. See the handout on the science core available from the School of Science.
Dual Majors
Dual majors are available in all three (cognitive science, philosophy, psychology) department curriculum areas. These options and their respective requirements are described below.

Cognitive Science
See the “Minds and Machines Program” in the Interdisciplinary Programs, and Research section.

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.

As an example of how such dual majors are structured, a student majoring in physics and philosophy would meet the requirements of the physics curriculum and take eight courses in philosophy. Among these would be PHIL-2130 Introduction to Philosophy of Science, PHIL-4360 Philosophical Problems of Space and Time, and PHIL-4310 Scientific Revolutions. A student majoring in computer science and philosophy would meet the requirements of the computer science curriculum and take eight philosophy courses including PHIL-2140 Introduction to Logic, PHIL-4260 Philosophy of Artificial Intelligence, and PHIL-4420 Computability and Logic. For a mathematics or computer science dual major, key courses in the philosophy major would be PHIL-4380 Philosophy of Mathematics, PHIL-4420 Computability and Logic, and PHIL-4720 Metaphysics.

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. Each of these is described in detail below.

Philosophy
To complete the minor in philosophy, a student chooses a minimum of four philosophy courses, at least one of which must be at the 4000 level.

Philosophy of Science and Logic
This minor focuses on the underlying assumptions, conceptual structures, and implications of mathematical and scientific knowledge. To complete this minor, a student chooses a minimum of at least four philosophy courses, three of which must be from the following list:

PHIL-2130 Introduction to Philosophy of Science  PHIL-4360 Philosophical Problems of Space and Time
PHIL-2140 Introduction to Logic  PHIL-4380 Philosophy of Mathematics
PHIL-4260 Philosophy of Artificial Intelligence  PHIL-4420 Computability and Logic
PHIL-4360 Philosophical Problems of Space and Time  PHIL-4440 Theory of Knowledge
PHIL-4440 Theory of Knowledge  PHIL-4720 Metaphysics
Philosophy of Human Values and Society
This minor emphasizes values in contemporary society. Human values in a technological society are explored through inquiries into the nature and function of art, morality, religion, and social institutions. To complete this minor, a student chooses a minimum of five philosophy courses, at least three of them from the following list:

PHIL-2300 Asian Philosophies
PHIL-2500 Bioethics
PHIL-2830 Comparative Religion
PHIL-4240 Ethics
PHIL-300 Environmental Philosophy
PHIL-420 Existentialism
PHIL-450 Buddhism

Psychology
To complete the minor in psychology, a student chooses a minimum of four psychology courses, with at least one at the 4000 level.

Brain and Behavior
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 Psychobiology is required for completion of the minor. The remaining two courses should be chosen from the following:

PSYC-2940 Readings in Brain and Behavior
PSYC-4110 Motivation and Performance
PSYC-4410 Sensation and Perception
PSYC-4450 Learning
PSYC-4500 Drugs, Society, and Behavior
PSYC-2960 Topics in Brain and Behavior
PSYC-4600 Cognition and the Brain
PSYC-4770 Psychopharmacology and Behavior
Toxicology
PSYC-4940 Readings in Brain and Behavior
PSYC-4960 Topics in Brain and Behavior

Community and Health Psychology
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:

PSYC-2730 Social Psychology
PSYC-2940 Readings in Community and Health Psychology
PSYC-2960 Topics in Community and Health Psychology
PSYC-4110 Motivation and Performance
PSYC-4340 Human Sexuality
PSYC-4440 Personality
PSYC-4500 Drugs, Society, and Behavior
PSYC-4630 Aids: Paradise Lost
PSYC-4770 Psychopharmacology and Behavior
Toxicology
PSYC-4940 Readings in Community and Health Psychology
PSYC-4960 Topics in Community and Health Psychology

General Psychology Minor
This customized minor is design 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.

PSYC-1200 General Psychology (required)
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.
Human Factors
This minor focuses on applying basic psychological principles to the interaction between person and machine. As technology becomes more sophisticated, it is critical to design equipment that optimally fits the needs and abilities of users. The prerequisite for this course is PSYC-1200 General Psychology and PSYC-2220 Human Factors in Design is required. The remaining two courses to complete the minor should be selected from the following:

- PSYC-4160 Human Factors Seminar
- PSYC-4180 Selected Topics in Engineering Psychology
- PSYC-4280 Human-Computer Interaction
- PSYC-2940 Readings in Human Factors

Industrial/Organizational Psychology
This minor focuses on applying psychology to performance in the workplace. It helps individuals develop the knowledge base needed to improve the performance of themselves and others in the workplace. PSYC-1200 General Psychology is a prerequisite for this minor and PSYC-4200 Industrial/Organizational Psychology is a requirement. An additional two courses should be chosen from the following:

- PSYC-2730 Social Psychology
- PSYC-4110 Motivation and Performance
- PSYC-2940 Readings in Industrial/Organizational Psychology
- PSYC-2960 Topics in Industrial/Organizational Psychology

Perception and Action
By considering the personal and situational factors influencing social behavior, individuals choosing this minor develop techniques to enhance their social perception, decision making, group influences on behavior, and attitudes. PSYC-4410 Sensation and Perception is a prerequisite, and PSYC-4420 Perception in Action is required. Two additional courses should be selected from the following:

- PSYC-2600 Moral Development
- PSYC-2940 Readings in Social Psychology
- PSYC-2960 Topics in Social Psychology
- PSYC-4940 Readings in Social Psychology
- PSYC-4960 Topics in Social Psychology
- PSYC-4720 Abnormal Psychology
- PSYC-4400 Personality
- PSYC-4340 Human Sexuality
- PSYC-4630 AIDS: Paradise Lost

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 Masters 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 masters. See “Accelerated Programs” for more information.

Accelerated 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 will emphasize one of the four areas (Human and Machine Reasoning, Computational Cognitive Modeling, Cognitive Engineering, or Perception and Action) that constitutes our approach to integrated cognitive systems. Prior to applying, we expect that students will have taken introductory courses in cognitive psychology, philosophy of mind, and cognitive science, as well as being involved in one of the several research laboratories sponsored by department faculty.

**Doctoral Program**
The new Ph.D. in Cognitive Science was approved by the State of New York in 2003. 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 osgane@rpi.edu or Paul Bauer, Director of Graduate Enrollment Programs, Enrollment Management, Admissions, at bauerp@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.

**Economics**
Chair: Donald Siegel

**Director, Ph.D. Program in Ecological Economics:** David Stern

**Department Home Page:** [http://www.rpi.edu/dept/economics](http://www.rpi.edu/dept/economics)

The Nobel Prize in Economic Science recognizes the rigor and analytical content of economics. The private sector also values economic analysis, and economists are widely sought as potential employees by leading financial institutions and consulting firms. At Rensselaer, undergraduate students are introduced to the key ideas of economics that revolve around scarcity of resources and the function of social institutions. They learn to make choices among alternatives in which it often is not possible to achieve all desirable outcomes.

Through a sequence of progressively more advanced courses, students learn the concepts and tools of economics as applied to a variety of public policy issues such as: 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 allocative decision making. For engineers, scientists, and managers, career choices and options are often heavily intermixed with economic problems and policies.

The basic one-term course, ECON-1200 Introductory Economics, creates an awareness of the country’s economic problems and furnishes the basic tools with which, as voting citizens, students will reach independent, rational judgments on 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 courses listed. However, under certain circumstances, this prerequisite may be waived.

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 also encouraged to work with undergraduates on research projects.
Research Innovations and Initiatives

At the graduate level, the training objective is to allow 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 environmental and ecological economics, economics of technological change, productivity analysis, cost-benefit analysis, economic regulation, and international competitiveness.

Faculty*

Professors
Adams, J.—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.
Gowdy, J.M.—Ph.D. (West Virginia University); ecological economics, industrial organization and public regulation, regional economics.
Siegel, D.S.—Ph.D. (Columbia University); economics of technological change, productivity analysis, university technology transfer, corporate social responsibility.
Vitaliano, D.F.—Ph.D. (City University of New York); public finance, cost-benefit analysis, health economics.

Associate Professor
Stern, D.—Ph.D. (Boston University); natural resource economics, quantitative methods, ecological economics.

Assistant Professor
Simons, K.—Ph.D. (Carnegie Mellon University); industrial organization and technical change, dynamics of economic systems.

Clinical Associate Professor
Heim, J.—Ph.D. (University at Albany); money and banking, international economics.

Clinical Assistant Professor
Jones, R.—Ph.D. (Rensselaer Polytechnic Institute); money and banking, introductory economics, econometrics.

Emeritus Faculty
Hohenberg, P.M.—Ph.D. (Massachusetts Institute of Technology); economic history, economics of technological change.

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 pursue various courses dealing with relevant aspects of environmental, ecological economics, and the economics of technological change.

* 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 2005 Board of Trustees meeting.
Baccalaureate Programs

A major in economics requires 34 credit hours 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 or ECON-4120 Quantitative Analysis, and ECON-4900 Seminar in Economics. An approved course in Statistics is a prerequisite to the Quantitative Analysis and Econometrics requirement.

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.

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1. Science options are CHEM-1100, CHEM-1200; PHYS-1100, PHYS-1200, ERTH-1030, ERTH-1040. Other sequences may be substituted with approval.

2. This is a special section of this course for H&SS students; MATH-1010 may be substituted for MATH-1500.

3. As required.

4. Special version of this course for H&SS majors.

5. Degree completion may require more credits.
Concentrations
Work in the major field can easily be combined with meaningful concentrations of study in other fields of interest. Some possibilities include:

- Emphasizing liberal electives in, for example, a prelaw program or 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.

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 H&SS Core. Otherwise the requirements are the same as for the single major in economics.

The department also offers two specially designed dual major options that uniquely combine economics with programs emphasizing science and technology and environmental issues. These include Ecological Economics, Values, and Policy and Environmental Studies, which, as programs that cross disciplines or even schools, are included in the School's Interdisciplinary Programs and Research section found at the end of the H&SS portion of the catalog.

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 Donald Vitaliano, Sage 3405, vitald@rpi.edu, ext. 8093 or John Heim, Sage 3410, heimj@rpi.edu, ext. 8096.

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 to 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 energy and environment; technological change and productivity measurement, cost-benefit analysis, health economics, international competitiveness, community sustainable development, the role of technology as an agent of change in the structure of national output in planned and market economies, global economic cooperation, cost-benefit analysis of state and local projects and policies, urbanization and industrial development; the economics of new technologies in nonprofit hospitals, technological change in input-output analysis, and innovation and international trade.
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.

Master of Science

Applicants for the M.S. in Economics program should have completed a bachelor’s program at an approved institution with basic undergraduate courses in economics and mathematics, including calculus. Some background in statistics is strongly recommended. Candidates must complete 24 credit hours of coursework selected in consultation with the program adviser, submit a six-credit thesis, and pass a comprehensive oral examination. There is no foreign language requirement.

Professional Masters Program in Ecological Economics, Values, and Policy

The Departments of Economics and Science and Technology Studies (STS) jointly offer this program, which builds on Rensselaer’s nationally recognized expertise and course offerings in the economic, political, social, cultural, and ethical implications and interactions of science, technology, environment, and society. EEVP targets early and mid-career professionals in state and local government, secondary education, business, and the nonprofit sector, for example, professionals in environmental NGOs (non-government organizations) who wish to upgrade their skills and advance their careers. Building on required courses in environmental, ecological, and natural resource economics and in environmental philosophy and policy, EEVP helps students acquire skills such as policy analysis and ecological valuation. These skills are necessary to address the complex multidisciplinary problems any society faces in such areas as environment and health, appropriate technology, and sustainable development. The 21st century promises a continuation of the march toward globalization. Dealing with prospects and problems of a world economy and the growing human impact on the natural world requires a broad and deep education. EEVP offers “hands-on” training that puts into practice the slogan “think globally, act locally.”

For more detailed information on the EEVP Master’s Program, see the Interdisciplinary Programs and Research section of this catalog.

Doctoral Programs

The Economics Department offers an interdisciplinary Ph.D. degree in ecological economics with cooperation from the Departments of Science and Technology Studies, Biology, and the Environmental Management and Policy Program in the School of Management.

This Ph.D. program allows for individual research specialization and independent study in an atmosphere of close contact between faculty and students based on research participation. Ecological economics is an interdisciplinary field involving economics, ecology, and social theory. Students take basic theory courses in micro- and macroeconomics and econometrics, as well as course sequences in the advanced fields of ecological economics and public sector economics. Beyond the required work in theory and quantitative methods, students can choose an elective field for advanced study and dissertation research. Students may choose other advanced courses from offerings within the Departments of Biology, Science and Technology Studies, and other Rensselaer departments that meet students’ interests.

The Ph.D. in economics requires 90 hours beyond the baccalaureate degree and 60 hours beyond an M.A. or M.S. in economics or a related field. This requirement entails a minimum of 30 hours of course work or 10 three-credit courses. However, most students will choose to take more courses and may be required to do so if their background so indicates. Thesis credit will vary between 15 and 30 hours.

Students must complete core courses in microeconomics, macroeconomics, and quantitative methods. In addition, two of the following three courses are required: ECON-6230 Environmental Economics,
ECON-6250 Ecological Economics, and ECON-6240 Natural Resource Economics. The rest of the program is chosen around other advanced courses in economics, biology, environmental management, philosophy, science and technology studies, or environmental engineering. Students are also encouraged to attend seminars conducted regularly in the economics department as well as in other Rensselaer departments, e.g., science and technology studies and biology.

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.

Economics Ph.D. students must also pass written qualifying exams that cover theory and application in the three required core fields. Exams are offered twice a year. The examining faculty will prepare study questions and a list of related readings for students planning to take the required exams in microeconomics, macroeconomics, and quantitative methods.

Upon successfully completing the qualifying exams, students organize a thesis committee for their dissertations. One member of the required four-person committee must be from outside the economics department. The student will prepare a dissertation prospectus that covers the theoretical and applied literature in the chosen field of study for the dissertation and outline the planned dissertation research. The prospectus presentation constitutes an additional oral field exam in a chosen area of specialization.

Course Descriptions
Courses related to all economics curricula are described in the Course Descriptions section of this catalog under the department code ECON.

Language, Literature, and Communication
Chair: James H. Watt
Department Home Page: http://www.llc.rpi.edu/

The Department of Language, Literature, and Communication (LL&C) 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), foreign languages, graphics and visual communication, literature and cultural studies, rhetoric, and technical communication.

The department offers a B.S. in Communication, including concentrations in Graphic Design and Web Design and Analysis (Web D&A); M.S. programs in Technical Communication, including a concentration in Human-Computer Interaction, and in Communication and Rhetoric, and a Ph.D. in Communication and Rhetoric. Also offered in partnership with the Department of the Arts is a B.S. in Electronic Media, Arts, and Communication (EMAC). Through another partnership with the Faculty of Information Technology, LL&C offers a B.S. in Information Technology (IT) with Communication as a concentration. The M.S. program in Technical Communication is available through Rensselaer’s distance education program as well as on campus.

The B.S. programs prepare students for advanced study or for 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. degrees can lead to 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 in Communication and Rhetoric find careers in business and government as well as in academia. The growing need for persons who understand the new communication technologies, and their impact on society and individuals, creates a demand for all LL&C program graduates.

Undergraduates may use some of their elective courses to complete a Certificate in Communication Design. Certificate programs in either Graphics or HCI are available to graduate students. Graphics or Communication Design can provide special competency in visual design and communication. The HCI certificate provides special competency in the design and analysis of computer-user interfaces. Either graduate certificate program can be incorporated into a standard M.S. program plan of study. The program in HCI is available via distance education and is an option in the M.S. in Management and Technology as well as in the M.S. in Technical Communication.

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 Computers
Research in this area focuses on technology-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 codes are current areas of research in this category.

Research Facilities
To support these programs, LL&C maintains a variety of research-centered laboratories and facilities:

- Human-Computer Interaction Laboratory-Situated in 4303 Sage Lab, the HCI Laboratory fosters interdisciplinary research and development. Ongoing projects include usability research, online support of physical performance, technological support for collaborative work, and community networking. The laboratory is equipped with computer workstations and video equipment for recording and analyzing human-computer interactions.

- LL&C Conference Circle-Located in 4305 Sage Lab, this technology-supported conference room is available by reservation to department students, faculty, and staff. Developed with funding from the National Science Foundation, NYNEX, and Intel, the Conference Circle provides three Pentium workstations linked to each other and to the campus network. Large screen monitors buried in the Conference Circle surface allow groups to view, discuss, and alter common work.

- Design Conference Room-Located in the basement level of the Folsom Library, this conference room facility integrates electronic and face-to-face interaction. Funded by the National Science Foundation, the Design Conference Room provides support for intellectual teamwork through individual private systems networked to a common public system. Reconfigurable Collaboration Network© software
permits participants to take turns controlling sessions on the public system, working together on common projects. The Design Conference Room is available to department faculty and student teams by reservation. For more information about the DCR access http://www.dcr.rpi.edu.

n Intel Laboratory-Students in LL&C and in the EMAC program have access to the Intel Lab in 4711 Sage Lab for both classes and individual work. The laboratory contains Pentium workstations with expanded memory and a variety of peripherals, all connected to the campus network via Ethernet. Large format printers, scanners, and digital cameras are also available. The laboratory also offers software packages from Adobe, Macromedia, and Microsoft. Additional software includes Cosmo Worlds, Extreme 3-D, SoftImage, QuarkXPress, RoboHelp, Chinese Word Processing, and a variety of browsers. More information on the Intel Lab is available by calling ext. 6467.

n Writing Center-This tutorial service available to all Rensselaer students offers help in all areas of writing such as lab reports, research projects, papers, proposals, reports, formal letters, and resumes. Students receive instruction from expert staff on a one-to-one basis. Attendance is voluntary, and no appointment is necessary. Students can also arrange more formal programs of writing improvement. Hours are posted at the center in 4508 Sage Lab. Additional information about the center’s resources (including on-line publications) can be accessed on its web site at http://www.rpi.edu/web/writingcenter/.

n Collaborative Classroom-Drawing on previous work in the Rensselaer Design Conference Room, the Collaborative Classroom, funded by the National Science Foundation and NYNEX and located in 2015 Troy Building, supports intellectual teamwork in the classroom. It provides teams of laptop users with the technological support required to generate, coordinate, and refine the joint action required in collaborative design. Furnished with technology-enhanced conference tables, the Collaborative Classroom provides across-the-table seating for seven teams of six students each.

n Social and Behavioral Research Laboratory (SBRL)-The SBRL contains space and equipment for applied and basic research in computer-mediated communication (CMC), human-computer interaction (HCI), psychology, cognitive science, community informatics, and technology studies. Faculty and graduate students from the Departments of Language, Literature, and Communication; Cognitive Science; Computer Science; Electronic Arts; Management; and Science and Technology Studies conduct multi-disciplinary studies in the social and behavioral impact of information technologies. The 8,500 square foot lab contains HCI and human factors research suites with eye tracking and observational video systems, focus group rooms with both direct and video observation and recording facilities, small CMC research rooms with computer and video systems, an immersive virtual reality studio, a computer-aided telephone and Web survey research lab, and a large-group research room. The SBRL is located in the newly renovated Gurley Building, which is listed in the National Registry of Historic Buildings, in downtown Troy adjacent to the Rensselaer campus.

Faculty*

Professors

Geisler, C.—Ph.D. (Carnegie-Mellon University); writing in workplace and professional contexts; the intersection of text, technology, and design; methods of the analysis of verbal data; genre theory; academic literacy.

Krull, R.—Ph.D. (University of Wisconsin-Madison); electronic user interfaces and performance support; embodied illustrations and language; usability research design.

Nadel, A.—Ph.D. (Rutgers University); literary theory and cultural narrative; American cultural studies; film and television studies; African-American studies; modern and contemporary American literature; creative writing.

*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 2005 Board of Trustees meeting.
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; multi-literacy models for intercultural communication.

Watt, J.—Ph.D. (University of Wisconsin-Madison); survey research via the Internet; marketing communication; media and web cognitive processes; web communication technologies; HCI interfaces for the visually impaired; and mathematical models of communication processes. Current projects involve investigations of the active nature of web advertising audiences, asynchronous web-based videoconferencing systems, and evaluation of computer interfaces for the blind.

Whitburn, M.—Ph.D. (University of Iowa); history and teaching of technical communication; history of rhetoric; rhetoric bibliography; history of English studies.

Associate Professors
Bennett, A.—M.F.A. (Yale University); graphic design theory and research; design pedagogy; collaborative design with remote grassroots participants.

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; theory of literature; theory and history of photography; modern literature; women writers.

Gordon, T.—Ph.D. (University of California, Berkeley); cultural anthropology; religion and globalization; ethnographic methods; themed environments; documentary film.

Zappen, J. P.—Ph.D. (University of Missouri); digital rhetoric; activity theory; community networking; participatory-design processes.

Clinical Associate Professors
Grice, R.—Ph.D. (Rensselaer Polytechnic Institute); information usability; human-computer interaction; communicating on the WWW; usability testing and evaluation; analysis of computer-games interfaces; effective teaching and learning in the virtual classroom.

Assistant Professors
Choi, J.—Ph.D. (State University of New York at Buffalo); social uses of the Internet; online journalism; global telecommunication systems; digital media production and policies; intercultural communication; social network analysis.

Haskins, E.—Ph.D. (University of Iowa); rhetorical theory and history, visual rhetoric, and rhetorical dimensions of public memory.

Hübscher-Younger, T.—Ph.D. (Auburn); computer-supported collaborative learning; educational technology; human-computer interaction; usability evaluation; software engineering; web application and interface design and development.

Isbister, K.—Ph.D. (Stanford University); social psychological and affective approaches to HCI, focusing on games, mobile, and other leisure and social technologies; game studies—games as both a research platform and as an emerging medium; embodied conversational agents; nonverbal communication and technology.

Clinical Assistant Professors
Gerber, L. R.—Ph.D. (University at Albany); scientific French; electronic media; computer-mediated communication in France: the concurrent development of the Minitel and Internet in France and the Francophone countries.
Gutmann, J.—D.A. (University at Albany); creative writing (poetry and poetics, creative nonfiction); environmental ethics and literature; Asian philosophies and religions; first year studies college pedagogy.

Miyamoto, P—M.F.A. (Otis Art Institute); visual design theory; publication design theory and practice; exploration of paint-based medium as an expressive art form.

Lecturers

Dubrawski, M.—M.A. (San Francisco State University); Japanese pedagogy; instructional technology; computer-assisted language learning.

Lynch, M.—M.A. (Univ. of Connecticut); human-computer interaction; analysis of computer game interfaces; design of AI within computer games in support of social interaction and communication; cognitive processes for modeling computer game AI; speech act theory.

Marko, M.—M.A. (University of Oregon); German language pedagogy, Internet in German-speaking Europe, Green movement, literature and the arts, film studies, 20th century German literature and culture, Romanticism.

Shen, T.—M.A. (Chinese Academy of Social Sciences); M.A. (University of Massachusetts-Amherst); Chinese linguistics, dialectology, phonology, and general linguistics.

Undergraduate Programs

LL&C undergraduate programs provide students with the multidisciplinary education essential for leadership in an “information society.” Rapidly transforming this society are new communication processes and technologies. Building on Rensselaer’s strong technological infrastructure, these programs offer hands-on education in the new communication technologies and theoretical frameworks to understand and shape the cultural impact of these technologies.

Baccalaureate Programs

Communication (Comm) Curriculum

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 and social sciences, and 24 are taken in math, science, and computing.

B.S. in General Communication

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<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Fall</td>
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<tr>
<td>IHSS-1966 / COMM-1510 Introduction to Communication Theory</td>
<td>4</td>
<td>LITR-2110 Introduction to Literature</td>
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<td>WRIT-2110</td>
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<td>COMM-2610 Introduction to Visual Communication</td>
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<td>MATH-1500</td>
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<td>Hum. Elective/First-Year Studies</td>
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<tr>
<td>IHSS-1969 / COMM-196x Communication and Information Technology</td>
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<td>MATH-1620 Contemp. Math Ideas in Society</td>
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<td>Social Science Elective</td>
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<tr>
<td>Math/Science Elective</td>
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<td>Free Elective</td>
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<td>Major Requirement 1</td>
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1. **Major Requirement (44 credit hours required)** All Communication majors are required to take IHSS-196x or COMM-1510, COMM-2610, and IHSS-196x or COMM-196x (Comm. and Info. Tech.) Students who are following the General Communications major (i.e., those who are not following the Graphic Design or the Web Design and Analysis Concentrations) are also required to take LITR-2110 and WRIT-2110. The remaining 24 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.
Web Design and Analysis Concentration

The Web Design and Analysis (Web D & A) concentration provides a curriculum for students who want to understand how communication principles affect the design and effectiveness of the World Wide Web and related systems. The concentration prepares students to provide leadership in designing, assessing, and shaping the World Wide Web and emerging Internet technologies. After completing this sequence, students will be able to conceptualize, construct, and critique WWW communications from an intellectual and practical perspective. This concentration also develops competencies in graphics, information architecture, media assessment, and technology applications such as e-business.

In consultation with their advisers, students in the Web Design and Analysis concentration choose 12 credit hours of LL&C electives. Students are especially encouraged to use these electives to take a set of related courses, such as graphics, communication design, or human-computer interaction. A four-credit hour Communication Internship focusing on Web design is also required.

B.S. in Communication (Concentration in Web Design and Analysis)

### First Year

**Fall**

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<thead>
<tr>
<th>Course/Major</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>IHSS-196x/COMM-1510 Intro. to Communication</td>
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<tr>
<td>IHSS-196x/COMM-1610 Comm. and Info. Tech</td>
<td>4</td>
</tr>
<tr>
<td>Hum. Elective/First Year Studies</td>
<td>4</td>
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<tr>
<td>MATH-1500 Calculus I for H&amp;SS</td>
<td>4</td>
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**Spring**

<table>
<thead>
<tr>
<th>Course/Major</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>COMM-2610 Intro. to Visual Communication</td>
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<tr>
<td>CSCI-1010 Intro. to Computer Programming</td>
<td>4</td>
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<tr>
<td>CSCI-1100</td>
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<tr>
<td>MATH-1620 Contemp. Math Ideas in Society</td>
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**Fall**

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<th>Credit hours</th>
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<tbody>
<tr>
<td>Info. Architecture Requirement</td>
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<tr>
<td>Writing Requirement</td>
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<tr>
<td>H&amp;SS Core</td>
<td>4</td>
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<tr>
<td>CSCI-1100 Computer Science I</td>
<td>4</td>
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<tr>
<td>or CSCI-1200 Computer Science II</td>
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<tr>
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<th>Credit hours</th>
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<tbody>
<tr>
<td>Graphics Requirement (LL&amp;C)</td>
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<tr>
<td>Open Elective</td>
<td>4</td>
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<tr>
<td>H&amp;SS Core</td>
<td>4</td>
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<tr>
<td>Math/Science Core</td>
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1. Twelve additional credit hours in Language, Literature, and Communication Electives. Students are encouraged to take a set of related courses, such as graphics, communication design, or human-computer interaction.
2. Four credits, Information Architecture: COMM-4690, WRIT-4610.
3. Four credits, Writing Requirement. Students in the Web Design and Analysis Concentration will meet the writing requirement by taking one of the following courses: WRIT-2110, WRIT-1110, WRIT-2520.
5. Math/Science Requirement. Required courses in of math and science are: MATH-1500, MATH -1620, and CSCI-1100, then CSCI-1200, or CSCI-1010, then CSCI-1100. MATH-1010 and MATH-1020 may be substituted for MATH-1500 and MATH-1620, respectively. All students must fulfill the Institute requirement of 24 credit hours of Math/Science. One-credit courses that are graded satisfactory/unsatisfactory do not satisfy science requirements. Please see departmental adviser for more information.
Graphic Design Concentration

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.

The B.S. in Communication with a Concentration in Graphic Design will require a total of 124 credit hours. It will consist of 64 credit hours of major requirements; 12 credit hours of free electives; and the Rensselaer requirements of 24 credit hours in the humanities and social sciences and 24 credit hours in math, science, and computing courses. The four-credit Communication Internship focusing on graphic design is also required.

Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approaches to Assessment</td>
<td>COMM-4300</td>
<td>Comm. Internship (focusing on Web Design)</td>
<td>6</td>
</tr>
<tr>
<td>Requirement (LL&amp;C) 3</td>
<td>H&amp;SS Core</td>
<td>LL&amp;C Elective 1</td>
<td>Open Elective</td>
</tr>
<tr>
<td>LL&amp;C Elective 1</td>
<td>Math/Science Core</td>
<td>H&amp;SS Core</td>
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<td>H&amp;SS Core</td>
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Fourth Year

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<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications Requirement</td>
<td>COMM-4300</td>
<td>LL&amp;C Elective 1</td>
<td>Open Elective</td>
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<tr>
<td>H&amp;SS Core</td>
<td>H&amp;SS Core</td>
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1 Twelve additional credit hours in Language, Literature, and Communication Electives. Students are encouraged to take a set of related courses, such as graphics, communication design, or human-computer interaction.

2 Four credits. Approaches to Assessment. Students will satisfy this requirement by taking a course that emphasizes either empirical assessment or social/critical assessment.
A) Empirical Assessment: COMM-4420, COMM-4590, COMM-4170 OR

3 Four credits, COMM-4300. Students must take a 4-credit hour communication internship focusing on a web design project. It is suggested that this requirement be fulfilled during the junior year.

4 Four credits, Applications Requirement: COMM-496x (Web Advertising).

5 Math/Science Requirement. Required courses in of math and science are: MATH-1500, MATH-1620, and CSCI-1100, then CSCI-1200, or CSCI-1010, then CSCI-1100. MATH-1010 and MATH-1020 may be substituted for MATH-1500 and MATH-1620, respectively. All students must fulfill the Institute requirement of 24 credit hours of Math/Science. One-credit courses that are graded satisfactory/unsatisfactory do not satisfy science requirements. Please see departmental adviser for more information.
B.S. in Communication with a Concentration in Graphic Design:
Theory, Research, Practice

First Year
Fall
- Credit hours
  - H&SS Core in Art or Design\(^1\) ..........4
  - COMM-2610 Intro. to Visual Communication .......4
  - COMM-1510/IHSS-196x Intro. to Communication Theory ............................................4
  - MATH-1500 Calculus I for H&SS ..............4

Spring
- Credit hours
  - COMM-4570 Typography ..................................4
  - MATH-1620 Contemp. Math Ideas in Society ......4
  - Math/Science Core\(^2\) .....................................4
  - H&SS Core in Art History\(^3\) .........................4

Second Year
Fall
- Credit hours
  - Writing Requirement\(^4\) .........................4
  - COMM-4660 Visual Literacy ..........................4
  - COMM-4460 Visual Design ............................4
  - Social Science Core\(^5\) ............................4

Spring
- Credit hours
  - COMM-4690 Interface Design: Hypermedia ........4
  - COMM-4650 Theory and Application\(^6\) .............4
  - Math/Science Core ....................................4
  - Communication Courses in Theory, Research\(^7\) ....4

Third Year
Fall
- Credit hours
  - Communication Courses in Theory, Research\(^8\) ..........4
  - Math/Science Core ....................................4
  - COMM-296x Color Theory/ ................................4
  - COMM-496x Adv. Typography ..........................4
  - Writing Requirement\(^9\) ................................4

Spring
- Credit hours
  - COMM-4650 Inter. Visual Communication ............4
  - Math/Science Core ....................................4
  - Social Science Core\(^10\) ................................4

Fourth Year
Fall
- Credit hours
  - H&SS Core in Art or Design\(^11\) ..........4
  - COMM-496x Information Design ..........................4
  - COMM-4400 Publication Practicum .......................4
  - Elective .............................................4

Spring
- Credit hours
  - COMM-4300 Communication Internship ...............4
  - COMM-496x Graphic Design for Corp. Identity .....4
  - Elective .............................................4

\(^{1}\) COMM-4690

\(^{2}\) Students should choose four credits from the following set of courses: WRIT-2520 (two credits), WRIT-296x Creating Electronic Portfolios, WRIT-2310, WRIT-2410 (two credits), and WRIT-2510.

\(^{3}\) Students should choose one of the following courses: WRIT-1110, WRIT-2110, WRIT-4550, or WRIT-4120.

\(^{4}\) Students should choose two of the following courses: COMM-496x Media Design: Theory and Research, COMM-496x Visual Change, COMM-496x Rhetoric of the Photograph, COMM-4580, COMM-4560, COMM-4780, LITR-496x Cultural Studies, LITR-2420, LITR-296x Postmodernism and Film, and/or a course in HCI. A comprehensive list of courses will be provided to the adviser each term.

\(^{5}\) Students may choose between CSCI-1010 or CSCI-1100. The latter is recommended for students who want to minor in Computer Science.

\(^{6}\) Students should choose the following courses: ARTS-296x Art History and ARTS-2540, or another course that the adviser approves.

\(^{7}\) A list of appropriate courses will be provided to the adviser each term.

\(^{8}\) 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.
Electronic Media, Arts, and Communication (EMAC) Curriculum

This joint B.S. degree is earned from both the Department of Language, Literature, and Communication and the Department of the Arts. As such, it is interdisciplinary in nature and is therefore described in detail under the heading Interdisciplinary Programs and Research at the end of the Humanities and Social Sciences section of this catalog.

Information Technology and Communication (IT/Comm) Curriculum

The B.S. in IT/Communication is an information technology degree with a concentration which includes 32 credits taken in Language, Literature, and Communication (LL&C). 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 IT/Comm should consider taking course work in one or more of the following LL&C pursuits: communication in new media, visual communication, and human-computer interaction.

All LL&C 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>
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<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>Fall</td>
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</tr>
<tr>
<td>ITEC-1210</td>
<td>Information in History &amp; Society......4</td>
<td>ITEC-1220</td>
<td>Politics and Economics of IT ..........4</td>
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<td>Computer Science II ..............4</td>
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<td>WRIT-2110</td>
<td>Rhetoric and Writing ..............4</td>
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<td>Intro. to Communication Theory...........4</td>
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<td>and ENGR-2350</td>
<td>Embedded Control ... ... (1)</td>
<td>–CSCI-2300</td>
<td>Data Structures &amp; Algorithms</td>
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<tr>
<td>–CSCI-2500</td>
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<td>ITEC-2210</td>
<td>Intro. to Human Computer Interaction..4</td>
<td>LITR-2110</td>
<td>Introduction to Literature ......4</td>
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<td>ITEC-2110</td>
<td>Exploiting the Information World ....4</td>
<td>Free Elective</td>
<td>.................................4</td>
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<tr>
<td>COMM-2610</td>
<td>Intro. to Visual Communication ......4</td>
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<td>Spring</td>
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<tr>
<td>Third Year</td>
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<tr>
<td>Fall</td>
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<td>Spring</td>
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<tr>
<td>ITEC-4310</td>
<td>Managing IT Resources</td>
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<td>IT Elective (one of):</td>
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<td>Probability and Statistics Elective (one of):</td>
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<td>–DSES-2010</td>
<td>Statistics for Management ........4</td>
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<td>Information Systems</td>
<td>–ENGR-2600</td>
<td>Modeling/Analysis of Uncertainty</td>
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<td>Communication, Writing, or Language Elective ..........4</td>
<td>–MGMT-2100</td>
<td>Statistical Methods</td>
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<td>H&amp;SS Elective</td>
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<td>–PSYC-2310</td>
<td>Experimental Methods &amp; Statistics</td>
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<td></td>
<td>........................................4</td>
<td>Science Elective</td>
<td>.................................4</td>
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<td></td>
<td>........................................4</td>
<td>Free Elective</td>
<td>.................................4</td>
<td></td>
</tr>
</tbody>
</table>

1 Select either the first course in both lists or the second course in both lists. Do not select the first course in one list and the second course in the other.

NOTE: Students are expected to notify the instructor at the beginning of the Culminating Experience course that they are taking it for Culminating Experience credit, and they should confer with the instructor to define the course project.
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 Language, Literature, and Communication offers a selection of minors for majors in other departments, all of which require at least 16 credit hours.

Communication
To complete this minor, students must take COMM-1510 Introduction to Communication Theory and one 4000-level Communication course. Two additional 4-credit communication courses under the codes COMM-xxxx or WRIT-xxxx are also required.

Literature
A literature minor must include LITR-2110 Introduction to Literature, plus three other 4-credit literature courses under the code LITR-xxxx.

French
This minor consists of French III, French IV, Business French I, and Business French II.

German
Required courses for this major include LANG-1320 German II, LANG-2310 German III, and two four-credit, 4000-level German courses. Students beginning the German sequence with German III must take three 4000-level German courses following German III. The appropriate department adviser may approve some course substitutions in order to meet individual student needs.

Graduate Programs
From founding the first graduate program in technical communication in the 1950s to receiving the Association of Computing Machinery Special Interest Group’s Diana Award in 1999 for organizational leadership in producing quality documentation to the department’s faculty receiving two national teaching awards in 2001, LL&C has been at the forefront of the field. Department faculty includes many active scholars who are winners of national awards for teaching and scholarship from technical communication professional associations. They are also members of the governing boards of these associations. In addition, department faculty members are unusually active in collaborating with corporations to improve processes both at industry work sites and in Rensselaer’s educational program.

Currently, the Department of Language, Literature, and Communication’s graduate programs consist of three master’s level degree programs, a Ph.D. in Communication and Rhetoric, and two certificate programs. Specific details of these programs are outlined below.
Master’s Programs
Master of Science
LL&C offers the M.S. in Technical Communication and in Communication and Rhetoric. The Technical Communication master’s degree combines course work in theory, writing, information design, graphics, and analysis of communication systems. This program enables students to work as technical communicators and Web designers and to team with user interface or electronic performance support system designers. In addition to the core M.S. courses, the program integrates courses leading to either the certificate in Human-Computer Interaction (HCI) or the Certificate in Graphics.

The M.S. in Technical Communication with an HCI concentration combines course work in human-computer interaction with theory in allied areas such as technical communication, human factors, and computer science. Students gain a breadth of theory in these areas and applied work in design and software implementation. Compared to graduates of Information Technology and Computer Science programs, these graduates emphasize knowledge of computer usability research and interface design over implementation skills. Graduates of this new HCI-focused curriculum are prepared to work as information architects, usability engineers, interface designers, or Website managers, depending on the student’s specific course selections.

The department also offers an M.S. in Communication and Rhetoric, which emphasizes a research approach to communication problems. Drawing on the core M.S. courses, this track additionally provides knowledge of existing research findings and the capacity to conduct original research. Both humanistic and social scientific perspectives are represented. The program enables students to conduct communication research, such as product usability studies in industry and government, and prepares them for doctoral study in communication and rhetoric at Rensselaer or elsewhere.

Both the M.S. in Technical Communication and the M.S. in Communication and Rhetoric require 30 credit hours for completion. Twenty-one of the 30 required credits towards the M.S. degree must come from courses offered by LL&C. Three to six credit hours may be devoted to a thesis. There is no foreign language requirement.

Doctoral Program
LL&C’s Ph.D. in Communication and Rhetoric prepares students for careers in both academic and nonacademic settings. In recent years, most graduates of the program have become scholars and teachers; others have accepted government and industry positions that require skills in analyzing and designing human communication systems and practices. In either case, the Ph.D. program prepares students to draw upon and develop theory and research from multiple disciplines—technical communication, rhetoric, composition, communication theory and research, graphic design, and critical theory—to address issues that are central to their work.

The emergence of new forms of technologically-mediated communication like the Internet, digital broadband, and wireless networks has led to the realization that the impact of these forms of communication is not fully explained by traditional theories of communication and rhetoric and can only be understood with new theoretical insights. The current challenge in theory and research in communication and rhetoric is to reconcile the canonical theory of the past with emerging theory that directly addresses the new technologically-mediated communication environment.

LL&C is uniquely positioned to develop new knowledge of this environment, as it combines the resources and cutting-edge research tradition of a premier technological university with a faculty that possesses a strong grounding in both fundamental communication research and new media effects. LL&C is also able to draw upon its unique strengths to resituate rhetorical studies at the intersection of rhetoric, culture,
and the new communication technologies, combining its traditional emphasis upon rhetorical theory and analysis with newer emphases upon digital, visual, and cultural rhetoric.

The Ph.D. curriculum provides students with a mix of core and methods courses, seminars, opportunities for directed research, and formal presentation requirements that provide an introduction to basic theory and research in communication and rhetoric and support and encourage projects that extend that theory and research into the future. To complete the Ph.D. in Communication and Rhetoric, students must fulfill specific requirements in each of these areas. They must also complete a minimum of 90 credit hours beyond the bachelor's degree, or 60 credits beyond the master's degree, including at least one course outside the department; pass a candidacy examination, including both written and oral portions; secure approval of a dissertation prospectus; and successfully research, write, and defend the dissertation. Details on these requirements are set forth in “A Guide to the Doctoral Program in Communication and Rhetoric,” accessible through the department’s Web site, http://www.llc.rpi.edu.

Special Graduate Opportunities

Graphics Certificate

The 12-credit graduate certificate is available as an option in both M.S. programs. The rapid advancement of computer graphics software for page layout, drawing, image editing, and interactive multimedia design presents communicators with a wide range of powerful design options. These technological developments create the need for communicators equally in command of words and visual imagery. The graphics program integrates design theory with in-depth studio work in design for print and electronic media including interactive multimedia design, Web design, and marketing and advertising design. In addition to graphics courses, students may pursue an internship or independent study (focused on graphics) as part of the concentration.

Certificate in Human-Computer Interaction

Computers are now embedded in devices ranging in size from space stations to fingernails, yet human brains must still understand their user interfaces. The Human-Computer Interaction (HCI) Certificate supplies the skills and knowledge students need to work in this new environment, which includes the Web, multimedia, wizards, agents, and still-developing technologies. The HCI certificate program consists of four three-credit courses related to the issues found in human-computer interactions: COMM-6740 Foundations of HCI Usability, COMM-6760 Electronic Coaching Systems, COMM-6750 Communication Design for the World Wide Web, and COMM-6810 Studio Design in HCI. This certificate is available to both on-campus and distance students as either a stand-alone certificate or as an option in both M.S. programs.

Cooperative Education

Rensselaer’s Career Development Center operates an extensive cooperative education program. Cooperative education assignments (co-ops) usually last from three to 12 months and provide full-time employment at full-time wages in industry or government. Employers throughout the United States offer LL&C students co-op opportunities in writing, graphic design, and other communication activities. Participating students reap a number of benefits from this experience: skills and practical experience, a concrete application for their academic work, and a way to test their interest in certain types of work.

While co-op opportunities cannot be guaranteed, usually the number of companies interested in sponsoring co-ops exceeds the number of available students. Students should note that co-ops also extend the amount of time required to complete the M.S. degree. Those who seek co-ops must plan to complete required courses while they are on campus. Since a co-op assignment involves full-time work at an employment site with no opportunity for Rensselaer faculty to directly observe the student's work performance, students are eligible for placement only after they have matriculated in the department,
spent at least a semester doing on-campus course work, and have completed COMM-6110 Writing and Editing (Technical Communication); COMM-6820 Foundations of HCI Usability (HCI concentration); and at least one additional LL&C course (such as COMM-6530 Communication Research I). International students should also be aware of the need to satisfy Immigration and Naturalization Service requirements before accepting employment in the United States.

Course Descriptions
Courses related to all LL&C curricula are described in the Course Descriptions section of this catalog under the department codes COMM, LANG, LITR, or WRIT.

Science and Technology Studies
Chair: Sharon Anderson-Gold
Undergraduate Adviser: David Nichols
Director of Graduate Programs: Steve Breyman
Director Professional EEVP Master's Program: Steve Breyman
Department Home Page: http://www.rpi.edu/dept/sts/

The Department of Science and Technology Studies (STS) conducts interdisciplinary teaching and research on the social aspects 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 human dimensions 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

**Anderson-Gold, S.**—Ph.D. (New School for Social Research); ethics, social and political philosophy, history of philosophy.

**Caporael, L.R.**—Ph.D. (University of California, Santa Barbara); evolutionary theory; decision making, interpersonal dimensions of computing.

**Hess, D.**—Ph.D. (Cornell University); science, technology, and communities; nutrition and health.

**Layne, L.**—Ph.D. (Princeton University); medicine and culture, new reproductive technologies, popular images of nature, feminist methods.

**Restivo, S.**—Ph.D. (Michigan State University); sociology of science, sociological theory.

**Winner, L.**—Ph.D. (University of California, Berkeley); political theory, politics of technology.

Associate Professors

**Breyman, S.**—Ph.D. (University of California, Santa Barbara); political economy of environment, science, and society.

**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); international politics, environmentalism, and the law.

**Woodhouse, E.J.**—Ph.D. (Yale University); policy of science and technology, decision making.

Assistant Professors

**Akera, A.**—Ph.D. (University of Pennsylvania); history of scientific and technical computing, innovation studies.

**Campbell, N.**—Ph.D. (University of California, Santa Cruz); drugs and pharmaceutical policy, women and health, women's studies.

**Fortun, M.**—Ph.D. (Harvard University); historical and ethnographic studies of genomics, biotechnology of life sciences, critical scientific literacy.

**Fouche, R.**—Ph.D. (Cornell University); history of American technology, theories of race and racism, African-American studies, invention, design, and intellectual property.

**Vostral, S.**—Ph.D. (Washington University); U.S. history, women's studies, reproductive products.

Clinical Assistant Professor

**Boyer, K.**—Ph.D. (McGill University); urban design; information technology; gender and work.

Institute Dean and Professor

**Phelan, T.**—S.T.L (Theological College of the Catholic University of America); Institute Dean and Historian.

Adjunct Assistant Professor

**Everett, M.**—A.B.D. (Erasmus University); sustainable livelihoods and sustainable development.

**Young, N.**—Ph.D. (University of Chicago); entrepreneurship.

*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 2005 Board of Trustees meeting.
Undergraduate Programs
The Department of Science and Technology Studies initiated a bachelor of science degree program in the 1985–86 academic year. 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
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, math, and computing requirement. 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 usually include the following: STSH/STSS-1110 Introduction to STS, two of the 2000-level STS concentration options courses, a methods/statistics option, two of the 4000-level STS advanced options, a public service internship, and a senior project or thesis. The department chair or undergraduate adviser may allow substitutions.

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 discussed. Additional elements include skills training in computing, statistics, and research methods; strong development of speaking and writing skills; and opportunities to serve as faculty research assistants.

In cooperation with a faculty adviser, each student tailors a program of study to his or her interests. So, for example, a student interested in environmental issues can combine technical courses in environmental engineering and/or science with STS Advanced Option courses in Environment and Society (see list below). These can also be accompanied by other courses in humanities and social sciences such as ECON-4230 Environmental Economics. An internship with a New York state environmental agency and a senior project on regulation of acid rain or hazardous waste are additional possibilities for environmentally geared students.

Although specific courses will vary based on such individual interests, the template below provides a sample STS curriculum.
## Undergraduate Curriculum

### First Year

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<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
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<tr>
<td>MATH-1500 Calculus ¹ ..........................4</td>
<td>MATH-1520 Mathematical Methods in Mgmt. and Eco. ¹ ..........................4</td>
</tr>
<tr>
<td>Science Seq. ¹ ................................4</td>
<td>Science Seq. II ² ................................4</td>
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<td>STSS-1110 Introduction to STS ................4</td>
<td>STS Conc. Options ................4</td>
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<td>Hum. or Soc. Sci. Elective ................4</td>
<td>Hum. or Soc. Sci. Elective ................4</td>
</tr>
<tr>
<td>CSCI-1100 Computer Science I ................4</td>
<td>Sci. or Math Elective ................4</td>
</tr>
<tr>
<td>STS Conc. Options ................4</td>
<td>STS Methods/Stats. Option ................4</td>
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### Second Year

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<tr>
<td>STSS-4800 Pub. Serv. Internship ................4</td>
<td>STS Technical Option ................4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective ................4</td>
<td>Advanced STS Option ................4</td>
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<tr>
<td>Elective ................4</td>
<td>Elective ................4</td>
</tr>
<tr>
<td>CSCI-1100 Computer Science I ................4</td>
<td>STS Technical Option ................4</td>
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<td>Advanced STS Option ................4</td>
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### Third Year

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<tr>
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<tr>
<td>STSS-2100 Medicine and Society: Perspectives on Science and Technology</td>
<td>STSS-2400 Law, Values, and Public Policy: Perspectives on Science and Technology</td>
</tr>
<tr>
<td>STSS-2200 Engineering, Design, and Society: Perspectives on Science and Technology</td>
<td>STSS-2550 Information, Society, and Culture: Perspectives on Science and Technology</td>
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<td>STSS-2300 Environment and Society: Perspectives on Science and Technology</td>
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### Fourth Year

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<tr>
<td>STS Technical Option ................4</td>
<td>STS Technical Option ................4</td>
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<tr>
<td>Advanced STS Option ................4</td>
<td>STSS-4980 STS Senior Project ................4</td>
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<td>STS Technical Option ................4</td>
<td>STSS-4980 STS Senior Project ................4</td>
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<td>Elective ................4</td>
</tr>
<tr>
<td>Electives ................8</td>
<td>Elective ................4</td>
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</table>

### Concentrations

STS offers several concentration “options,” each of which is described below.

**STS Concentration options**

These are two survey courses, selected with student adviser assistance from among the following five courses, each of which represents one of the concentrations in science and technology. In addition, STSS-2500 Historical and Cultural Perspectives on Science and Technology may be included. STSS-2960 Century of the Gene* may be taken instead of STSS-2100 Medicine and Society and STSS-2200 Engineering, Design, Culture, and Society* may be taken instead of STSS-2200 Engineering, Design and Society.

1. Other mathematics options may be selected with the permission of the student’s adviser.
2. The science sequence may be selected, with the assistance of the student’s adviser, from among 1000-level introductory sequences in biology, chemistry, geology, or physics, including ERTH-1030, ERTH-1040. See the handout on the science core available from the School of Science.

* A special topics course.
**STS Methods/Statistics Option** is one course, selected with the assistance of the student’s adviser, in either (1) research methods, (such as STSS-4130 Decision Making), a third course from among the STS Concentration Options listed above, or under special circumstances, a graduate-level research methods seminar; or (2) statistical methods, such as ENGR-2600 Modeling and Analysis of Uncertainty, ECON-4120 Quantitative Analysis, PSYC-2310 Experimental Methods and Statistics, or DSES-2010 Statistics for Management.

**Advanced STS options**
These are two related courses selected with adviser assistance from one of the following five lists, each of which represents one of the concentrations on science and technology.

**Biology, Medicine, and Society: Perspectives on Science and Technology**
- STSH-4960 Biofutures*
- STSS-4260 Sociology of Medicine
- STSS-4303 Body: Self, Symbol, and Politics
- STSS-4620 History of Medicine
- STSS-4290 Topics in Science, Technology, and Society
- STSS-4960 Human Evolution

**Environment and Society: Perspectives on Science and Technology**
- STSH-4300 Environmental Philosophy
- STSS-4320 Environmental Politics and Policy
- STSS-4390 Environment and International Policy
- STSS-4400 Risky Technologies
- STSS-4500 Environment and Development
- STSS-4540 Environment, Law, and Culture
- STSS-4920 Topics in Science, Technology, and Society

**Law, Values, and Public Policy: Perspectives on Science and Technology**
- STSH-4170 Ethical Issues in Computing
- STSS-4230 Engineering Ethics
- STSS-4740 Philosophy of Law
- STSS-4920 Topics in Science, Technology, and Society
- STSS-4110 Social Effects of Science and Technology
- STSS-4130 Decision Making
- STSS-4140 Inequality in America
- STSS-4270 Social Relations of Science
- STSS-4310 Politics of Science and Technology
- STSS-4350 Politics of Design
- STSS-4360 Contemporary Political Thought
- STSS-4390 Environment and International Policy
- STSS-4540 Environment, Law, and Culture
- STSS-4920 Topics in Science, Technology, and Society

**Engineering, Design, and Society: Perspectives on Science and Technology**
- STSH-4170 Ethical Issues in Computing
- STSS-4230 Engineering Ethics
- STSS-4920 Topics in Science, Technology, and Society
- STSS-4110 Social Effects of Science and Technology
- STSS-4250 Human Dimensions of Biomedical Technologies
- STSS-4270 Social Relations of Science
- STSS-4310 Politics of Science and Technology
- STSS-4350 Politics of Design
- STSS-4400 Risky Technologies
- STSS-4560 Gender, Science, and Technology
- STSS-4650 History of American Technology
- STSS-4660 History of American Science
- STSS-4920 Topics in Science, Technology, and Society
- STSS-4960 History of Information Technology*

**Information and Society: Perspectives on Science and Technology**
- STSH-4170 Ethical Issues in Computing
- STSS-4670 History of Information Technology
- STSS-4130 Decision-Making
- STSS-4310 Politics of Science and Technology
- STSS-4350 Politics of Design
- STSS-4650 History of American Technology
- STSS-4600 History of American Science
- STSS-4960 Mind, Self, and Culture*
- STSS-4960 Information Technology: Social, Legal, and Policy Issues*
- STSS-4960 AI, Robotics, and Society*

* This is a special topics course
**STS Technical options**
These four related courses are selected with student adviser assistance from among the course offerings of the Schools of Architecture, Engineering, Management, or Science (and Electronic Arts for dual majors). Students are encouraged to earn a minor or a second major through these courses or in combination with other electives. Minors can be earned, for example, in biology, computer science, environmental engineering, or science and management. The STS adviser may approve a proposal for a technical option in the School of Humanities and Social Sciences.

**Dual Major Programs**
Many STS majors choose to fulfill the requirements for a second major. For example, a pre-med student pursuing the biology, medicine, and society track within the STS major may pursue a dual major with biology, or an STS major pursuing the information and society track may pursue a dual major with computer science or information technology. There are also dozens of other dual major possibilities. There are also interdisciplinary dual major programs that have been specially developed for STS majors. These include Product Design and Innovation and Ecological Economics, Values, and Policy. For more information on these options, consult the Interdisciplinary Programs and Research section at the end of this Humanities and Social Sciences portion of the catalog.

**Minor Programs**
The STS department offers five minors, all of which are explained below. These minors generally consist of four related courses in a specialized area of study. At least two of these courses must be at the 4000-level. No Pass/Fail courses may be applied to the 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.

In addition to minors administered solely by the STS department, there are some interdisciplinary minor options. These include the interdepartmental minors Ecological Economics, Values, and Policy (EEVP) and Gender, Science, and Technology, and the Interschool Minor in Energy. While the EEVP minor program is outlined below, the latter program is detailed at the end of this departmental section under the heading Interdisciplinary Programs and Research.

STS department administered minors are as follows:

**Science, Technology, and Society**
All STS courses, including the first-year IHSS-1963 Science, Technology and Society*, may count toward the minor in STS, provided that the restrictions described for all department minors described above are met.

**Anthropology**
Anthropology is the study of the origins, development, and cultures of the human species. Cultural anthropology studies the full range of human societies—from tribal to complex modern societies. These studies are approached from a cultural perspective involving a community’s body of shared knowledge and understanding about the world. The anthropological perspective is multidisciplinary, comparative, holistic, and historical evolutionary.

Anthropology courses are listed under the course code STSS in the Course Descriptions section of this catalog. The following courses are those that the undergraduate director has approved for credit toward the anthropology minor.

*A special topics course.*
History

Today’s events and circumstances are a consequence of past situations and developments. As a result, understanding the present—as distinct from simply experiencing it—requires attention to history. The disciplined study of the past through written records and artifacts, as well as descriptions of witnesses, commentators, and critics, has long been part of the intellectual foundation of an educated person. History unfolds in ways that sometimes confound the expectations of both logic and predictive science, demonstrating the depth and complexity of human affairs. Thus, historical study provides valuable insight otherwise lacking in a curriculum of specialized, present-oriented branches of science and engineering. Simultaneously, historical cases present valuable evidence for social scientists or managers seeking the regularities of human events. Well-trained professionals ignore such resources at their peril.

History courses are listed in the STSH and STSS sections in the Course Descriptions section of this catalog. The following courses or those approved by the undergraduate director count toward the history minor:

- STSH-2670 History of 19th Century Europe
- STSH-296x/STSS 2960 War Since Napoleon*
- STSS-2630 Foundations of American History
- STSS-2640 History of the United States since 1877
- STSS-2680 History of Contemporary Europe
- STSS-2740 World War II
- STSS-2940/STSS 4940 Readings in History 1860-1980
- STSS 296x/4960 Topics in History
- STSS-296x/STSS 2960 Historical and Cultural Perspectives on Science and Technology
- STSS-2640 History of the United States since 1877
- STSS-2840 World War II
- STSS-2940/STSS 4940 Readings in History 1860-1980
- STSS 296x/4960 Topics in History
- STSS-2640 History of the United States since 1877

Political Science

Political science is the investigation of how people govern themselves. This investigation encompasses both normative and empirical dimensions, i.e., the goals and purposes of politics as well as the political behavior of people as individuals and in groups. Emphasizing public policy integrates the normative and empirical aspects of political science. Social and economic questions, which always have moral and ethical dimensions, are framed as policy questions and addressed in policy decisions within the political process. Many of the department’s political science courses deal explicitly with facets of science and technology policy. The political science curriculum thus provides an excellent adjunct to professional training in science and engineering.

Political science courses are listed under STSS in the Course Descriptions section of this catalog. The following courses or those approved by the undergraduate director count toward the political science minor:

- STSS-1310 Principles and Practices of American Government
- STSS-1330 International Relations
- STSS-2400 Law, Values, Public Policy
- STSS-4130 Politics of Science and Technology
- STSS-4230 Environmental Politics and Policy
- STSS-4330 World Politics
- STSS-4350 Politics of Design
- STSS-4360 Contemporary Political Thought
- STSS-4400 Risky Technologies
- STSS-4500 Environment and Development
- STSS-4800 Public Service/Professional Careers Internships
- STSS-2940/4940 Readings in Political Science
- STSS-2960/4960 Topics in Political Science

* A special topics course.
Sociology
Sociology is the study of human interactions and social groups. It concentrates on the aspects and trends of social life that are common to all cultures: social institutions, social problems, social movements, population problems, science, medicine, and social change. The sociologist studies all aspects of social behavior—in couples; families; laboratories and operating rooms; religious, professional, and political organizations; assembly lines; and national and international contexts. This information adds a perspective for understanding human ethical problems, developing policy alternatives, and mitigating emerging social problems.

Sociology courses are listed under STSS in the Course Descriptions section of this catalog. The following course or those approved by the undergraduate director count toward the sociology minor.

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
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<td>STSS-4110</td>
<td>Social Effects of Science and Technology</td>
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<tr>
<td>STSS-4140</td>
<td>Inequality in America</td>
</tr>
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<td>STSS-4200</td>
<td>China: Past and Present</td>
</tr>
<tr>
<td>STSS-4250</td>
<td>Human Dimensions of Biomedical Technologies</td>
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<tr>
<td>STSS-4260</td>
<td>Sociology of Medicine</td>
</tr>
<tr>
<td>STSS-4270</td>
<td>The Social Relations of Science</td>
</tr>
<tr>
<td>STSS-296x/496x</td>
<td>Topics in Sociology</td>
</tr>
</tbody>
</table>

Ecological Economics, Values, and Policy
The EEVP minor combines the best of both the Economics and STS departments—incisive economic analysis and broad humanities and social science analysis that emphasize the roles science and technology play in today’s global political-economy and culture. Given the strong interdisciplinary background acquired in EEVP, graduates can play a leading role in resolving the critical environmental and social problems of the 21st century. The United Nations reports that the demand for EEVP-type program graduates exceeds the supply. According to the UN, it is crucial that we educate people who understand that “sustainable development does not merely deal with the conservation of nature or the management of ecosystems, but more broadly and fundamentally aims at new models of societal development and social transformations.”

EEVP courses are listed under ECON, STSH, and STSS in the Course Descriptions section of this catalog. The following courses or those approved by the undergraduate director count toward the EEVP minor.

**Required:**
- ECON-2010 Managerial Economics
- STSS-2300 Environment and Society

**Choice of one of the following:**
- ECON-4230 Environmental Economics
- ECON-4240 Natural Resource Economics
- ECON-4250 Ecological Economics
- ECON-4960 Topics in Economics*

**Choice of one of the following:**
- STSS-4300 Environmental Philosophy
- STSS-4540 Environment, Law, and Culture
- STSS-4320 Environmental Politics and Policy
- STSS-4500 Environment and Development
- STSS-4390 Environment and International Policy
- STSH/STSS-4920, 4960 Topics in Science, Technology, and Society/STS*

*A special topics course.
Gender, Science, and Technology
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.

1000 Level (must take at least one):
IHSS-1960 Art, Technology, and Society **
IHSS-1960/STSH-1110/STSS-1110 Introduction to Science and Technology Studies **

2000 Level:
ARTS-2100 Television and Culture
COMM-2800 Interpersonal Communication
LITR-2770 Women Writers
PHIL-2500 Bioethics
PHIL-2600 Moral Development

4000 Level
ARTS-6960 Electronic Arts Theory: Contemporary Art and Culture *
COMM-4640 Language and Power
COMM-4960 Advertising and Culture *
PHIL-4300 Feminist Theory *
PHIL-4750 Cognition and Education

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 laynel@rpi.edu for more information.

Interschool Minor in Energy
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 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.

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.

* With approval of EEVP Minor Adviser, Professor Steve Breyman, ext. 8515, Sage 5207, or breyms@rpi.edu
** These IHSS-1960 courses are in the First Year Studies Program
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. In addition Rensselaer has established a working relationship with Columbia University Law School that allows an especially gifted STS-law student to become a candidate for admission after his or her third year at Rensselaer, if nominated by a committee within the STS Department. Rensselaer’s inclusion in Columbia’s Accelerated Interdisciplinary Legal Education Program (AILE) has made this opportunity possible. 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
Rensselaer’s Department of Science and Technology Studies is one of the few such departments in the world to offer STS degrees from the baccalaureate to the doctoral level. Graduate programs lead to the Master of Science and the Doctor of Philosophy degrees in Science and Technology Studies. Rensselaer is committed to developing STS as a field of inquiry emphasizing the historical, political, and social dimensions of our technological society. The diverse STS faculty, drawn from a broad range of academic disciplines, provides students with the concepts and methods necessary to develop an integrated understanding of the culture’s technological and human elements.

STS faculty and graduate students are involved in a variety of research projects. Topics include careers of technical professionals, the ethnography of science, history of medicine and the role of quantification, and the nature of scientific inquiry. Additional research efforts focus on gender and reproductive technology;

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Option One

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
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<td>STSH-4300</td>
<td>Environmental Philosophy</td>
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<tr>
<td>STSS-2300</td>
<td>Environment and Society</td>
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<tr>
<td>STSS-4320</td>
<td>Environmental Politics and Policy</td>
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<td>STSS-4300</td>
<td>Word Politics</td>
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<td>STSS-4390</td>
<td>Environmental and International Policy</td>
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<td>STSS-4400</td>
<td>Risky Technologies</td>
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<tr>
<td>STSS-4500</td>
<td>Environment and Development</td>
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<tr>
<td>STSS-4540</td>
<td>Environment, Law, and Culture</td>
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Option Two

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<td>ARCH-4350</td>
<td>Energy-Conscious Design</td>
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<td>CIVL-2020</td>
<td>Transportation Engineering Fundamentals</td>
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<tr>
<td>ENVE-4430</td>
<td>Nuclear Power Plant Systems</td>
</tr>
<tr>
<td>EPOW-4010</td>
<td>Power Engineering Fundamentals</td>
</tr>
<tr>
<td>MANE-4700</td>
<td>Solar Devices and Renewable Energy</td>
</tr>
<tr>
<td>MGMT-4960</td>
<td>Electric Utilities and Environmental Management*</td>
</tr>
</tbody>
</table>

* A special topics course.
science, psychiatry, and religion; the politics of technological design; community impact of technological change; the impact of scientific instruments; science/government relations; and ethics and values in science and engineering.

Master’s Programs
The STS Department offers several master of science degree options, all of which are described in detail below.

Master of Science
This program is designed for students with undergraduate training in the natural and social sciences, engineering, or humanities. 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. Students may use the M.S. as a professional program or as a prerequisite for doctoral studies at Rensselaer or other universities.

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 is available for Rensselaer undergraduates wishing to earn an STS graduate degree. Students may apply to the program on completion of their sophomore year.

Master of Science/Doctor of Philosophy
Students who are enrolled in the M.S./Ph.D. program must complete a total of 90 credit hours (up to 30 in the dissertation). Students in the combined M.S./Ph.D. program are not required to take the core master’s courses, but they 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.

Doctoral Programs
The STS Department’s doctor of philosophy program trains professionals for stewardship of the complex technological society as researchers, teachers, planners, and advisers in academic, government, and private institutions.

The curriculum requires a total of 90 credit hours (up to 30 in dissertation) including 60 hours of study beyond the master’s degree. 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-6030 Nature of Inquiry, 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 to meet the theory option. The graduate committee may also approve substitutions of other graduate courses for Advanced Research Methods, either inside or outside the STS Department.

Remaining course work is drawn from three areas: policy studies, science studies, and technology studies. At least two additional 6000-level STS seminars (or independent reading courses of three or more
students) must be included. The field examination covers two of these three areas.

**Special Graduate Opportunities**

**Certificate in Multidisciplinary Environmental Studies**

This certificate may be awarded to master’s students who choose to add 15 credit hours of science and/or engineering, earning the equivalent of a minor in environmental science or engineering. Courses may include BIOL-4850 Principles of Ecology, CHEM-4810 Chemistry of the Environment, ERTH-4810 Environmental Geology, and IENV-4700 One Mile of the Hudson River, or other environmental courses as approved by the adviser. Students should focus their additional 15 credit hours on an area of study that complements their individual project work in the rest of the program.

**Course Descriptions**

Courses related to all STS curricula are described in the Course Descriptions section of this catalog under the department codes STSH or STSS. Students in these programs often take courses in other Institute 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 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 and Social Sciences described below, 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.

**Electronic Media, Arts, and Communication**

**Chair:** Kathy High, Art

**Chair:** James Watt, Language, Literature, and Communication

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 Language, Literature, and Communication (LL&C). It combines offerings in LL&C 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; ARTS-1020 Media Studio: Imaging; ARTS-1010 Media Studio: Video/Audio. In Level Two, students complete 24 credit hours in selected LL&C and Arts courses in writing (4), art history/theory (4), and a short list of courses in the areas of electronic art; electronic communication and design; literature, film, media and culture; and professional communication. Level Three requires an EMAC concentration, consisting of 12 credit hours of 4000-level LL&C, Arts, or other courses as part of a plan of study approved by the academic adviser. Senior students at Level Four take eight credits of Honors Capstone or Culminating Experience Sequence, consisting of four credit hours in each of their last two semesters.
<table>
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<th>First Year</th>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
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<tr>
<td>IHSS-196x (COMM-1510) Introduction to Communication Theory</td>
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<td>ARTS-1010</td>
<td>Media Studio: Video/Audio ............ 4</td>
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<tr>
<td>ARTS-1020</td>
<td>Media Studio: Imaging ............ 4</td>
<td>COMM-2610</td>
<td>Intro. to Visual Communication ....... 4</td>
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<td>MATH-1500</td>
<td>Calculus I for H&amp;SS ............ 4</td>
<td>CSCI-1010</td>
<td>Intro. to Computer Programming ...... 4</td>
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<td>or</td>
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<td>Elective 2 ................. 4</td>
<td>EMAC Art History/Theory</td>
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<tr>
<td>EMAC Electronic Art Elective 3</td>
<td>...... 4</td>
<td>EMAC Language, Literature and Comm. Elective 4</td>
<td>Humanities Elective ................ 4</td>
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<td>EMAC Concentration 5</td>
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<td>EMAC Language, Literature, and Comm. Elective 4</td>
<td>............ 4</td>
<td>Humanities Elective</td>
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<td>Social Science Elective</td>
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<td>Honors Capstone or Culminating Experience Sequence</td>
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<td>Free Elective</td>
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<tr>
<td>Free Elective</td>
<td>.................. 4</td>
<td>Honors Capstone or Culminating Experience Sequence</td>
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<tr>
<td>Free Elective</td>
<td>.................. 4</td>
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</table>

1 EMAC Writing Electives (4 credit hours required) WRIT-1110; WRIT-2110.
2 Art History/Theory Electives (4 credit hours required) ARTS-2100; ARTS-2500; ARTS-2540; ARTS-2510; ARTS-296x (approved Topics Courses in Art History/Theory); ARTS-4100; ARTS-4120.
3 EMAC Computer Arts Electives (8 credit hours required) ARTS-2010; ARTS-2020; ARTS-2030; ARTS-2040.
4 EMAC Language, Literature, and Communication Electives (8 credit hours required) Students must select courses from two separate areas of EMAC LL&C Electives. These areas are: Electronic Communication and Design; Literature, Film, Media, and Culture; and Professional Communication. Electronic Communication and Design: COMM-296x (approved Topics courses in Electronic Communication and Design); COMM-4340; COMM-4650; COMM-4750; COMM-4720; WRIT-2510. Literature, Film, Media, and Culture: COMM-2410; COMM-2460; COMM-296x (Religion, Culture, and Media); COMM-4580; Any literature course (LITR 2000-4000); LITR-2420; LITR-2460; LITR-4410; LITR-4450. Professional Communication: WRIT-2340; WRIT-2360; WRIT-2410; WRIT-2500; WRIT-2520; WRIT-296x. (approved Topics in Profess. Comm.)
5 EMAC Concentration (12 credit hours at 4000 level required) A thematic concentration is required of all EMAC majors. ARTS, LL&C, or any thematically related courses in other departments may be taken with approval of the academic adviser. This concentration will provide depth and may lead toward (or be taken in conjunction with) the EMAC Honors Capstone or Culminating Experience Sequence.
Ecological Economics, Values, and Policy

Director: Steven Breyman, Science and Technology Studies

The Departments of Science and Technology Studies and Economics jointly offer the Program in Ecological Economics, Values, and Policy (EEVP), which offers both bachelor’s and master’s of science degrees. EEVP 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. Given the strong interdisciplinary background acquired in EEVP, graduates can play leading roles in resolving the critical environmental and social problems of the 21st century. The United Nations reports that the demand for EEVP-type program graduates exceeds the supply. According to the UN, it is crucial that we educate people who understand that “sustainable development does not merely deal with the conservation of nature or the management of ecosystems, but more broadly and fundamentally aims at new models of societal development and social transformation.”

Baccalaureate Program

EEVP has four main components: eight economics courses (all courses are four credit hours), eight STS courses, 10 science or engineering courses, and four free electives as well as an H&SS First-Year Studies course. The science and engineering component should earn the equivalent of a minor in environmental science or engineering, which can cover such topics as ecology, environmental chemistry or geology, water and wastewater infrastructure, and hazardous waste management. In addition, the economics and social science courses that form the core of EEVP equip students with a variety of skills and methods to assess the economic costs, human health impacts, and quality-of-life changes that are associated with the evolving lifestyles and living conditions in today’s society. Cultural studies add to EEVP’s strong global focus, which prepares students for a successful career in policy analysis, international development, project assessment, and many other areas. The capstone STS Senior Project, on which students work with an adviser from each department, integrates the economics and STS components.

To illustrate a typical distribution of these courses over the regular four-year period of bachelor’s degree study, a sample semester layout is provided below.

Concentrations

The EEVP curriculum offers several concentration “options” each of which is described below.

STS Concentration option In addition to taking STSS-2300 Environment and Society in the fall of the second year, students choose one other STS concentration course: STSS-2100 Medicine and Society; STSS-2400 Law, Values, and Public Policy; STSS-2500 Historical and Cultural Perspectives on Science and Technology; or STSS-2200 Engineering, Design, and Society.

STS Methods/Statistics option Students choose one course in either research methods, such as STSS-4130 Decision Making; or statistical methods, such as PSYC-2310 Experimental Methods and Statistics or DSES-4140 Statistical Analysis.

STS Technical option Students choose four courses, together with the Institute Science core requirement of six courses, to earn the equivalent of a minor in environmental science or engineering. This option includes such courses as BIOL-4850 Principles of Ecology, CHEM-4810 Chemistry of the Environment, and ERTH-1200 Geology II (surface geology) or ENVE courses as approved by the adviser.
**Advanced STS option** Students choose two courses from the following list:

ECON-4210 Cost Benefit-Analysis  
ECON-4230 Environmental Economics  
ECON-4240 Natural Resource Economics, and  
ECON-4250 Ecological Economics  
STSH-4300 Environmental Philosophy  
STSS-4320 Environmental Politics and Policy  
STSS-4400 Risky Technologies  
STSS-4500 Environment and Development  
STSS-4540 Environment, Law, and Culture  
STSS-4920 Topics in STS (e.g., Environment and Health)

### First Year

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<th>Spring</th>
<th>Credit hours</th>
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Professional Master’s Program

The Departments of Science and Technology Studies and Economics also jointly offer an EEVP master’s program. The program builds on Rensselaer’s nationally recognized expertise and course offerings in the economic, political, social, cultural, and ethical implications in the interactions of science, technology, environment, and society. EEVP is meant for early and mid-career professionals in state and local government, secondary education, business, and the nonprofit sector (professionals in environmental nongovernmental organizations) who wish to upgrade their skills and advance their careers.

Building on required courses in environmental, ecological, and natural resource economics and in environmental philosophy and policy, EEVP helps students acquire the skills such as policy analysis and ecological valuation that are necessary to address the complex multidisciplinary problems any society faces in areas such as environment and health, appropriate technology, and sustainable development. The 21st century promises a continuation of the march toward globalization. Dealing with the prospects and problems of a world economy and the growing human impact on the natural world requires an education that is both broad and deep. EEVP offers “hands on” training that puts into practice the slogan “think globally, act locally.”

Economics requirements for the EEVP master’s degree include two common courses for a total of six credit hours—ECON/STSS-6600 Seminar in EEVP (the common introductory course) and ECON/STSS-6650 EEVP Professional Project (the common capstone course). Also required are four economics courses for a minimum of 12 credit hours.

Additional requirements include ECON-6490 Introduction to Economic Theory, and two of the following three courses:

- ECON-6230 Advanced Environmental Economics
- ECON-6240 Advanced Natural Resource Economics
- ECON-6250 Advanced Ecological Economics

Sample electives are ECON-4150 Economics of Government Regulation, ECON-4160 Public Finance, ECON-4190 International Economics, ECON-6210 Advanced Cost Benefit Analysis, ECON-6550 Advanced Microeconomic Analysis, and ECON-6590 Advanced Macroeconomic Analysis. In addition, students must take four STS course electives for a minimum of 12 credit hours.

STS course requirements for the EEVP masters include STSH-6300 Environmental Philosophy, STSS-6300 Environment and Social Theory, and one of the following two courses:

- STSS-6320 Environmental Politics and Policy
- STSS-6540 Environment, Law, and Culture


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.
Minds and Machines Program

**Director:** Bram van Heuveln, Cognitive Science

**Department Home Page:** [http://www.cogsci.rpi.edu/minds_machines](http://www.cogsci.rpi.edu/minds_machines)

The Minds & Machines Program is an applied cognitive science undergraduate program. Students who enter the Minds & Machines Program perform cutting-edge scientific research into the nature of cognition (human or non-human), and apply this knowledge to create artificial intelligence and cognitive technologies. Students can also address philosophical questions about the fundamental nature of our mind and the ethical implications of artificial intelligence and other advanced cognitive technology. Minds & Machines Students meet biweekly to interact with fellow Minds & Machines students and associated faculty, work side by side with professors and graduate students in any of our dedicated labs, and attend guest lectures given by dominant thinkers in the field.

**Baccalaureate Program**

Cognitive science is a highly interdisciplinary science at the intersection of philosophy, psychology, and computer science. In recognition of this, students in the undergraduate Minds & Machines Program are required to do a dual major, one major reflecting the ‘Minds’ part, the other major reflecting the ‘Machines’ part. The dual major also reflects the Program’s aim of doing scientific investigation alongside technological application and innovation. Some popular trajectories are:

- Computer Science and Psychology—appropriate for students interested in the understanding and computational modeling of human reasoning, perception, and learning.
- Computer Science and Philosophy—appropriate for students interested in artificial intelligence and philosophy of mind.
- Computer Systems Engineering (or Electrical or Mechanical Engineering)—appropriate for students interested in robotics.
- Information Technology and Psychology—appropriate for students interested in cognitive engineering (engineering technology that dovetails with, or enhances, human cognition).

In addition to developing technical expertise in the relevant areas of information technology, the Minds and Machines dual majors allow students to analyze and discuss (with the help of science fiction films) the "big" questions that research and engineering in the program raise. These include questions such as: How smart can machines get? Can they become as smart as human? Is creativity the line that machines will never cross? Can machines be conscious, and how can humans tell?

For further information, access the program’s Web site at [http://www.cogsci.rpi.edu/minds_machines](http://www.cogsci.rpi.edu/minds_machines) or contact the director at heuveb@rpi.edu.
## Sample Four-Year Sequence for CSCI/PSYC Dual Major

### First Year

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<th>Fall</th>
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<th>Spring</th>
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<td>Intro. to Discrete Structures</td>
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### Second Year

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<th>Spring</th>
<th>Credit hours</th>
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<td>Data Structures &amp; Algorithms</td>
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<td>Models of Computation</td>
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<td>Computer Organization</td>
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<td>Math Elective</td>
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<td>Psychology Elective</td>
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<td>Operating Systems</td>
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<td>Psychology Elective</td>
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<td>Hum. or Soc. Sci. Elective</td>
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<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
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<tbody>
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<td>Senior Thesis</td>
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<td>Free Elective</td>
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\(^1\) Recommended.
# Sample Four-Year Sequence for CSCI/PHIL Dual Major

## First Year

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<td>Computer Science I</td>
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<td>Calculus I</td>
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<td>Introduction to Philosophy</td>
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<tbody>
<tr>
<td>Data Structures &amp; Algorithms</td>
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<td>AI for Cog Sci(^1)</td>
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<th>Spring</th>
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<tbody>
<tr>
<td>Operating Systems</td>
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<td>Computability and Logic(^1)</td>
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\(^1\) Recommended.
Product Design and Innovation
Chair: Sharon Anderson-Gold, Science and Technology Studies (Interim)
Chair: Mark Steiner (Interim)

The Schools of Engineering, Architecture, Science, and Humanities and Social Sciences jointly offer this dual major program called Product Design and Innovation (PDI). The program offers four tracks: the first satisfies the requirements for the B.S. programs in both Mechanical Engineering and Science, Technology, and Society (STS); the second satisfies the requirements for the B.S. programs in both Information Technology and STS; the third satisfies the requirements for the B.S. program in both Building Sciences and STS; and the fourth satisfies the requirements for the B.S. program in both Management and STS.

PDI 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 every semester, PDI combines the technical, aesthetic, and cultural sophistication of Rensselaer’s engineering, information technology, or building science curricula with the insight and vision of the humanities and social sciences disciplines in the STS curriculum.

Through the PDI core of design studios taken every semester, students obtain a hands-on opportunity that brings together the major curricula. The accredited mechanical engineering curriculum provides a fundamental education in mechanical engineering with a focus on design methodology in general and mechanical design techniques in particular (see template below). The information technology curriculum provides a foundation for applying information technology to other disciplines, including high technology product design. The distinction between product design and software design is that in addition to learning how to design technical aspects of the product, students will create work that is a bridge between both digital and physical form (see template below). The building science curriculum provides a fundamental education in building science and architectural design through basic and advanced courses in structures, environmental, and construction systems, as well as physical and theoretical approaches in design (see template below). The management curriculum provides a fundamental education in management with course offerings in product design, marketing, and entrepreneurship. The STS 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 studies 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. Some fall and spring semester studios are taught as a sequence to give students experience with the design process from beginning to 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 market or in a smaller business that creates an unusual solution to a local problem.
## PDI Curriculum in Mechanical Engineering and STS

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<td>Design Studio I</td>
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<td>Introduction to STS (First-Year Studies)</td>
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<td>ENGR-1300</td>
<td>Chemical Principles for Engineers</td>
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<td>ENGR-1200</td>
<td>Engineering Graphics and CAD</td>
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<td>MATH-2400</td>
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<td>ENGR-2530</td>
<td>Strength of Materials</td>
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<td>ENGR-2350</td>
<td>Embedded Control</td>
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<td>ENGR-2710</td>
<td>General Manufacturing Processes</td>
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<td>ENGR-2600</td>
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<td>ENGR-4050</td>
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<td>Thermos/Fluids Engineering I</td>
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<td>MANE-4260</td>
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<td>STSS-4800</td>
<td>Public Service Internship</td>
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<tr>
<td></td>
<td>ENGR-4300</td>
<td>Electronic Instrumentation</td>
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<td></td>
<td>MANE-4030</td>
<td>Elements of Mechanical Design</td>
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<td>ENGR-4010</td>
<td>Professional Develop. III</td>
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<tr>
<td><strong>Spring</strong></td>
<td>STSS-4980</td>
<td>STS Senior Project</td>
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<tr>
<td></td>
<td>MANE-4020</td>
<td>Thermal and Fluids Engineering II</td>
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<tr>
<td></td>
<td>MANE-4040</td>
<td>Mechanical Systems Lab</td>
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<td></td>
<td>MANE-4020</td>
<td>Thermal and Fluids Lab</td>
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</tbody>
</table>

1. These courses may be taken in any order.
2. PDI Studios II, V, VI, and VII satisfy the mechanical engineering requirement for the concentration elective.
3. For PDI students, Design Studio III can be substituted for one of the two STS concentration options.
4. IED is Design Studio IV.
5. Candidate courses include: STSS-4350; STSH-4230; STSS-4110; STSS-4250; STSS-4310; STSS-4560; and STSS-4650.
6. Design of Mechanical Systems is Design Studio VII.
7. This course satisfies the requirement for Professional Development II.
8. The STS Senior Project can be combined with the Capstone Design Studio to make an eight-credit capstone studio project.
9. See adviser for fall/spring order of fourth-year courses.
# PDI Curriculum in Information Technology and STS

## First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>ITEC-1210</td>
<td>IT Revolution 2</td>
<td>ITEC-1220</td>
<td>Politics &amp; Economics of IT 2</td>
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<tr>
<td>STSH-1110</td>
<td>Science, Technology, &amp; Society 3</td>
<td>MATH-1010</td>
<td>Calculus 1</td>
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<td>(First-Year Studies)</td>
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<td>CSCI-1200</td>
<td>Comp Science 2</td>
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<td>CSCI-1100</td>
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<td>ENGR-1300</td>
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<td>ARCH-196</td>
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## Second Year

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<tbody>
<tr>
<td>CSCI-2500</td>
<td>Computer Organization 3</td>
<td>CSCI-2300</td>
<td>Data Structures and Algorithms 3</td>
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<td>ITEC-2210</td>
<td>Intro. to HCI 3</td>
<td>STSS-2500</td>
<td>Information, Society, and Culture 3 or</td>
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<tr>
<td>ITEC-2110</td>
<td>Exploiting the Info. World 4</td>
<td>STSSH-2960</td>
<td>Design, Culture, and Society 3</td>
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<td>IHSS-2500</td>
<td>Design Studio III 5</td>
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## Third Year

<table>
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<tbody>
<tr>
<td>ITEC-4310</td>
<td>Managing IT Resources 4</td>
<td>IT Technology Elective 4</td>
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<tr>
<td>Science Core Elective 4</td>
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<td>Science Core Elective 4</td>
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<td>Probability &amp; Statistics Elective 4</td>
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<td>STS Methods Option 4</td>
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<td>ITEC-4960</td>
<td>Design Studio VI: Creative Design in IT</td>
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<td>ARCH-4960</td>
<td>Design Studio V: Industrial Design</td>
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<td>STSSH-4960</td>
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## Fourth Year

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<tbody>
<tr>
<td>STSS-4800</td>
<td>Public Service Internship 3</td>
<td>STSS-4980</td>
<td>STS Senior Project 4</td>
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<td>H&amp;SS Core Elective 4</td>
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<tr>
<td>ITEC-4100</td>
<td>Design Studio VII: IT Capstone</td>
<td>STSS-4960</td>
<td>Design Studio VIII: PDI Capstone 4</td>
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<tr>
<td>Studio 4</td>
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1. The total number of credits is 132.
2. Fulfills the requirements for the H&SS core.
3. Fulfills the requirements for the science core.
4. Fulfills the IT core requirements. For the Probability & Statistics Elective (fall third year) and the IT Technology Elective (spring third year), see the IT requirements in the Information Technology section of the catalog.
5. Fulfills the requirements for the second discipline in IT and the STS major core. For the STS Advanced Option (a 4000-level STS course), it is recommended that students select a course in either the “Engineering, Design, and Society” track or the “Information, Society, and Culture” track. See the STS section of the catalog for details on this and other STS course requirements. For PDI students, Design Studio III can be substituted for one of the two STS concentration options.
### PDI Curriculum in Building Science and STS

#### First Year

<table>
<thead>
<tr>
<th>Term</th>
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<tbody>
<tr>
<td>Fall</td>
<td>IHSS-1970</td>
<td>Design, History, and Society</td>
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<td></td>
<td>MATH-1010</td>
<td>Calculus I</td>
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<td></td>
<td>ARCH-2110</td>
<td>The Building And Thinking of Arch. 1</td>
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<td></td>
<td>ARCH-2200</td>
<td>Design Studio</td>
<td>4</td>
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<tr>
<td>Spring</td>
<td>ARCH-2210</td>
<td>Architecture Design 1</td>
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<td>STSH-296x</td>
<td>Design, Culture, and Society</td>
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<td>PHYS-1050</td>
<td>Physical Principles of Design</td>
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<td>ARCH-2120</td>
<td>The Building And Thinking of Arch. 2</td>
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<td>ARCH-2510</td>
<td>Materials and Design</td>
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<tbody>
<tr>
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<td>IHSS-2500</td>
<td>PDI Studio 3 (Industrial Design) ^1</td>
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<td>STSS-1110</td>
<td>Introduction to STS</td>
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<tr>
<td></td>
<td>ARCH-xxxx</td>
<td>Structures 1</td>
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<td>ARCH-xxxx</td>
<td>Professional Elective</td>
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<td>DSES-2010</td>
<td>Statistics</td>
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<td>ARCH-4810</td>
<td>Advanced Technology Seminar</td>
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<td>Spring</td>
<td>ENGR-2050</td>
<td>Introduction to Eng. Design ^1</td>
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<tr>
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<td>ARCH-2360</td>
<td>Env. and Ecol. Systems</td>
<td>4</td>
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<td>ARCH-2140</td>
<td>The Building And Thinking of Arch. 3</td>
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<td></td>
<td>BIOL-1010</td>
<td>Intro. to Biology</td>
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#### Second Year

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<th>Term</th>
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<tr>
<td>Fall</td>
<td>STSH-496x</td>
<td>Design Studio 5</td>
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<td>STSS-xxxx</td>
<td>STS Advanced Option ^1</td>
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<td>ARCH-4330</td>
<td>Structures 2</td>
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<td>Spring</td>
<td>ARCH-4960</td>
<td>Design Studio 6</td>
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<td>Public Service Internship</td>
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#### Third Year

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<tr>
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<td>ARCH-4960</td>
<td>Design Studio 7</td>
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<td>STSS-xxxx</td>
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<td>ARCH-xxxx</td>
<td>Final Project</td>
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<td>ARCH-4510</td>
<td>Construction Industry Seminar</td>
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<tr>
<td>Spring</td>
<td>ARCH-4960</td>
<td>Capstone Design Studio with B.S.</td>
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<td>STSS-4980</td>
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#### Fourth Year

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<tr>
<th>Term</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
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<tr>
<td>Fall</td>
<td>ARCH-4960</td>
<td>Design Studio 7</td>
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<tr>
<td></td>
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<td>ARCH-xxxx</td>
<td>Final Project</td>
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<td>ARCH-4510</td>
<td>Construction Industry Seminar</td>
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<tr>
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<td>ARCH-4960</td>
<td>Capstone Design Studio with B.S.</td>
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<tr>
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<td>STSS-4980</td>
<td>STS Senior Project ^4</td>
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<tr>
<td></td>
<td>Elective</td>
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<td>4</td>
</tr>
</tbody>
</table>

^1 For PDI students, IHSS-2500 can be substituted for the second STS concentration option.

^2 Four credits of the Institute core science requirements are embedded within the technology sequence. The science sequence may be selected, with the assistance of the student's adviser, from among 1000-level introductory sequences in Biology, Chemistry, Geology, or Physics, including ERTH-1030, ERTH-1040.

^3 Or other studio course as approved by advisers.

^4 These special design studios meet jointly with ENGR-4960 Design Studios 6, 7.

^5 Candidate courses include: STSS-4350, STSS-4960, STSH-4230, STSS-4110, STSS-4250, STSS-4310, STSS-4560, and STSS-4650.

^6 The STS Senior Project can be combined with the Capstone Design Studio to make an eight-credit capstone studio project.
### PDI Curriculum in Management and STS

#### First Year

**Fall**
- MATH-1500: Calc. For Management .....................4
- MGMT-1100: Intro. to Management.......................4
- STSH-1110: Intro. to STS .............................4
- IHSS-1500: Design Studio 1 ...........................4

**Spring**
- MATH-1520: Math Methods in Mgmt ....................4
- MGMT-2100: Statistical Methods 1 .....................4
- MGMT-2300: Accounting ...............................4
- ECON-1200: Introductory Economics ..................4
- STSH-296x: Design Studio 2 ...........................4

#### Second Year

**Fall**
- MGMT-2100: Statistical Methods 1 .....................4
- MGMT-2300: Accounting ...............................4
- ECON-1200: Introductory Economics ..................4
- STSH-296x: Design Studio 3 ...........................4

**Spring**
- MGMT-4110: Operations Management ..................4
- MGMT-4430: Marketing Principals .....................4
- MGMT-4140: Computer Information Systems ..........4
- STSS-4xxx: Advanced Option ..........................4
- STSH-4961: Design Studio 5 ...........................4

#### Third Year

**Fall**
- MGMT-4110: Quant. Methods for Business ............4
- MGMT-4430: Marketing Principals .....................4
- MGMT-4140: Computer Information Systems ..........4
- STSS-4xxx: Advanced Option ..........................4
- STSH-4961: Design Studio 5 ...........................4

**Spring**
- MGMT-4850: Managing High Perf. Org. 1 ............4
- MGMT-1260: External Environ. of Business ..........4
- STSS-4xxx: Advanced Option ..........................4
- ENGR 4960: Design Studio 6 ..........................4

#### Fourth Year

**Fall**
- MGMT-4860: Managing High Perf. Org. II .............4
- STSS-4800: Public Service Internship .................4
- Science Elective .......................................4
- Design Studio 7† .....................................4

**Spring**
- MGMT 4870: Strategy and Policy .......................4
- STSS-4980: Senior Project ............................4
- Science Elective .......................................4
- Design Studio 8† .....................................4

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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 adviser.
Table of Contents

Undergraduate Programs 309
Graduate Program 313
Recognizing that Information Technology (IT) 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 IT’s application to nearly every field from science and engineering to management to humanities and social sciences. The IT degree programs are designed for students with a strong technical aptitude that they wish to apply to other interests.

Rensselaer’s undergraduate and graduate IT degree programs consist of two components. The first is a set of core courses, many of which are technical in nature. The second is the concentration area in which students are expected to employ their technical expertise.

Each of Rensselaer’s five schools offers concentration area options to IT students. The curriculum of each of the five schools supported and formulated the IT degrees. 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 IT and the breadth of its impact on the world.

Information technology degrees available at Rensselaer include the Bachelor of Science and the Master of Science. Opportunities for Ph.D. level work in IT are under development. Those holding these degrees are in great demand and command some of the highest starting salaries and bonuses in any profession.

Faculty*

Professors
Bailey, R.A.—Ph.D. (McGill University); coordination chemistry and chemistry of molten salts (Science).
Breneman, C.M.—Ph.D. (University of California, Santa Barbara); physical organic chemistry (Science).
Bringsjord, S.—Ph.D. (Brown University); logic, philosophical logic, philosophy of artificial intelligence (Humanities and Social Sciences).
Connor, K.—Ph.D. (Polytechnic Institute of New York); electromagnetic theory, wave propagation, plasmas for fusion research and industrial applications, finite element methods (Engineering).
Flaherty, J.E.—Ph.D. (Polytechnic Institute of Brooklyn); numerical analysis, scientific computation, parallel computation, adaptive methods (Science).
Gabriele, G.A.—Ph.D. (Purdue University); design automation, design optimization (Engineering).
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 (Engineering).
Goldberg, M.K.—Ph.D. (Institute of Mathematics, Novosibirsk, Russia); algorithms for combinatorial optimization, experimental algorithm design and analysis, computational learning theory, graph theory (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 2005 Board of Trustees meeting.
Gowdy, J.M.—Ph.D. (West Virginia University); ecological economics, industrial organization and public regulation, regional economics (Humanities and Social Sciences).

Haddock, J.—Ph.D. (Purdue University); modeling of production and service systems including simulation and optimization techniques (Management).

Herron, I.—Ph.D. (Johns Hopkins University); applied mathematics, fluid mechanics, hydrodynamics, stability (Science).

Hess, D.—Ph.D. (Cornell University); science, culture, and power; social studies of alternative medicine (Humanities and Social Sciences).

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 (Engineering).

Isaacson, D.—Ph.D. (New York University); mathematical physics, biomedical applications (Science).

Kapila, A.—Ph.D. (Cornell University); applied mathematics, combustion, fluid mechanics (Science).

Lahey, R.T., Jr.—Ph.D. (Stanford University); multiphase flow and boiling heat transfer, reactor safety analysis, reactor thermal-hydraulics, and applications of chaos theory (Engineering).

List, G.F.—PE, Ph.D. (University of Pennsylvania); intelligent transportation systems, sensors, instrumentation and control, multiobjective stochastic routing and siting, freight network planning (Engineering).

Malmborg, C.J.—Ph.D. (Georgia Institute of Technology); modeling and analysis of problems in facility design, materials handling, materials flow, storage systems, simulation-based optimization methods, manufacturing systems, decision analysis (Engineering).

Miller, B.—M.F.A. (New York University Graduate Film and Television Program) (Humanities and Social Sciences).

Musser, D.—Ph.D. (University of Wisconsin); programming methodology, generic software libraries, formal methods of specification and verification, automated theorem proving (Science).

Napolitano, J.—Ph.D. (Stanford University); experimental nuclear and particle physics (Science).

Nierzwicki-Bauer, S.A.—Ph.D. (University of New Hampshire); plant molecular biology; subsurface microbiology (Science).

Rajan, K.—Sc.D. (Massachusetts Institute of Technology); electron microscopy, electronic materials, thin films and super lattices (Engineering).

Restivo, S.—Ph.D (Michigan State University) information and society; social robotics; nanotechnology and social organization; the knowledge society (Humanities and Social Sciences).

Roberge, W.G.—Ph.D. (Harvard University); theoretical astrophysics (Science).

Rolnick, N.B.—Ph.D. (University of California, Berkeley) music composition including interaction between computers and performers, distributed performance (over I2 or other networking technologies), computer as a musical instrument (Humanities and Social Sciences).

Salerno, J.C.—Ph.D. (University of Pennsylvania); bioenergetics, spectroscopy, metalloproteins (Science).

Siegel, D.—Ph.D. (Columbia University) economics of technological change, productivity analysis, corporate social responsibility (Humanities and Social Sciences).

Siegmann, W.L.—Ph.D. (Massachusetts Institute of Technology); applied mathematics, wave propagation (Science).

Spooner, D.L.—Ph.D. (Pennsylvania State University); database systems, database security, and database browsing and visualization (Science).

Wait, S.C., Jr.—Ph.D. (Rensselaer Polytechnic Institute); spectroscopy, vibrational and electronic spectroscopy (Science).

Warden, J.T.—Ph.D. (University of Minnesota); ESR spectroscopy, photosynthetic electron transport mechanisms (Science).
Willemain, T.—Ph.D. (Massachusetts Institute of Technology); probabilistic modeling, data analysis, forecasting (Engineering).

Clinical Professors
Danchak, M.M.—Ph.D. (Rensselaer Polytechnic Institute); human computer interaction, usability, information visualization, techniques for distance learning and human learning models (Science).
DeNoia, L.—Ph.D. (Brown University); telecommunications, networking, network management, effective IT organizations (Rensselaer at Hartford).
Hughes, G.—Ph.D. (Princeton University); global economics, economics of information technology (Management).
Younessi, H.—Ph.D. (Swinburne University of Technology); computer and information sciences (Rensselaer at Hartford).

Associate Professors
Adali, S.—Ph.D. (University of Maryland); heterogenous distributed information systems, database systems (Science).
Breyman, S.—Ph.D. (University of California, Santa Barbara); political economy of environment, science, and society (Humanities and Social Sciences).
Carothers, C.—Ph.D. (Georgia Institute of Technology); computer simulation, parallel simulation, parallel systems (Science).
Durgee, J.—University of Pittsburgh (Management).
Embrechts, M.J.—Ph.D. (Virginia Polytechnic Institute); fusion engineering, applied chaos theory, neural networks (Engineering).
Fortun, K.—Ph.D. (Rice University); international politics, environmentalism and the law (Humanities and Social Sciences).
Hanna, M.H.—Ph.D. (University of Illinois); slime mold development and genetics (Science).
Hannigan, J.—M.Arch. (Pratt Institute); product design, sustainable systems, history of communication (Humanities and Social Science).
Kalsher, M.J.—Ph.D. (Virginia Polytechnic Institute and State University); human factors, industrial/organizational psychology, applied experimental psychology (Humanities and Social Sciences).
Krishnamoorthy, M.S.—Ph.D. (Indian Institute of Technology); programming languages, analysis of algorithms (Science).
Krueger, T.—M.Arch. (Columbia University); human-environment interaction, design (Architecture).
Leifer, R.—Ph.D. (University of Wisconsin); organizational behavior and organizational design, management information systems (Management).
Massie, W.—M.Arch (Columbia University); architectural design, advanced computer applications and emerging technologies, computerized construction, architectural practice (Architecture).
Mistur, M.—B.Arch. (Rensselaer Polytechnic Institute); architectural design (Architecture).
Nambisan, S.—Ph.D. (Syracuse University); information systems (Management).
Parsons, R.H.—Ph.D. (Oregon State University); cellular physiology, epithelial transport (Science).
Phan, P.—Ph.D. (University of Washington); strategic management, entrepreneurship (Management).
Piper, B.R.—Ph.D. (University of Utah); computer-aided geometric design, numerical analysis, computer graphics (Science).
Ravichandran, T.—Ph.D. (Southern Illinois University, Carbondale); management information systems (Management).
Saulnier, G.J.—Ph.D. (Rensselaer Polytechnic Institute); circuits and electronics, communication systems, digital signal processing (Engineering).
Woodhouse, E.J.—Ph.D. (Yale University); policy of science and technology, decision making (Humanities and Social Sciences).
Clinical Associate Professors
Ellis, H.J.C.—Ph.D. (University of Connecticut); computer and information sciences (Rensselaer at Hartford).
Grice, R.—Ph.D. (Rensselaer Polytechnic Institute); information usability, human-computer interfaces, applications of computers to technical communication, information development in industry (Humanities and Social Sciences).
Heim, J.—Ph.D. (University at Albany); money and banking, international economics (Humanities and Social Science).
Martyn, T.O.—Ed.D. (University of Massachusetts); database systems, management information systems, client/server systems (Rensselaer at Hartford).
Peters, L.B.—Ph.D. (Rensselaer Polytechnic Institute); management information systems (Management).
St. John, W.C.—Ph.D. (Rensselaer Polytechnic Institute) accounting information systems, systems compliance with the Sarbanes-Oxley Act (Management).
Triscari, T.—Ph.D. (Rensselaer Polytechnic Institute); information systems (Management).

Assistant Professors
Akera, A.—Ph.D. (University of Pennsylvania); history of scientific and technical computing, innovation studies (Humanities and Social Sciences).
Bustamante, N.—M.F.A. (San Francisco Art Institute) art (Humanities and Social Sciences).
Bystroff, C.—Ph.D. (University of California, San Diego); bioinformatics, protein folding, computational biology (Science).
De, S.—Sc.D. (Massachusetts Institute of Technology); numerical methods in engineering, multimodal virtual environments, fast computational techniques of MEMS (Engineering).
Hübscher-Younger, T.—Ph.D. (Auburn University); computer-supported collaborative learning; educational technology; human-computer interaction; usability evaluation; software engineering; web application and interface design and development (Humanities and Social Sciences).
Korniss, G.—Ph.D. (Virginia Polytechnic Institute); theoretical and computational physics (Science).
Lonsway, B.—M.Arch. (Columbia University); architectural theory and electronic media (Architecture).
Magdon-Ismail, M.—Ph.D. (California Institute of Technology); machine learning, computational finance, bioinformatics (Science).
Nelson, M.—Ph.D. (University at Albany); information systems (Management).

Clinical Assistant Professors
Boyer, K.—Ph.D. (McGill University); IT, cities and social change; gender, work, and the politics of technology (Humanities and Social Sciences).
Brown, R.H.—M.S.E.E. (University of Illinois); computer communication networks, network management, client/server architectures (Rensselaer at Hartford).
Murtagh, J.P. Jr.—Ph.D. (Rensselaer Polytechnic Institute); investment analysis and financial services (Management).
Robbins, R.W.—M.S. (Binghamton University); accounting, information systems implementation (Management).
Sands, R.—M.S., MBA (University at Albany); organizational behavior and human resource management (Management).

Other
Hollinger, D.L.—M.S. (Rensselaer Polytechnic Institute); machine learning, AI applications for the World Wide Web, genetic algorithms, Web programming (Lecturer – Computer Science) (Science).
Kolb, J.—P. E., M. Eng. (Rensselaer Polytechnic Institute); Management of Information Systems (Chief Information Officer, DotCIO) (Management).

Miner, J.—M. S. (Stevens Institute of Technology); Information technology management, enterprise computing architectures (Director-IACS, Integrated Administrative Computing Services, DotCIO) (Management).

Undergraduate Programs

The objectives of the BSIT curriculum are to prepare students to enter a rewarding career in IT 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 IT 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 IT industry. The program is designed especially for students with interests outside the technical world, but nevertheless requires substantial technical talents and skills.

Baccalaureate Programs

Completion of the B.S. in Information Technology requires a total of 128 credit hours, of which 56 credits constitute an IT Core and 32 credits are devoted to a concentration. The remaining credit hours fulfill Rensselaer degree requirements. The IT core requirements establish a solid foundation for applying IT 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 IT 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 are illustrated below.

Math and Science Requirements: (24 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1010</td>
<td>Calculus I..................................................</td>
<td>4 credits</td>
</tr>
<tr>
<td></td>
<td>Math Elective .............................................</td>
<td>4 credits</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I.......................................</td>
<td>4 credits</td>
</tr>
<tr>
<td>CSCI-1200</td>
<td>Computer Science II......................................</td>
<td>4 credits</td>
</tr>
<tr>
<td></td>
<td>Physical-Science Elective</td>
<td>4 credits</td>
</tr>
<tr>
<td></td>
<td>Life-Science Elective</td>
<td>4 credits</td>
</tr>
</tbody>
</table>

Humanities and Social Sciences Requirements: (24 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEC-1210</td>
<td>Information in History and Society</td>
<td>4 credits</td>
</tr>
<tr>
<td>ITEC-1220</td>
<td>Politics and Economics of IT..................................</td>
<td>4 credits</td>
</tr>
<tr>
<td></td>
<td>Humanities Elective</td>
<td>4 credits</td>
</tr>
<tr>
<td></td>
<td>Social Science Elective</td>
<td>4 credits</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4 credits</td>
</tr>
</tbody>
</table>

We encourage students to take ECON-296x — The Economics of ITEC as one of their H&SS electives prior to taking ITEC-4310 — Managing IT Resources.
Free Elective Requirements: (12 credits)

- Free Elective .................................................................................................................. 4 credits
- Free Elective .................................................................................................................. 4 credits
- Free Elective .................................................................................................................. 4 credits

IT Core Requirements: (35–40 credits)

Pick either the ECSE-2610/ENGR-2350/ECSE-2660\(^2\) sequence or the CSCI-2300/2500 sequence:

- ECSE-2610 Computer Components and Operations .................................................. 4 credits
- ENGR-2350 Embedded Control .................................................................................. 4 credits
- ECSE-2660 Computer Architecture, Networking, and OS ........................................ 4 credits

or

- CSCI-2500 Computer Organization ........................................................................... 4 credits
- CSCI-2300 Data Structures and Algorithms ............................................................... 4 credits

- ITEC-2110 Exploiting the Information World ............................................................... 4 credits

IT Technology Elective (one of):

- CSCI-4380 Database Systems ..................................................................................... 4 credits
- DSES-4530 Information Systems ................................................................................ 4 credits

- ITEC-4310 Managing IT Resources ............................................................................. 4 credits
- ITEC-2960 Creativity and IT\(^1\) ................................................................................... 4 credits
- ITEC-2210 Intro. to Human Computer Interaction .................................................... 4 credits

Probability and Statistics Elective (one of):

- DSES-2010 Statistics for Management .......................................................................... 4 credits
- ENGR-2600 Modeling and Analysis of Uncertainty ..................................................... 3 credits
- MGMT-2100 Statistical Methods .................................................................................. 4 credits
- PSYC-2310 Experimental Methods and Statistics ....................................................... 4 credits

- ITEC-4100 IT Studio/Capstone Experience ................................................................... 4 credits

Student-Selected Concentration: (32 credits)

- Concentration course ................................................................................................. 4 credits
- Concentration course ................................................................................................. 4 credits
- Concentration course ................................................................................................. 4 credits
- Concentration course ................................................................................................. 4 credits
- Concentration course ................................................................................................. 4 credits
- Concentration course ................................................................................................. 4 credits
- Concentration course ................................................................................................. 4 credits
- Concentration Capstone Experience .......................................................................... 4 credits

\(^{2}\) If this sequence is chosen, ENGR-2350 can be counted towards the free elective requirement.

\(^{1}\) A special topics course.
The Concentrations from which students may choose are as follows:

<table>
<thead>
<tr>
<th>Arts</th>
<th>Finance</th>
<th>Product Design and Innovation (PDI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Sciences (Architecture)</td>
<td>Industrial Engineering</td>
<td></td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>Machine and Computational Learning</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Management Information Systems</td>
<td>Science and Technology Studies: Information and Society</td>
</tr>
<tr>
<td>Communication and Networks</td>
<td>Mechanical/Aeronautical Engineering</td>
<td>Science Informatics</td>
</tr>
<tr>
<td>Computer Hardware</td>
<td>Medicine</td>
<td>Special Interest Web Technologies</td>
</tr>
<tr>
<td>Economics</td>
<td>Pre-law</td>
<td></td>
</tr>
<tr>
<td>E-Commerce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The above list, as well as associated required courses for each Concentration, is available on the IT program web page. The list expands as new Concentrations are developed. Students wishing to devise a special interest Concentration specific to individual interests should consult their faculty advisers.

Each Concentration also stipulates an appropriate probability and statistics course for students who pursue it. This course is taken as part of the IT core. Courses that fulfill this purpose include: ENGR-2600, MGMT-2100, PSYC-2310, and DSES-2010.

Below is a typical, but not required, eight-semester course schedule for obtaining the B.S. in IT.

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEC-1210 Information in History and Society</td>
<td>ITEC-1220 Politics and Economics of IT</td>
</tr>
<tr>
<td>CSCI-1100 Computer Science I</td>
<td>CSCI-1200 Computer Science II</td>
</tr>
<tr>
<td>MATH-1010 Calculus I</td>
<td>Math Elective</td>
</tr>
<tr>
<td>Physical-Science Elective</td>
<td>Life-Science Elective</td>
</tr>
</tbody>
</table>

### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEC-2960 Creativity and IT</td>
<td>ITEC-2210 Intro. to Human Computer Interaction Concentration Course</td>
</tr>
<tr>
<td>ITEC-2110 Exploiting the Information World Concentration Course</td>
<td>One of:</td>
</tr>
<tr>
<td>One of:</td>
<td>One of:</td>
</tr>
<tr>
<td>ECSE-2610 Computer Components and Operations</td>
<td>ECSE-2660 Computer Architecture, Networking and OS</td>
</tr>
<tr>
<td>or</td>
<td>or</td>
</tr>
<tr>
<td>ENGR-2350 Embedded Control</td>
<td>CSCI-2300 Data Structures and Algorithms</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>CSCI-2500 Computer Organization</td>
<td>Probability and Statistics Elective (one of):</td>
</tr>
<tr>
<td></td>
<td>DSES-2010 Statistics for Management</td>
</tr>
<tr>
<td></td>
<td>ENGR-2600 Modeling and Analysis Uncertainty</td>
</tr>
<tr>
<td></td>
<td>MGMT-2100 Statistical Methods</td>
</tr>
<tr>
<td></td>
<td>PSYC-2310 Experimental Methods and Statistics</td>
</tr>
</tbody>
</table>

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1 Students must select either the ECSE-2610, ENGR-2350, ECSE-2660 sequence or the CSCI-2500, CSCI-2300 sequence. Students cannot mix courses from these sequences. Students interested in pursuing the MS in IT degree should take the CSCI-2500, CSCI-2300 sequence. CSCI-2300 is required for admission into the MS in IT program.

* The PDI concentration is 132 credits. Upon completion of this concentration, the student will receive a dual degree with IT and STS. See the H&SS Interdisciplinary Programs and Research Section of the catalog for the eight-semester schedule (pp. 294).
Only free electives and six credits of the H&SS electives may be taken with the Pass/No Credit option.

If a student chooses to pursue a dual degree with Information Technology as one of the degrees, the dual degree must be the degree 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. Currently, Electronic Media, Arts & Communication (EMAC) and Management are not available as a dual degree option.

**Minor Programs**

The IT minor requires four courses:

n One of the following two:

ITEC-1210/IHSS-1210 Information in History and Society
ITEC-1220/IHSS-1220 Politics and Economics of IT

n ITEC-2110 Exploiting the Information World

n Two of the following four:

CSCI-1200 Computer Science II *
ITEC-2210 Introduction to Human Computer Interaction
ITEC-4310 Managing IT Resources **
PHYS-2050 Science of Information Technology

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\* Cannot be used by CSCI and CSYS majors to satisfy this requirement.

\** Cannot be used by MGMT majors to satisfy this requirement.

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1 See Hum. and Soc. Sci. Elective requirements in H&SS section of the catalog.
Graduate Program

Information Technology is the focal point of a revolution in which computer science and computing tools and techniques drive innovation across a wide spectrum of businesses and industries. Rensselaer’s interdisciplinary Master of Science program in Information Technology, distinguished by its currency, intensity and rigor, is educating a cadre of leaders in this revolution.

Rensselaer’s degree is not an overview nor an introduction to the IT field. Students gain a theoretical grounding in computing not often acquired “on the job” and a significant body of course work in a technical IT Concentration area that will qualify them as IT specialists in that field. Rensselaer’s IT graduates are able to “do” as well as “talk about” the application of Information Technology.

The MS in IT program prepares students for advanced level employment and/or advanced study in Information Technology fields. Student interaction with Rensselaer faculty who are working on leading-edge IT research has encouraged a significant number of master’s students to continue for IT related Ph.D.’s.

The Rensselaer IT master’s program provides graduates with a breadth of experience in database systems, networking, software design, management of technology, and human computer interaction through the IT Core. In addition, students obtain in-depth experience in the application of information technology by selecting one of nine Concentrations.

The IT program is available through the Troy, N.Y., campus; Rensselaer at Hartford in Hartford, Conn.; and via Rensselaer’s Office of Education for Working Professionals.

Students seeking admission must have highly competitive academic records and have completed course work that is equivalent to the following Rensselaer courses prior to applying:

- 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 Computer Science II (pointers, classes, operator overloading, deep vs. shallow copy constructors, inheritance, file I/O, templates in C++, introductory algorithm analysis, and data structures)
- CSCI-2300 Data Structures and 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)

The Graduate Record Examination (GRE) is required of all full and part-time applicants in Troy. Applicants to the Hartford campus will be notified in writing if results of the Graduate Record Examination are required.

Master’s Program Requirements

Students admitted to the M.S. in IT develop an approved Plan of Study that must include the following:

- Ten courses in IT (a minimum of thirty 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
- A minimum of three courses (nine credit hours or more) in an approved Concentration
- One elective approved by the adviser
- The IT Master’s Capstone course
The Core and Concentration courses are designed to accommodate a wide range of backgrounds. Students can waive an IT Core area requirement and substitute an approved elective only if they have already taken the equivalent of all the courses listed in that Core area. 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 Enterprise Database Systems. 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.

Core courses are generally taken in the fall and Concentration courses in the spring. Full-time students normally begin in the fall term and take five courses in the fall and five the following spring to complete the program. Part-time students typically complete the program in two and one-half years of continuous study. Students may elect to extend the program to three semesters enabling the completion of two concentrations (12 courses) and a paid summer or summer/fall co-op assignment.

Rensselaer currently offers numerous Ph.D. degrees with significant IT 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. Once admitted to both, the student and the Ph.D. and M.S. advisers determine if the regular IT curriculum or the IT Research Track is preferred. If the Research Track is chosen, the student and the adviser select a set of concentration courses that lead to an IT intensive Master’s Thesis in place of the IT Master’s Capstone course.

**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. Courses may be delivered in a variety of modes including on-site, synchronous, asynchronous, and via videoconferencing. 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 IT web site for the most current information: [www.it.rpi.edu](http://www.it.rpi.edu).

Students enrolling at the Hartford campus or via Rensselaer’s Office of Education for Working Professionals should consult the following Web sites for course options:

- Hartford: [www.rh.edu](http://www.rh.edu/)
- Education for Working Professionals: [www.pde.rpi.edu](http://www.pde.rpi.edu/)

<table>
<thead>
<tr>
<th>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</td>
</tr>
<tr>
<td>Networking</td>
<td>ECSE-4670 Computer Communication Networks</td>
<td>Fall</td>
</tr>
<tr>
<td>Software Design</td>
<td>ECSE-6770 Software Engineering I</td>
<td>Fall</td>
</tr>
<tr>
<td>Management of Technology</td>
<td>ITEC-6300 Business Issues for Engineers and Scientists</td>
<td>Fall/Spring</td>
</tr>
<tr>
<td>Human-Computer Interaction</td>
<td>COMM-6420 Foundations of HCI Usability</td>
<td>Fall</td>
</tr>
</tbody>
</table>
IT Advanced Core

Students who have already completed the Core courses listed above select one of the advanced courses noted below:

<table>
<thead>
<tr>
<th>Advanced Core</th>
<th>Course Name</th>
<th>Term(s) Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database Systems</td>
<td>DSES-6520 Enterprise Database Systems</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6460 Advanced Database Management Topics</td>
<td>Spring</td>
</tr>
<tr>
<td>Networking</td>
<td>ECSE-6600 Internet Protocols</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>ECSE-6660 Broadband Networks</td>
<td>Spring</td>
</tr>
<tr>
<td>Software Design</td>
<td>CSCI-6090 Generic Software Design</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>CSCI-6320 Graphical User Interfaces</td>
<td>Fall</td>
</tr>
<tr>
<td>Management of Technology</td>
<td>MGMT-6610/ DSES-6470 Global Strategic Management of Technological Innovation</td>
<td>Fall/Spring</td>
</tr>
<tr>
<td></td>
<td>MGMT-6810 Management of Technical Projects</td>
<td>Fall</td>
</tr>
<tr>
<td>Human Computer Interaction</td>
<td>COMM-6750 Communication Design for WWW</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>COMM-6760 Electronic Coaching Systems</td>
<td>Spring</td>
</tr>
</tbody>
</table>

Concentration Requirements

The IT faculty designed the IT 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 e-business). 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. A new concentration in Financial Engineering is under development. For current status, please visit www.it.rpi.edu.

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Course Number and Name</th>
<th>Term(s) Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Networking</td>
<td>Select three of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSCI-4220 Network Programming</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>ECSE-6660 Broadband and Optical Networks</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>ECSE-6670 Local Computer Networks and Multiaccess Communication</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>ECSE-6600 Internet Protocols</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-4900 Computer Networking II</td>
<td>Fall/Spring</td>
</tr>
<tr>
<td></td>
<td>ECSE-6820 Queuing Systems &amp; Applications</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6500 Distributed Computing Over the Internet</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>ECSE-6900 Mobile Wireless Networks</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>CSCI-6510 Distributed Algorithms &amp; Systems</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6900 Network Security</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>CSCI-6900 Parallel &amp; Distributed Simulation</td>
<td>Spring</td>
</tr>
<tr>
<td>Human-Computer Interaction</td>
<td>COMM-6760 Electronic Coaching Systems</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>COMM-6750 Communication Design for the WWW</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>COMM-6810 Studio Design in HCI</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6320 Graphical User Interfaces</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>COMM-6770 User Centered Design</td>
<td>Spring</td>
</tr>
</tbody>
</table>
Database Systems Design
Select three of the following courses:
- CSCI-4020 Computer Algorithms Spring
- CSCI-6460 Advanced Database Management Topics Spring
- CSCI-6390 Database Mining Fall
- DSES-6180 Knowledge Discovery with Data Mining Spring
- DSES-6520 Enterprise Database Systems Spring
- CSCI-6900 Multimedia Database Systems Spring
- DSES-6530 Decision Support & Expert Systems Spring
- ECSE-6710 Fuzzy Sets & Expert Systems Fall
- CSCI-4150 Introduction to AI Fall

Software Design
Select three of the following courses:
- MGMT-6170 Advanced Systems Analysis and Design Fall
- CSCI-4440 Software Design and Documentation Fall/Spring
- CSCI-6090 Generic Software Design Fall
- CSCI-6320 Graphical User Interfaces Fall
- ECSE-6780 Software Engineering II Spring
- COMM-6810 Studio Design in HCI Spring
- CSCI-6500 Distributed Computing over the Internet Spring
- CSCI-6960 Program Analysis for Software Tools Spring

Information Systems
Select one or more Database Systems Design or Software Design courses beyond the courses taken for the core. Select two or more of the following courses:
- DSES-6500 Information and Decision Technologies for Industrial and Service Systems Fall
- DSES-6570 IT and Systems for E-Business Spring
- DSES-6560 IT and Systems for Enterprise Engineering Fall
- DSES-6530 Decision Support and Expert Systems Spring
- DSES-6620 Discrete Event Simulation Fall
- DSES-6610 Systems Modeling in Decision Sciences Fall

Management Information Systems
Select three of the following courses:
- MGMT-6170 Advanced Systems Analysis and Design Fall
- MGMT-6180 Strategic IS Management Spring
- MGMT-6810 Management of Technical Projects Fall
- MGMT-4130 Enterprise Information Architecture Spring
- MGMT-6710 Designing, Developing, and Staffing of High-Performance Organizations I Summer
- DSES-6180 Knowledge Discovery with Data Mining Spring
- DSES-6530 Decision Support & Expert Systems Spring
- MGMT-6690 Supply Chain Mgmt. for E-Business Fall

E-Business Engineering
Select two of the following courses:
- MGMT-6690 Supply Chain Mgmt. For E-Business Fall
- ECSE-6600 Internet Protocols Spring
- DSES-6180 Knowledge Discovery with Data Mining Spring
- MGMT-6560 Managing New Product Development Fall
- CSCI-6390 Database Mining Fall

1 A maximum of five management courses (code: MGMT) may be taken towards the IT degree.
| Bioinformatics | BIOL-6410 Bioinformatics I: Sequence Analysis | Fall |
|               | BIOL-6420 Bioinformatics II: Molecular Modeling | Spring |
|               | CSCI-6390 Database Mining or | Fall |
|               | CSCI-6210 Design and Analysis of Algorithms | Fall |
| Select one of the following electives: | | |
| DSES-6180 Knowledge Discovery with Data Mining | Spring |
| CSCI-6460 Advanced Database Management Topics | Spring |
| CSCI-6390 Database Mining | Fall |
| Research Track | | |
| (Example from Chemistry) | | |
| CHEM-6510 Computational Chemistry | Spring |
| CSCI-6100 Machine and Computational Learning | Fall |
| ITEC-6990 Master's Thesis (in place of IT Capstone) | TBD |

<table>
<thead>
<tr>
<th>IT Capstone Requirement</th>
<th>Course Number and Name</th>
<th>Term Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ITEC-6800 IT Master’s Capstone</td>
<td>Spring</td>
</tr>
</tbody>
</table>

2 Additional electives available subject to approval.

3 The Research Track and the Bioinformatics Concentration require a Master’s Thesis in place of the IT Master’s Capstone course.
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Lally School of Management and Technology

Dean: Iftekhar Hasan (Acting)
Associate Dean: vacant
Assistant Dean, Undergraduate Programs: Jeffrey Durgee
Director, MBA/M.S. Programs: Gina O'Connor
Associate Director, MBA/M.S. Programs (Student Services): vacant
Director, MBA/M.S. Admissions: Frank J. Mendelson
Director, Executive Programs: Richard Leifer
Co-Director, Ph.D. Program: Satish Nambisan
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 apply it across business functions. Our programs are built around the themes of innovation and entrepreneurship.

As a student you 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 position yourself 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 the students and faculty from architecture, engineering, humanities and social sciences, information technology, science, the Rensselaer Incubator, the Rensselaer Technology Park and the Severino Center for Technological Entrepreneurship.

The Lally School offers six areas of educational specialization and research for students:

- Technological entrepreneurship
- Management of information systems
- Finance
- Marketing and new product development
- Production and operations management
- Environmental management and policy (graduate-level only)

In addition, 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 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 non-residential campus focused on executive cohort Master’s programs and education for working professionals in Hartford, Conn. The Troy campus also includes Lally’s Office of Executive Programs, which administers the Executive MBA program for working managers as well as a number of customized executive-education programs for the school’s corporate partners at home and abroad.

**Degrees Offered**

Management B.S., M.S., MBA, Ph.D.

**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 Management program requires a minimum of 124 credit hours. A typical program is described below.
Concentrations

Students are encouraged to select one or more concentrations in order to provide further depth in an area of student interest. The concentrations and their associated courses are as follows:

<table>
<thead>
<tr>
<th>Financial Systems</th>
<th>Management Information Systems</th>
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</thead>
<tbody>
<tr>
<td>MGMT-4320 Investments I</td>
<td>MGMT-4240 Systems Analysis and Design</td>
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<tr>
<td>MGMT-4330 Investments II</td>
<td>MGMT-4160 Telecommunications for Business</td>
</tr>
<tr>
<td>MGMT-4340 Advanced Corporate Finance</td>
<td>MGMT-4960 Data Resource Management</td>
</tr>
<tr>
<td>MGMT-4370 Risk Management</td>
<td><strong>Restricted Elective (choose one from three below)</strong></td>
</tr>
<tr>
<td></td>
<td>MGMT-4130 Enterprise IT Integration</td>
</tr>
<tr>
<td></td>
<td>MGMT-4150 IT Project Management</td>
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<tr>
<td></td>
<td>MGMT-4550 Business Models for Digital Enterprise</td>
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</tbody>
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<table>
<thead>
<tr>
<th>First Year</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td><strong>Credit hours</strong></td>
</tr>
<tr>
<td>MATH-1500 Calculus for Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT-2510 Microcomputers and Applications</td>
<td>4</td>
</tr>
<tr>
<td>MGMT-1100 Introduction to Management</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td><strong>Second Year</strong></td>
<td><strong>Credit hours</strong></td>
</tr>
<tr>
<td>MGMT-2100 Statistical Methods</td>
<td>4</td>
</tr>
<tr>
<td>Biology Elective</td>
<td>4</td>
</tr>
<tr>
<td>MGMT-2300 Accounting for Decision Making</td>
<td>4</td>
</tr>
<tr>
<td>ECON-1200 Introductory Economics</td>
<td>4</td>
</tr>
<tr>
<td>MGMT-1240 Management Leadership I</td>
<td>2</td>
</tr>
<tr>
<td><strong>Spring</strong></td>
<td><strong>Credit hours</strong></td>
</tr>
<tr>
<td>MGMT-4110 Operations Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT-4140 Computer Information Systems</td>
<td>4</td>
</tr>
<tr>
<td>MGMT-2320 Managerial Finance</td>
<td>4</td>
</tr>
<tr>
<td>Humanities Elective</td>
<td>4</td>
</tr>
<tr>
<td>MGMT-1250 Management Leadership II</td>
<td>2</td>
</tr>
<tr>
<td><strong>Third Year</strong></td>
<td><strong>Credit hours</strong></td>
</tr>
<tr>
<td>MGMT-4100 Quantitative Methods for Business</td>
<td>4</td>
</tr>
<tr>
<td>MGMT-4430 Marketing Principles</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Writing Requirement (Humanities)</td>
<td>4</td>
</tr>
<tr>
<td><strong>Spring</strong></td>
<td><strong>Credit hours</strong></td>
</tr>
<tr>
<td>MGMT-4850 Organizational Behavior in High-Performance Organizations</td>
<td>4</td>
</tr>
<tr>
<td>Science Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Humanities or Social Science Elective</td>
<td>4</td>
</tr>
<tr>
<td>(4000 level)</td>
<td></td>
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<tr>
<td><strong>Fourth Year</strong></td>
<td><strong>Credit hours</strong></td>
</tr>
<tr>
<td>MGMT-4860 Human Resources in High-Performance Organizations</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Non-Management Elective</td>
<td>4</td>
</tr>
<tr>
<td><strong>Spring</strong></td>
<td><strong>Credit hours</strong></td>
</tr>
<tr>
<td>MGMT-4870 Strategy and Policy</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Non-management Elective</td>
<td>4</td>
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</table>

| Credit hours                     | Intro. to Computer Programming | 4 |
|----------------------------------|--------------------------------|
| CSCI-1010                        | External Environment of Business | 4 |
| MGMT-1260                        | Humanities or Social Science Elective | 4 |
| Elective                         |                                | 4 |

**Concentrations**

**First Year**

**Fall**
- MATH -1500 Calculus for Management
- MGMT-2510 Microcomputers and Applications
- MGMT-1100 Introduction to Management
- Elective

**Spring**
- MATH-1520 Math Methods in Management and Economics
- CSCI-1010 Intro. to Computer Programming
- MGMT-1260 External Environment of Business
- Elective

**Second Year**

**Fall**
- MGMT-2100 Statistical Methods
- Biology Elective
- MGMT-2300 Accounting for Decision Making
- ECON-1200 Introductory Economics
- MGMT-1240 Management Leadership I

**Spring**
- MGMT-4110 Operations Management
- MGMT-4140 Computer Information Systems
- MGMT-2320 Managerial Finance
- Humanities Elective
- MGMT-1250 Management Leadership II

**Third Year**

**Fall**
- MGMT-4100 Quantitative Methods for Business
- MGMT-4430 Marketing Principles
- Elective
- Writing Requirement (Humanities)

**Spring**
- MGMT-4850 Organizational Behavior in High-Performance Organizations
- Science Elective
- Elective
- Humanities or Social Science Elective (4000 level)

**Fourth Year**

**Fall**
- MGMT-4860 Human Resources in High-Performance Organizations
- Elective
- Non-Management Elective

**Spring**
- MGMT-4870 Strategy and Policy
- Elective
- Non-management Elective
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 following minors are offered by the Lally School and require a minimum of 16 credit hours. Each student’s designated minor adviser can approve course substitutions to meet individual student needs.

Management and Technology Minor
The minor in management and technology usually consists of the following four courses:
- MGMT-1100 Introduction to Management
- MGMT-2300 Fundamentals of Accounting for Decision Making
- MGMT-4520 Introduction to Technological Entrepreneurship
- MGMT-4510 Invention, Innovation, and Entrepreneurship
- MGMT-4530 Starting Up a New Venture
- Restricted Elective (see minor adviser)

Technological Entrepreneurship Minor
The minor in technological entrepreneurship usually consists of the following four courses:
- MGMT-1100 Introduction to Management
- MGMT-4520 Introduction to Technological Entrepreneurship
- MGMT-4510 Invention, Innovation, and Entrepreneurship
- MGMT-4530 Starting Up a New Venture
- Restricted Elective (see minor adviser)

Marketing Minor
The minor in marketing usually consists of the following four courses:
- MGMT-1100 Introduction to Management
- MGMT-4430 Marketing Principles
- MGMT-4460 Marketing Research
- MGMT-4490 Advertising Strategy and Promotions
- or MGMT-4470 Consumer Behavior and Product Design
- Restricted Elective (see adviser)

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 curriculum.

Such options can be arranged with the schools of engineering, science, architecture, or humanities 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 co-operative 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.

### Marketing
- **MGMT-4470** Marketing Research
- **MGMT-4490** Advertising Strategy and Promotions
- **MGMT-4460** Consumer Behavior and Product Design
- Restricted Elective (see adviser)

### Technological Entrepreneurship
- **MGMT-4520** Introduction to Technological Entrepreneurship
- **MGMT-4510** Invention, Innovation, and Entrepreneurship
- **MGMT-4530** Starting Up a New Venture
- Restricted Elective (see adviser)
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. Management-law students also have applied successfully for early admission to Harvard, Stanford, Cornell, and the University of Virginia. The Lally School is committed to assisting each student attain their individual educational goals and objectives.

International Management Exchange Program
Rensselaer’s Lally School has agreements with more than 12 schools in 10 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 durgej@rpi.edu.

The Lally Graduate Programs
Rensselaer’s Lally School offers three graduate programs: a Master of Science in Management, 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 MBA is a degree in general management. It is suited for those who aspire to leadership positions in their organizations and who desire to learn about all aspects of business management and how they combine to create a healthy, vibrant organization. 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 mainstay MBA program, the Lally School offers three additional tracks. The Executive MBA is a two-year, weekend-based, intensive study for working professionals. The Sino-U.S. MBA addresses the needs of Chinese and foreign companies establishing and expanding businesses in China. The J.D.-MBA allows a student to simultaneously pursue a law degree and an MBA degree.

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, career development, employment preparation, and job interviewing opportunities. Other resources include the Severino Center for Technological Entrepreneurship and the Graduate Management Student Association. These organizations provide activities throughout the year, including a business etiquette dinner, a team-building ropes course, 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 Career Resources and Rensselaer’s Career Development Center (CDC) 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.

The work opportunities are varied, depending on the student’s skills, area of specialization, and work authorization. Lally students have been employed at a variety of firms including General Electric, Kodak, IBM, Intel, Pratt and Whitney, SAP America, Texas Instruments, Shell Chemical, and Boeing, as well as in start-up companies and small- and medium-sized local businesses.

**Master of Science in Management**

The M.S. in Management is a specialized 30-credit program that may be pursued on a part- or full-time basis. The program is designed for students who wish to concentrate their studies in a particular area. The criteria for candidates completing the M.S. program are as follows:

- The academic program must specialize and focus on management and technology.
- The approved plan of study must include four core courses covering finance, marketing, quantitative analysis, and organizational behavior or human resource management. In addition, a concentration consisting of four related courses is required.
- The conclusion of the academic program must include a culminating experience. The recommended course is MGMT-6680 Strategy, Technology, and Global Competitive Advantage.
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. All M.S. diplomas specify management as the discipline of study; however, the concentration is not identified.

M.S. Concentrations
- Technological entrepreneurship
- Management of information systems
- Finance
- Marketing and new product development
- Production and operations management
- Environmental management and policy

Management concentrations are based on student interest and will vary over time in response to strategic business and technological developments. For a list of M.S. concentrations and associated courses, visit www.lallyschool.rpi.edu.

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.

This 60-credit residential MBA, which is operated on a cohort basis, is a comprehensive 21-month program. A summer work experience also is an important part of the MBA program. Options include working for companies ranging from Fortune 500 firms to local technology start-ups associated with the internationally recognized Rensselaer Technology Park and/or Rensselaer Incubator Center.

The MBA curriculum is built around five, year-long interdisciplinary courses called “streams of knowledge,” each of which addresses the challenge of innovation. Taken together, these streams provide students not only with the basic tools and concepts of the business leader, but also with the critical creative problem-solving expertise considered essential for meeting both the strategic and day-to-day challenges of running successful business in today’s rapidly changing global marketplace. The streams concentrate on the five following themes: 1) creating and managing the enterprise; 2) value creation, managing business/technology networks, and driving innovation; 3) developing innovative new products and services; 4) formulating and implementing competitive business strategy; and 5) managing the business implications of emerging technologies.

The infusion of innovation and the entrepreneurial spirit begins prior to the start of official classes with a special week-long orientation program called Leaders, Heroes and Innovators. The program immerses new students in the examination of the key characteristics of successful business leaders; the experience and behaviors of these leaders from both inside and outside of the business world is done through case
studies, laboratory simulations, and classroom exchanges. Students then engage in an intensive, six-week building blocks course on business fundamentals where they develop a “toolkit” composed of critical skills in finance, economics, accounting, and statistics.

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. In one of their final courses, Managing on the Edge, students marshal together their accumulated learning from across the entire program to develop creative solutions for a series of unique, unanticipated business problems characterized by their non-linear, unpredictable nature.

Students graduate from the Lally School’s MBA program not only imbued with an innovative spirit and entrepreneurial mindset, but also with their own “business portfolio” that reflects their broad array of business skills and know-how. Each student portfolio contains specific examples of the student’s work that they can share with prospective employers for placement purposes upon graduation. Included in the portfolio are the following types of items: business plan, marketing plan, strategic plan, technology assessment, competitive analysis, etc.

The five “streams of knowledge” are as follows:
MGMT-6040 and 6050 Creating and Managing an Enterprise [I & II] (3 credits each)
MGMT-6060 and 6070 Business Implications of Emerging Technologies [I & II] (3 credits each)
MGMT-6080 and 6090 Networks, Innovation and Value Creation [I & II] (3 credits each)
MGMT-7050 and 7060 Developing Innovative New Products and Services [I & II] (3 credits each)
MGMT-7030 Strategy, Technology & Competition I (2 credits each)
MGMT-7040 Strategy, Technology & Competition II (3 credits)

The key modules in the MBA program are as follows:
MGMT-6010 Heroes, Leaders and Innovators (orientation)
MGMT-696x Professional Development Workshop I, II, & III
MGMT-6020 Economic & Financial Analysis I (9 credits)
MGMT-6030 Economic & Financial Analysis II (3 credits)
MGMT-7080 Succeeding in Knowledge Intensive Organizations (1 credit)
MGMT-7020 Global Business (1 credit)
MGMT-7010 Decision Models (1 credit)
MGMT-7090 Social Responsibility and Business Ethics (1 credit)
MGMT-7070 Managing on the Edge (3 credits)

The remaining courses in the 60-credit program include four electives taken from a broad range of courses reflecting the school’s interest in developing business leaders who are comfortable working at the intersection of management and technology. In selecting these courses, students may wish to select a concentration from the five options listed below or they may develop a customized management and technology concentration in conjunction with their adviser. Lally MBA students can also take courses in other Rensselaer schools as part of the program's interdisciplinary orientation.
MBA Concentrations

 Technological Entrepreneurship
The Technological Entrepreneurship concentration has been developed for students who have an interest in new venture creation in start-ups and established firms. In addition to a powerful and integrated curriculum, this concentration includes significant out-of-the-classroom opportunities for interaction with Rensselaer’s highly regarded Incubator Program, Technology Park, Venture Affiliates of RPI, Office of Technology Commercialization, and extensive networks of successful entrepreneurs. This concentration consists of three courses from a set of course options. Students may wish to take a fourth course in Entrepreneurship from a set of elective options.

 Management of Information Systems
The Lally School’s Management of Information Systems concentration is designed for professionals seeking executive positions responsible for achieving competitive advantage through the effective development and integration of information technology into organizations. The concentration courses use an interdisciplinary approach to the practices and methodologies of systems analysis, design, development, integration and evaluation of information technology into business functions and processes. This concentration requires students to take MGMT-6140 if they do not have an IT background. All students concentrating in MIS should take MGMT-6180 and two other MIS electives.

 Finance
The Finance concentration 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. Students should take the two introduction courses and may select from one of the additional course options. Students may wish to select a fourth course in finance from a set of elective options.

 Environmental Management and Policy
This concentration prepares managers to provide business leadership in corporations, governmental agencies, or non-profit organizations with environmental and energy responsibilities and services. This MBA concentration recognizes the business argument for a global approach to environmental stewardship and sustainable development. The concentration builds on a cross-disciplinary curriculum by integrating environmental courses from departments and schools through the Rensselaer campus, including the Department of Economics, Science & Technology studies, Environmental Engineering, Earth Science, Electric Power Engineering, Architecture and Interdisciplinary Environmental courses.

A student pursuing an MBA with an Environmental Management concentration would typically take the Environmental Management and Policy course in addition to a set of electives selected in coordination with your academic and faculty adviser.

 Production & Operations Management
The purpose of this concentration is to provide students with an understanding of how product requirements are translated into the organizations, procedures, facilities and methods of manufacturing and service operations. This concentration prepares students for management careers at several different levels of the manufacturing and service organization by developing the knowledge necessary to support and add value to the underlying strategic focus of an operating manufacturing system. Students are encouraged to assemble a set of operations courses which will best facilitate their professional development and career potential. Students may select three courses from a set of course options.
Marketing and New Product Development
This concentration is available to graduate students interested in a career path in new product development or in product management, and is geared toward the special problems associated with managing high-tech products. Students focus their attention on understanding the links between an organization’s design, manufacturing, and marketing efforts for achieving successful product/market development, commercialization, and management throughout the life cycle. The Marketing and Product Development Management concentration requires students to take three courses from a set of course options.

Dual Master’s Programs
The dual degree option offers students the opportunity to receive two master’s degrees from Rensselaer:

J.D.-MBA Program
In collaboration with Albany Law School of Union University, a student may simultaneously pursue an MBA and 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.

Sino-U.S. Programs
The Lally School has initiated several programs that allow students to develop an understanding of the management and technology practices appropriate to Chinese business conditions. Among the programs offered at Rensselaer are:

- Sino-U.S. MBA in Management and Technology-This program was initiated in 1995 and is designed to develop cross-cultural managers for multinational companies operating in China. Students follow a similar curriculum to that of other MBA students as part of this 21-month program.

- Certificate Programs-Specialized executive programs for working professionals from China in such areas as “The Management of Software Development Firms.”

- Sino-U.S. Center for China Enterprises Strategic Studies (SUCCESS)-This on-campus research center is dedicated to the analysis of local, wholly foreign-owned, and joint venture enterprises operating in China. Activities include study trips to China, hosting visiting professors from China, and supporting doctoral-level research.

- Specialized M.S. in Management-This option offers concentrations in management of power utilities, software firm management, management of technology and R&D, and international business strategy.

Executive Master of Business Administration (EMBA)
The Lally school offers an Executive Master of Business Administration designed for individuals who possess significant (more than six years) management experience. Its unique format of meeting alternate Fridays and Saturdays over the course of two academic years allows students to continue their normal career activities and immediately apply the techniques and ideas learned throughout the program. Lally School senior faculty provide instruction. The program is cohesive; each course builds upon previous courses while laying the foundation for upcoming courses. In addition, this is a cohort approach, the EMBA class moves together through the program. Between the first and second year of the program, the students take part in a three-day residency in Washington, D.C., which focuses on government-business relations.
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 and a two-course sequence in advanced statistical techniques. Since 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. The student’s past experience and study may allow for considerable flexibility in plan development. By the third year, the student is expected to complete all course work, a comprehensive examination on business and 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 tutorial relationships with faculty. They include traditional disciplines such as finance, marketing, and organization, 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, concentration area advisers, and members of the research committee. 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 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 students choose their 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 research 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 concerned with management processes. 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.

**Research 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, 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**

Baron, R.A.—Ph.D. (University of Iowa); organizational behavior, entrepreneurship (Dean R. Wellington ’83 Professorship in Management).

Berg, D.—Ph.D. (Yale University); management of technological organizations, policy issues of research and development in the service sector (Institute Professor of Science and Technology).

Haddock, J.—Ph.D. (Purdue University); modeling of production and service systems including simulation and optimization techniques (Associate Dean).

Hasan, I.—Ph.D. (University of Houston); finance (Acting Dean)

Judd, G.—Ph.D. (Rensselaer Polytechnic Institute); strategy, materials engineering.

Norsworthy, J.R.—Ph.D. (University of Virginia); economics, business economics.

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).

**Clinical Professors**

Abetti, P.A.—P.E., Ph.D. (Illinois Institute of Technology); management of technology, international business development and strategic planning, entrepreneurship.

Hughes, G.—Ph.D. (Princeton University); strategy, entrepreneurship, information technology.

**Associate Professors**

Durgee, J.F.—Ph.D. (University of Pittsburgh); marketing research and advertising.

Ensley, M.—Ph.D. (Mississippi State University); entrepreneurship, strategy, organizational theory.

Francis, B.B.—Ph.D. (University of Toronto); corporate and international finance.

Goldenberg, D.H.—Ph.D. (University of Florida); investments, derivatives markets, mathematical and computational finance.

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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 2005 Board of Trustees meeting.
Leifer, R.P.—Ph.D. (University of Wisconsin); organizational behavior and organizational design, management information systems.

McDermott, C.—Ph.D. (University of North Carolina, Chapel Hill); manufacturing strategy, operations management.

Nambisan, S.—Ph.D. (Syracuse University); information systems.

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.

Phan, P.—Ph.D. (University of Washington); strategic management, entrepreneurship (Warren H. Bruggeman ’46 and Pauline Urban Bruggeman Distinguished Associate Professor).

Ravichandran, T.—Ph.D. (Southern Illinois University, Carbondale); management information systems.

Sanderson, S.—Ph.D. (University of Pittsburgh); international business, manufacturing policy, new product development.

Veryzer, R.—Ph.D. (University of Florida); marketing and consumer behavior.

Clinical Associate Professors

Miccio, R.—J.D. (Albany Law School); law, ethics.

Peters, L.B.—Ph.D. (Rensselaer Polytechnic Institute); management information systems.

St. John, W.C.—Ph.D. (Rensselaer Polytechnic Institute); accounting, finance.

Triscari, T.—Ph.D. (Rensselaer Polytechnic Institute); information systems.

Assistant Professors

Berkley, R.—Ph.D. (University of Wisconsin, Madison); organizational behavior, human resource management.

Choo, A.—Ph.D. (University of Minnesota, Carlson School of Management); operations management, knowledge management, operations strategy.

Corbett, A.—Ph.D. (University of Colorado, Boulder); entrepreneurship.

Golden, T.—Ph.D. (University of Connecticut); organizational behavior, human resource management.

Jahng, J.J.—Ph.D. (University of Wisconsin at Milwaukee); information systems.

Jayanthi, S.—Ph.D. (University of Minnesota); manufacturing operations, operations management.

Linton, J.—Ph.D. (York University); operations management.

Nelson, M.—Ph.D. (University at Albany); information systems.

Shin, Y.C.—Ph.D. (Massachusetts Institute of Technology); financial accounting.

Young, N.—Ph.D. (University of Chicago); entrepreneurship.

Research Assistant Professors

Mehta, S.—Ph.D. (University of Texas Southwestern Medical Center); biotechnology.

Clinical Assistant Professors

Murtagh, J.P., Jr.—Ph.D. (Rensselaer Polytechnic Institute); investment analysis and financial services.

Sands, R.—M.S., MBA (University at Albany); organizational behavior and human resource management.
Adjunct Faculty
Alben, R.—Ph.D. (Harvard University); physics, operations management.
Johnson, H.—A.B. (Dartmouth College); financial markets and analysis.
Nealon, W.—MBA (Rensselaer Polytechnic Institute); accounting.
Nugent, P.—Ph.D. (University at Albany); organization theory.
Wright, F.—M.S.E.E. (Naval Postgraduate School); general management, manufacturing operations, international business.

Hartford Campus Faculty
Clinical Professors
Bragaw, L.K., Jr.—D.B.A. (George Washington University); policy and strategy, ethical and social issues (Professor of Management on sabbatical leave).
Kelly, L.J.—Ph.D. (University of Connecticut); statistics, operations, management engineering.
Luddy, W.J., Jr.—J.D. (University of Connecticut); ethics, social and legal issues, policy and strategy.
Schroth, P.W.—S.J.D. (University of Michigan); international finance, financial markets (Clinical Professor on sabbatical leave).

Clinical Associate Professors
Albright, R.R.—Ph.D. (University of Pittsburgh); strategy.
Fransson, M.C.—MBA (Dartmouth College); marketing, financial services.
Gingerella, L.W., Jr.—MBA (Rensselaer Polytechnic Institute); accounting, finance.
Jenkins, E.C.—MBA (University of Pennsylvania); finance, acquisitions and mergers.
Maleyeff, J.—Ph.D. (University of Massachusetts); statistics, operations, management engineering.
Rainey, D.L.—Ph.D. (Rensselaer Polytechnic Institute); environmental management, operations, technology management, new product development.
Stodder, J.P.—Ph.D. (Yale University); economics, international.

Clinical Assistant Professors
Arnheiter, E.D.—Ph.D. (University of Massachusetts); manufacturing, operations, quality management.
Ilovici, I.—Ph.D. (University of Connecticut); management information systems.
Peteros, R.G.—J.D. (Western New England College School of Law); finance.

Course Descriptions
Courses directly related to all Management curricula are described in the Course Description section of this catalog under the department code MGMT.
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School of Science

Dean: Joseph E. Flaherty
Associate Dean: Samuel C. Wait Jr.
Associate Dean of Graduate Education and Research: William L. Siegmann
Associate Dean of Science and Information Technology: David L. Spooner
Institute Professor: E. Bruce Watson
Institute Professor Emeritus: Ivar Giaever

School of Science Home Page: http://www.rpi.edu/dept/science

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. In the 1990’s, for instance, the School of Science introduced new degree programs in biochemistry/biophysics and bioinformatics and molecular biology.

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. New curricula in bioinformatics and molecular biology and information technology are meeting the high demand for scientists in these areas. A new Center for Biotechnology and Interdisciplinary Studies building 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 Institute 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; 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 parallel computers 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 of 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 the Institute’s major interdisciplinary research centers, including the Center for Integrated Electronics (CIE), the Nanotechnology Center, the Scientific Computation Research Center (SCOREC), the Terahertz Research Center, and the Center for Pervasive Computing and Networking.

Also providing unique opportunities to its students are a number of School of Science administered research centers. These are the Margaret A. and David M. Darrin ’40 Fresh Water Institute, the New York State Center for Polymer Synthesis, the New York State Center for Studies on the Origins of Life, the Rensselaer-Wadsworth Center for Bioinformatics, the Center for Biophysics, and the Center for Inverse Problems at RPI. 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 Program and offers a full complement of interdisciplinary degree programs that are described in detail under Interdisciplinary Degree Programs later in this section and in the Information Technology section of this catalog.

### Degrees Offered and Associated Departments

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<td>Biology</td>
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<td>Biochemistry/Biophysics</td>
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<td>Chemistry</td>
<td>Chemistry and Chemical Biology</td>
</tr>
<tr>
<td>Computer Science</td>
<td>Computer Science</td>
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<tr>
<td>Environmental Science</td>
<td>Earth and Environmental Sciences</td>
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<tr>
<td>Geology</td>
<td>Earth and Environmental Sciences</td>
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<td>Hydrogeology</td>
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<td>Mathematics</td>
<td>Mathematical Sciences</td>
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<td>Natural Sciences</td>
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<td>Physics</td>
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<tr>
<td>Applied Physics</td>
<td>Physics, Applied Physics, and Astronomy</td>
</tr>
<tr>
<td>Interdisciplinary Science</td>
<td>Administered by Dean of Science</td>
</tr>
</tbody>
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### Overview of Undergraduate Programs

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, however, are to give them:

- A broad background in their particular field
- Working knowledge of modern research and technological tools
An appreciation of good theoretical, experimental, and computational research

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 (IT) degree 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 section of this catalog.

All programs offer a large number of electives so that students can emphasize their areas of interest, select 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 undeclared may defer their choice of major until the sophomore 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. Entering students who have not yet selected a major may choose the department from which their initial adviser is selected.

Advanced placement credit or credit for courses taken in the 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.

Any of the courses with the following course codes meet the physical, life, and engineering sciences requirement: ASTR, BCBP, BIOL, CHEM, CISH, CSCI, ERTH, MATH, MATP, PHYS. In addition, the following courses also meet these requirements:

- IENV-4500 (cross-listed as ERTH-4500)
- IENV-4700
- ISCI-4500
- ENGR-1100 (as Science not Mathematics)
- ENGR-1600
- ENGR-2090
- ENGR-2250
- ENGR-2830
- ESCE-2100

Other courses may fulfill this requirement and will be reviewed by the science core curriculum adviser (currently the associate dean of science) on a case-by-case basis. A number of upper-level courses in several engineering disciplines satisfy the requirement, but generally they 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.

Students who have advanced placement or who have the International Baccalaureate may be granted credit for all such mathematics and science courses depending on their scores.

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 science core curriculum adviser (currently the associate dean of science). Transfer students entering Rensselaer at the junior level or above are not limited in the number of courses they may transfer for science core credit.

Students enrolled at Rensselaer who wish to take a science course for core credit or other science credit 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. A maximum of eight credit hours of transfers is allowed towards the 24-credit-hour science core. Additional credit hours may be used as electives outside the core.

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 with a concentration in mathematics or science is also available.

Additional 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. Eight of these credit hours must be in mathematics (course codes MATH and MATP), including Calculus I. Each curriculum must include courses in at least four science disciplines (for this purpose, the course codes for mathematics, MATH, and mathematical programming, MATP, are considered a single discipline), including BIOL-1010, Introduction to Biology or an approved alternate life sciences course. PHYS-1100, Physics I is also required for all science majors. Each curriculum must also contain a culminating experience carrying three or four credits and being 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 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 Institute 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**
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. An accelerated B.S./Ph.D. program leading to both degrees in six to seven years is also possible in all departments within the School of Science. Students apply to this program after their first year of study at Rensselaer.

**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 website 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 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 Career Development Center heading.

**Study Abroad/Exchange Programs**
Although the School of Science does not specifically administer any such programs, the Institute 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 also key to the Institute's ability to remain in the forefront of research and education in the sciences and to apply its research findings to needs of society.

Considerable personal attention is focused upon graduate students as they enter and develop their programs of study. A graduate adviser guides each student by assisting in the establishment of a suitable
program to meet particular needs of that individual. 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 as distinct as they once were, 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 in the New York Center for Polymer Synthesis; environmental research in the Margaret A. and David M. Darrin '40 Fresh Water Institute; the New York Center for Studies on the Origins of Life; the focus on advanced computation in the areas of software, databases, and parallel computation; and the Center for Biophysics foci on natural processes as well as bio-organic chemistry, pharmaceuticals, and biotechnology; research into terahertz radiation for innovative imaging and sensing; and inverse problems to find objects and their properties that cannot be measured directly.

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 more details on graduate cooperative education opportunities, contact the Career Development Center.

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 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, particularly the program in multidisciplinary science, 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
Chair: Robert E. Palazzo
Associate Chair: Robert Parsons
Accelerated Program Head: Michael H. Hanna
Graduate Admissions Coordinator: Joelle Willis
Department Home Page: http://j2ee.rpi.edu/biology
For two decades, the science of biology has been undergoing revolutionary change. Many problems once handled only descriptively are now analyzed molecularly, and biological systems are now characterized in molecular terms. With this trend expected to continue into future advances in biology, Rensselaer is adapting and introducing undergraduate and graduate biology programs to meet this challenge.

All areas of biology require knowledge of chemistry and physics as well. The undergraduate biology curriculum, therefore, thoroughly trains students in the fundamentals of the life sciences and the chemistry and physics of the life processes, providing the background necessary for professional training in research or medicine. Options are available to prepare students for careers in applied biology and in 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, 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. Current work at the gene and protein levels is being applied in cell biology and physiology. Research in this area includes developing computer models of how the lens accommodates the human eye. Studies on the lens protein alpha crystalline include biochemical and biophysical characterization. Novel molecular genetics approaches are used to compare properties of alpha crystalline to members of the small heat shock protein family. Additional studies include investigation of how muscle is designed to power locomotion and how variation between muscle fiber types is generated. Current investigations of structure/function relations of myosin use molecular biology and genetic techniques. Recent research focuses include the application of nuclear magnetic resonance (NMR) spectroscopy to study important and interesting problems in neuroscience and aging, e.g. Alzheimer’s disease, the most common senile dementia. These studies focus on the important roles of membrane proteins in signaling and transport.

In the area of enzymology, several projects are available. Work on the nitric oxide synthase isoforms, enzymes important to signal transduction (e.g., in the central nervous system and for blood pressure control) and as producers of cytotoxic NO in immune responses utilize molecular genetics and biochemical methods. Nitrogen fixation and nitrogen cycle enzymes in cyanobacteria are also under investigation. Additional studies of energy conversion in living organisms utilize a family of respiratory enzymes known as heme-copper oxidases. These "terminal" oxidases contain the site where oxygen binds and is reduced to water.

Bioinformatics and Molecular Biology
Research in bioinformatics and molecular biology includes both computational work and applications using molecular genetic approaches. In the computational sphere, design and application of database research and sequence alignment algorithms, molecular modeling, and simulation are used in studies ranging from structural characterization of relevant biomedical proteins to studies of basic protein folding mechanisms. Protein folding mechanisms are studied using modeling and data mining from genomic and structural databases. Molecular genetic approaches are used to test the prediction of modeling studies, to design and produce probes, and to obtain sequence information for novel genes. Three laboratories are involved in engineering novel proteins or activities of existing proteins, using molecular gene manipulations.

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.

**Cellular, Developmental and Molecular Biology**

Research in these areas is a high priority in the Biology Department. The vast majority of labs in the department utilize molecular and/or genetic approaches in their studies. Several areas in cellular biology are prominently featured. The first focuses on the biochemical control of cytoskeletal organization, microtubule dynamics, cell polarity, and cell differentiation. The second is centered on the role of extracellular matrix proteins and their control of normal and cancerous cell growth and migration, as well as wound healing. The third is concerned with signal transduction mechanisms controlling cell-cell interactions during tumor cell migration. The fourth focuses on stem cell growth and regulation in the context of tissue engineering. An undergraduate laboratory course that teaches basic research techniques in these areas is available, and students are encouraged to work in research labs upon completion of this course.

Model organisms utilized to study developmental and cellular phenomena are a significant theme in the Biology Department. Research using the nematode worm Caenorhabditis elegans as a model system is focused on the developmental functions of the conserved GTP-binding proteins, the septins. Septins are studied for their role in cytokinesis in fungi and animals, and are implicated in some cancers and neurodegenerative diseases. Research with the fruit fly Drosophila melanogaster focuses on a family of proteases, the matrix metalloproteinases (MMPs). In vitro these proteins cleave most extracellular matrix components and in vivo, increases in MMP expression correlate with some cancer and inflammatory diseases. Research utilizing zebra fish makes it possible to study the organization, regulation, and function of the neural circuits in the central nervous system that coordinate environmental responses such as the startle response.

**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.

Diwan, J.J.—Ph.D. (University of Illinois); cell physiology, bioenergetics.

Dordick, J.—Ph.D. (Massachusetts Institute of Technology); (joint appointment with Chemical and Biological Engineering) biochemical engineering, enzyme technology, bioseparations.

Koretz, J.F.—Ph.D. (University of Chicago); structural biophysics of protein aggregation, computer modeling.

Lindhardt, R.—Ph.D. (John Hopkins University); (joint appointment with Chemistry and Chemical Biology) medicinal chemistry and biocatalysis, carbohydrate chemistry.

McDaniel, C.N.—Ph.D. (Wesleyan University); plant development and cell culture.

Nierzwicki-Bauer, S.A.—Ph.D. (University of New Hampshire); plant molecular biology, subsurface microbiology.

* 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 2005 Board of Trustees meeting.
Palazzo, R.E.—Ph.D. (Wayne State University); cellular organization, cell replication, cell motility, development and cancer.

Roy, H.—Ph.D. (Johns Hopkins University); plant molecular biology and biochemistry.

Salerno, J.C.—Ph.D. (University of Pennsylvania); enzymology, spectroscopy, molecular structures, bioinformatics.

Zuker, M.—Ph.D. (Massachusetts Institute of Technology); algorithms for predicting RNA and DNA secondary structure (joint appointment with Mathematics).

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, undergraduate education (joint appointment with The Anderson Center for Innovation in Undergraduate Education).

Associate Professors

Hanna, M.H.—Ph.D. (University of Illinois); directed evolution of proteins, scientific teaching.

Parsons, R.H.—Ph.D. (Oregon State University); cellular physiology, epithelial transport.

Assistant Professors

Barquera, B.—Ph.D. (National Autonomous University of Mexico); bioenergetics of Vibrio cholerae

Bystroff, C.—Ph.D. (University of California, San Diego); genomics, protein structural prediction.

Finger, F.—Ph.D. (Yale University); analysis of septin function in C. elegans development.

Page-McCaw, A.—Ph.D. (Massachusetts Institute of Technology); genetic and molecular analysis of matrix metalloproteinases during development in Drosophila melanogaster.

Page-McCaw, P.—Ph.D. (Massachusetts Institute of Technology); genetic analysis of learning and memory in the zebrafish, Danio rerio.

Plopper, G.—Ph.D. (Harvard University); signal transduction in tumor cell biology and tissue engineering.

Swank, Douglas—Assistant Professor of Biology; Ph.D. (University of Pennsylvania); structure/function relations of myosin.

Wang, Chunyu—Assistant Professor of Biology; Ph.D. (Cornell University); NMR spectroscopy, neuroscience and aging, Alzheimer’s disease.

Xu, J.—Ph.D. (Meharry Medical College); signal transduction by extracellular matrix.

Professors Emeritus

Ehrlich, H.L.—Ph.D. (University of Wisconsin); geomicrobiology, mineral transformations by bacteria.

Pfau, C.J.—Ph.D. (Indiana University); molecular biology of animal viruses, antiviral drugs.

Associate Professor Emeritus

Clesceri, L.S.—Ph.D. (University of Wisconsin); microbial ecology, biotransformation and biodegradation of natural polymers and pesticides, biotechnology.

Research Assistant Professor

Morgan, J.—Ph.D. (California Institute of Technology), energy transduction.

Clinical Assistant Professor

Smith, S.M.E.—Ph.D. (Rensselaer Polytechnic Institute); bioinformatics, enzyme structure.

Adjunct Faculty

Flaherty, L.—Ph.D. (Cornell University Medical School).

Manella, C.—Ph.D. (University of Pennsylvania); mitochondrial membrane transport.
Undergraduate Programs

Undergraduate students may pursue either a baccalaureate program or an accelerated degree program. Both of these degree programs are explained on the next page.

Baccalaureate Programs

The undergraduate curriculum in biology is designed to prepare students for admission to graduate or professional school. 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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<thead>
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<th>First Year</th>
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<tr>
<td>Elective ...............4</td>
<td>Culminating Experience1 .........................3</td>
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</table>

1 Chosen from one of the following three courses: BIOL-4710, BIOL-4720, or BIOL-4740. All three courses are writing intensive.

2 One of the biology electives can be chosen from any of the following classes: All BCBP except BCBP-4760, CHEM-2440, CHEM-4300, or CHEM-4330.

3 Chosen from one of the following three courses: BIOL-4968, BIOL-4070, or BIOL-4990.
Electives
Twelve courses in biology are required for graduation. 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.

Students who anticipate working on a senior thesis are strongly urged to take two 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.

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.

Minor Programs
The Biology Department offers minors in biochemistry, biophysics, astrobiology, and biology. The biochemistry minor is designed specifically for biology or bioinformatics majors and the biophysics minor is designed specifically for students majoring in biology. The requirements for all department minors are given below.

Astrobiology
To complete this minor, students must take a minimum of 16 credits of course work in this field. These courses include 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:

- ENVE-2110 Intro. to Environmental Engineering
- BIOL-4320 Geomicrobiology
- BIOL-4440 Microbial Ecology
- BIOL-4620 Molecular Biology
- BIOL-4760 Molecular Biochemistry I
- BCBP-4810 Biological Spectroscopy
- BCBP-4860 Protein and Nucleic Acid Structure
- CHEM-2250 Organic Chemistry I
- CHEM-4810 Chemistry of the Environment
- ERTH-4070 Sedimentology
- ERTH-4540 Organic Geochemistry
- ASTR-2050 Intro. to Astronomy and Astrophysics
- CHEM-4310 Bioorganic Mechanisms
- BCBP-4860 Protein and Nucleic Acid Structure
- BCBP-4810 Biological Spectroscopy
- BCBP-4780 Protein Folding
- ENVE-2110 Intro. to Environmental Engineering
- BIOL-4320 Geomicrobiology
- BIOL-4440 Microbial Ecology
- BIOL-4620 Molecular Biology
- BIOL-4760 Molecular Biochemistry I
- BCBP-4810 Biological Spectroscopy
- BCBP-4860 Protein and Nucleic Acid Structure
- CHEM-2250 Organic Chemistry I
- CHEM-4810 Chemistry of the Environment
- ERTH-4070 Sedimentology
- ERTH-4540 Organic Geochemistry
- ASTR-2050 Intro. to Astronomy and Astrophysics
- CHEM-4310 Bioorganic Mechanisms
- BCBP-4860 Protein and Nucleic Acid Structure
- BCBP-4810 Biological Spectroscopy
- BCBP-4780 Protein Folding

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).

Biochemistry
To complete this minor, a biology major must take BCBP-4770, CHEM-2440, and two of the following courses:

- BIOL-4260 Cell Biology
- BCBP-4710 Biochemistry Laboratory
- BCBP-4310 Genetic Engineering
- BCBP-4860 Protein and Nucleic Acid Structure
- BCBP-4810 Biological Spectroscopy
- BCBP-4780 Protein Folding
- CHEM-2440 Physical Chemistry
- CHEM-4310 Bioorganic Mechanisms
- CHEM-4310 Bioorganic Mechanisms
Biophysics
To complete this minor, a biology major must take BCBP-4770, CHEM-2440, and two of the following courses:

MATH-2400    Differential Equations    BCBP-4210    Biophysical Methods
MATH-4720    Mathematics in Medicine and Biology    BCBP-4810    Biological Spectroscopy
BIOL-4270    Human Physiology I    PHYS-2510    Quantum Physics

(requires MATH-2400)

Biology
Students not majoring in biology may receive a minor in this discipline by taking eight credits of introductory biology. These credits must include BIOL-1010 and either BIOL-2310 or BIOL-2120. Also included are BIOL-2500 and three 4000-level courses of the student’s choice.

Accelerated Program
The Biology Department offers highly motivated students interested in the medical profession the opportunity to combine undergraduate and graduate study to reduce the number of years spent in academic study. The program is described below.

Physician-Scientist Program
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 precalculus. The Scholastic Aptitude Test (SAT) I or ACT examination and SAT II in mathematics (Level I, Level IC, Level II, or Level IIC), writing, and physics, biology, or chemistry are required, and must be completed by the November testing date prior to the proposed September matriculation in the program. 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 December 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 3.40 (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 3.40 is required both in overall course work and in science/math for promotion to the medical portion of the curriculum. 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 humanities 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

**Fall**

<table>
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<th>Course</th>
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<td>CHEM-1100 Chemistry I</td>
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<td>BIOL-1010 Intro. to Biology</td>
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**Spring**

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<td>BIOL-2120 Intro. to Cell and Molec. Biology</td>
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#### Academic Year II

**Fall**

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<td>BIOL-2500 Genetics and Evolution</td>
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**Spring**

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<td>BIOL-4620 Molecular Biology</td>
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<tr>
<td>CHEM-2260 Organic Chemistry II</td>
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<td>CHEM-2240 Organic Chemistry Lab. II</td>
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#### Academic Year III

**Fall**

<table>
<thead>
<tr>
<th>Course</th>
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<tr>
<td>BIOL-4760 Molecular Biochemistry I</td>
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<tr>
<td>BIOL-4290 Human Phys. Systems</td>
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<td>Elective</td>
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**Spring**

<table>
<thead>
<tr>
<th>Course</th>
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<tr>
<td>BIOL-2410 Embryology</td>
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<tr>
<td>BIOL-2980 Biomedical Research</td>
<td>4</td>
</tr>
<tr>
<td>BIOL-4080 Principles of Research</td>
<td>2</td>
</tr>
<tr>
<td>BIOL-4090 Seminal Dev. Bmed. Res.</td>
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<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>
Summer Session at Albany Medical College

Credit hours
Research ................................................................................................................................................................8

Academic Years IV–VII (at Albany Medical College)

The following courses are transferred from the Albany Medical College

Credit hours
Research ................................................................................................................................................................8
Musculoskeletal System ..........................................................................................................................................6
Nervous System ..................................................................................................................................................6
Cardiovascular System ............................................................................................................................................4
Gastrointestinal System ..........................................................................................................................................3
Acid/Basal/Renal System..........................................................................................................................................4
Total credits transferred from Albany Medical College ..........................................................................................31

Graduate Programs

The biology research laboratories at Rensselaer are equipped for graduate study and projects in Biochemistry & Biophysics, Bioinformatics & Computational Biology, Biotechnology, Cell Biology & Cell Signaling, Microbial Ecology, Geomicrobiology, & Environmental Biology, Molecular Genetics & Developmental Biology, and Neurobiology & Behavior. 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 that includes courses in general biochemistry and molecular biology 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 may take a candidacy examination 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.

Master’s Programs

Thirty credit hours of course work are necessary to complete the M.S. program. A minimum of six credits and a maximum of nine must be in research. Of the remaining credits, 15 must be in graduate-level courses. A thesis based on an original research project is required.

Doctoral Programs

Candidates for the Ph.D. must satisfy the requirements of the graduate evaluation committee (GEC), pass the qualifying exam, and pass a candidacy exam. The latter consists of a written and an oral portion, and should usually be taken during the second year of full-time study. A degree candidate also must submit a dissertation based on an original research project. The GEC requires a high level of performance in selected courses and research, and reports its 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 teaching should he or she select an academic career. Sixty credit hours past the M.S. degree are required.
Course Descriptions
Courses directly related to all Biology curricula are described in the Course Description section of this catalog under the department code BIOL.

Chemistry and Chemical Biology
Chair: Linda B. McGown
Associate Chair: Ronald A. Bailey
Undergraduate Advising: Charles W. Gillies
Graduate Admissions: Curtis M. Breneman
Department Home Page: 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 Materials Research Center, the New York State Center for Polymer Synthesis, the nearby Science Center, and, the newly completed Biotechnology and Interdisciplinary Studies Center.

Research Innovations and Initiatives
Analytical Chemistry
Areas of research include the development and application of methods to study in vivo processes, particularly the advancement of microdialysis technology, microscale separations, genomics, proteomics, and affinity-based methods. Molecular probe techniques that employ optical spectroscopic measurements of absorbance, circular dichroism, and dynamic fluorescence are employed in studies of the properties of complex molecular and biomolecular systems. Techniques such as high field and solid state NMR, FTIR, GC-MS, LC-MS and MALDI-TOF mass spectrometry are used in developing analytical procedures to detect, quantitatively determine, and structurally characterize materials in a variety of areas.

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 State Center for Studies on the Origins of Life. 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 for the mechanisms are studied by electron spin resonance and time-resolved optical and electroabsorption spectroscopies. 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. Carbohydrate biochemistry and glycobiology are used to understand disease processes and to develop new therapeutic agents.
biochemical aspects of biotechnology including biocatalysis and metabolic engineering are being explored. The methodologies used include kinetic and spectroscopic analysis (NMR, fluorescence, circular dichroism, surface plasma 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 protein and carbohydrate chemistry is centered on the computer design and organic synthesis of proteins and carbohydrates with novel functionalities and non-natural architectures. The research will provide new capabilities to design purpose-specific proteins such as synthetic enzymes and artificial membrane protein receptors.

Inorganic Chemistry and Solid-State Chemistry
Inorganic chemistry involves the preparation and investigation of substances that include coordination complexes, metalloenzymes, organometallic compounds, anion-sequestering agents, and inorganic solids with extended network structures. Materials and solid-state chemistry focuses on the application of both inorganic and organic substances as structural, optical, and electronic materials, and include theoretical studies on the defect structures of inorganic solids. Syntheses of organometallic compounds and inorganic polymers provide sources of novel solid-state materials, both as molecular solids and as precursors for the pyrolytic preparation of inorganic solids, such as aluminum nitride and silicon carbide.

Organic Chemistry, Medicinal Chemistry and Organometallic Chemistry
Active areas of synthetic organic and medicinal chemistry research include the design and synthesis of novel agents to treat cocaine addiction and carbohydrate-based cardiovascular anti-infection and anti-cancer agents. Research in the areas of transition organometallic chemistry and homogeneous catalysis focuses on synthetic and mechanistic studies of organometallic complexes applicable to the conversion of carbon monoxide and carbon dioxide into organic molecules. The development of molecular modeling programs that evaluate intermolecular electrostatics may result in the deeper understanding of enzyme-substrate interactions.

Photochemistry
Mechanistic and synthetic photochemistry are areas of major emphasis. Investigations involve the photochemical transformations of heterocycles, carbonyl containing compounds, and naturally occurring materials. The atmospheric chemistry of Jupiter and Titan (Saturn’s largest moon), and the role of photochemical reactions in the origins of life also are under investigation. Photosynthesis and rearrangement of heterocyclic purines and photochemical reactions 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 high-performance thermally stable polymers, conductive polymer membranes for fuel cell applications, liquid crystalline polymers, block copolymers, and photosensitive thermosets and thermoplastics. Novel synthetic and biorenewable-monomers and methods for their synthesis are being studied. New approaches to polymer preparation, including photochemical, photo-electroinitiated, transition metal catalyzed, and vapor-deposition polymerization are also under study. Development of biologically compatible polymers that can serve as scaffolding for tissue regeneration is an area of recent interest. Polymers are characterized by means of gel permeation chromatography, viscometry, differential scanning calorimetry, scanning and transmission electron microscopy, atomic force microscopy, low-angle light, X-ray, and neutron scattering and mass spectrometry (MALDI TOF and ESI). Surface interactions between immiscible crystallizable polymers

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are being studied using X-ray photoelectron spectroscopy, polarized light microscopy, electron microprobe methods, and Raman spectroscopy. Properties of multiphase polymer alloys and solutions are being investigated in shear, electric, and magnetic fields. Polymerization processes are being investigated from the aspect of mechanistic organic chemistry. Coordination complexes and organometallic compounds are being considered as inorganic polymers and as precursors for the pyrolytic preparation of inorganic solid-state materials.

**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.

**Computational Chemistry and Spectroscopy**
Computational chemistry and molecular modeling are being developed and used to understand the relationships between molecular structures and their properties. Specialized electron density reconstruction methods, such as the Transferable Atom Equivalent (TAE) technique, have permitted the construction of predictive models that allow good estimates of the properties of new compounds to be synthesized, as well as predicting the behavior of protein displacers in the biotechnological chromatography of fermentation products. These techniques have been developed as part of the NSF Project DDASSL, together with novel machine learning and drug delivery modeling algorithms. Other theoretical chemistry projects under way emphasize understanding nonlinear optical properties of polymers. Spectroscopic research is directed particularly toward structure and properties of a wide range of compounds, with emphasis on vibrational (infrared and Raman), linear and nonlinear laser and microwave spectroscopy, NMR spectroscopy, electronic spectroscopy, and X-ray diffraction. Pulsed-beam Fourier-transform microwave spectroscopy is used to study van der Waals complexes and transient chemical species, with an emphasis upon understanding the mechanisms of simple chemical reactions. Solid-state NMR spectroscopy is used extensively in materials and polymer chemistry research, and in the characterization of catalysts.

**Research Facilities and Equipment**
Department research facilities include the Center for Biotechnology and Interdisciplinary Studies, Cogswell Laboratory, the New York State Center for Polymer Synthesis, the Science Center, and the Materials Research 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 (both solution and solid state) and other techniques. This equipment, serviced and operated by a professional staff, is available to all researchers in the department. The central mass spectroscopy facility includes GC-MS, MALDI-TOF for macromolecular analysis, and LC-MS(i on trap) equipment. Other instruments available for research include NIR, visible, UV, fluorescence, atomic absorption, surface plasma resonance and FTIR spectrophotometers, G.C. and HPLC equipment, electrochemical equipment, ESR spectrometers, DSC, DTA, TGA, and TMA instruments for thermal studies, and X-ray fluorescence and diffraction instruments. A molecular modeling laboratory contains computer workstations and a variety of sophisticated computer programs for molecular modeling, conformational analysis, energy calculation, and synthesis design.
Faculty*

Professors
Apple, T.M.—Ph.D. (University of Delaware); solid-state NMR spectroscopy.
Bailey, R.A.—Ph.D. (McGill University); coordination chemistry and chemistry of molten salts.
Benicewicz, B.C.—Ph.D. (University of Connecticut); polymer chemistry.
Breneman, C.M.—Ph.D. (University of California, Santa Barbara); physical organic chemistry.
Crivello, J.V.—Ph.D. (University of Notre Dame); polymer chemistry.
Cutler, A.R.—Ph.D. (Brandeis University); organometallic chemistry.
Interrante, L.V.—Ph.D. (University of Illinois); inorganic and solid-state materials synthesis.
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.
Nalamasu, O.—Ph.D. (University of British Columbia); electronic and photonic polymers, nano-patternings, micro and nano-fabrication, electronic and photonic devices.
Wait, S.C., Jr.—Ph.D. (Rensselaer Polytechnic Institute); spectroscopy, vibrational and electronic spectroscopy.
Warden, J.T.—Ph.D. (University of Minnesota); ESR spectroscopy, biophysical chemistry.
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.
Willis, J.—Ph.D. (University of Connecticut); bioanalytical chemistry

Associate Professors
Choma, C.T.—Ph.D. (University of Ottawa, Canada); biochemistry, protein design and synthesis.
Colon, W.—Ph.D. (Texas A&M University); biophysical chemistry.
Gillies, C.W.—Ph.D. (University of Michigan); microwave spectroscopy.
Stenken, J.A.—Ph.D. (University of Kansas); bioanalytical chemistry.

Assistant Professors
Akpalu, Y.—Ph.D. (University of Massachusetts, Amherst); polymer physical and machomolecular chemistry.
Ryu, C.Y.—Ph.D. (University of Minnesota); polymer physical and materials chemistry.
Zhang, C.X.—Ph.D. (John Hopkins University); bioinorganic chemistry.

Clinical Assistant Professor
Carter, J.H., Jr.—Ph.D. (University of Oregon); physical chemistry, (Edward P. Hamilton Faculty Fellow).

Adjunct Faculty
Bello, S.C.—M.D. (SUNY Downstate Medical Center); general chemistry, biochemistry.
Choe, E.W.—Ph.D. (Illinois Institute of Technology); organic-polymer chemistry.
Eisman, E.D.—Ph.D. (Northeastern University); Physical Inorganic Chemistry

* 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 2005 Board of Trustees meeting.
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. All of these opportunities are explained in detail below.

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 nontraditional 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.

Curriculum

First Year

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<tr>
<th>Fall Credit hours</th>
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<td>MATH-1010 Calculus I ........................................4</td>
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<td>CHEM-1100 Chemistry I ........................................4</td>
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<td>PHYS-1100 Physics I ........................................4</td>
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Second Year

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<tr>
<td>CHEM-2210 Organic Compounds and Reactions ........................4</td>
<td>CHEM-2220 Organic Synthesis ..................................2</td>
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<td>CHEM-2110 Equilb. Chem. &amp; .......................................3</td>
<td>CHEM-2280 Experimental Chemistry II ..................................2</td>
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<td>Quantitative Analysis ............................................3</td>
<td>CHEM-2030 Inorganic Chemistry I ..................................4</td>
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<td>CHEM-2120 Experimental Chemistry I ................................2</td>
<td>BIOL-1010 Intro. to Biology ......................................4</td>
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<td>MATH-2400 Intro. to Differential Equations ........................4</td>
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Third Year

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<td>CHEM-4410 Macroscopic Physical Chemistry ..................................3</td>
<td>CHEM-4110 Instrumental Analysis ..................................2</td>
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<td>CHEM-4010 Inorganic Chemistry II ......................................2</td>
<td>CHEM-4120 Experimental Chemistry IV .................................2</td>
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<tr>
<td>CHEM-4020 Experimental Chemistry III ....................................2</td>
<td>CHEM-4460 Microscopic Physical Chemistry ..........................4</td>
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<tr>
<td>CHEM-4760 Molecular Biochemistry I ....................................4</td>
<td>Elective ..............................................................4</td>
<td>4</td>
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</tbody>
</table>

1 CHEM-1300 may be substituted for CHEM-1100 by students transferring into Chemistry.
2 ENGR-1600 may be substituted for CHEM-1200 by students transferring into Chemistry.
3 CHEM-4310 may be substituted for this course.
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 H&SS 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.

- BIOL-1020 Introduction to Biology Laboratory
- BIOL-2120 Introduction to Cell and Molecular Biology
- BIOL-4270 Human Physiology I
- BIOL-4280 Human Physiology II
- BIOL-4620 Molecular Biology

In addition, two communications courses should be included among Humanities and Social Sciences elective options.

**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 H&SS 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 below, chemistry majors may minor in other disciplines through programs offered within other departments.

**Biochemistry Minor for Chemistry Majors**

This program is particularly advisable for chemistry students who wish to pursue scientific careers in medicinal research or at the interface of biology and chemistry. Students should take BIOL-2120, BCBP-4770, and two courses from the following:

- BCBP-4710 Biochemistry Laboratory
- BIOL-4260 Cell Biology
- BIOL-4510 Molecular Genetics
- BIOL-4620 Molecular Biology

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**Fourth Year**

<table>
<thead>
<tr>
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<th>Fall</th>
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<tr>
<td>CHEM-4900</td>
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<td>CHEM-4620</td>
<td>Intro. to Polymer Chemistry</td>
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<td>CHEM-4950</td>
<td>Senior Experience</td>
<td>3</td>
<td>Electives</td>
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<tr>
<td>Electives</td>
<td>.........................................12</td>
<td></td>
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</tr>
</tbody>
</table>
BCBP-4310  Genetic Engineering
BCBP-4210  Biophysical Methods
BCBP-4860  Protein and Nucleic Acid Structure
CHEM-4310  Biorganic Mechanisms
BCBP-4780 or CHEM-4780  Protein Folding

**Biophysics Minor for Chemistry Majors**
This program is advisable for chemistry students who wish to pursue scientific careers in medicinal research or at the interface of biology and chemistry. For this minor, students should take BIOL-2120, BCBP-4770, and two courses from the following:

- MATH-4720  Mathematics in Medicine and Biology
- BIOL-4270  Human Physiology I
- BCBP-4210  Biophysical Methods
- BCBP-4810  Biological Spectroscopy
- PHYS-2510  Introduction to Quantum Physics

**Astrobiology Minor for Chemistry Majors**
Obtaining a minor in Astrobiology requires a minimum of 16 credits of course work that must include ASTR-4510 and ISCI-4500 (four credits each), two semesters of ISCI-4510 (one credit each) and two courses outside of the major field of study selected from the following:

- ENVE-2110  Introduction to Environmental Engineering
- BIOL-4320  Geomicrobiology
- BIOL-4440  Microbial Ecology
- BIOL-4620  Molecular Biology
- BCBP-4810  Biological Spectroscopy
- BCBP-4860  Protein and Nucleic Acid Structure
- CHEM-4810  Chemistry of the Environment
- ERTH-4070  Sedimentology
- ERTH-4540  Organic Geochemistry
- ASTR-2050  Introductory Astronomy and Astrophysics

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).

**Chemistry minor for Non-Chemistry majors**
Students not majoring in chemistry may receive a minor in this discipline by passing 24 credits of courses bearing the CHEM- prefix, 16 of which are at or above the 2000 level and include at least two credits of laboratory. The combination cannot include both CHEM-2150 and CHEM-4530. 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**

A student who is within 18 credit hours of the B.S. can apply for admission to the graduate program. With advanced placement credit, extra courses, and by starting research while still an undergraduate, the time required for the advanced degree can be reduced by a year or more. Students who enter the Chemistry graduate program through the 18-hour rule may be eligible for graduate teaching or research assistantship support.

Highly motivated students who carry out significant research as undergraduates may 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 typically begin their studies with graduate courses in analytical, inorganic, organic, and physical chemistry. The courses that are required depend on the student’s background, area of interest, and performance in entering placement exams. Additionally, in consultation with the adviser, students may select a number of specialized advanced-level courses in chemistry, as well as from offerings in other departments that meet their needs. Chemistry graduate students may also select the biochemistry/bio-physics option described earlier. Each student plans a program with his or her adviser 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, participating in undergraduate
laboratory or workshop-mode 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 90 credit hours (60 beyond the M.S. degree) 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

Chair: Jeffrey C. Trinkle
Executive Officer: Robert P. Ingalls

Computer Science 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, scientific and numeric computation, computer vision, data mining, robotics, computational learning, and user-interface design.

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 offers its own well-equipped computer laboratories for instruction and research. There are 20 Sun Ultra 10 workstations running Solaris 9 in a public lab in the Amos Eaton building (room 217) as well as a dedicated Enterprise 450 serving 32 thin clients (room 215). Each of our Ultra 10 workstations includes a PC subsystem, providing Windows 2000 in the public labs. In the Networking and Distributed Simulation lab, there are 41 IBM x220 servers, along with 13 Cisco routers and a Myrinet Cluster for experimenting with different network layouts. Our World Wide Computing lab houses 4 Sun Blade-1000 computers, which are also interconnected via Myrinet. Additionally, our Networking lab contains over 130 interconnected Cisco routers, switches and firewalls, which support a number of networking technologies such as FDDI, HSSI, ISDN, and Ethernet. Numerous
other specialized research computers include a Silicon Graphics Origin 2000 with 12 CPUs, a 16 processor IBM pSerial 655 cluster, and a cluster of four Intel Itanium2 quad-processor machines, all interconnected via Myrinet. Also available are two robotics labs, a distributed/parallel computing laboratory, and a multimedia database lab. Student offices contain more than 50 other Unix workstations and PCs. Supporting all of these is a network of file servers with more than 0.75 terabytes of storage, print servers, mail servers, and Web servers. Most offices have a 100Mb dedicated connection to the gigabit Ethernet backbone.

**Research Innovations and Initiatives**

**Bioinformatics**
Bioinformatics is the science of managing, retrieving, analyzing, and interpreting biological data. Research is being carried out on topics such as multiple sequence alignment, sequence assembly, protein and RNA structure prediction, and regulatory networks. Research also spans emerging areas like 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 allow 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.

**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 and biomedical image analysis research in the Department of Computer Science covers a wide range of topics. Developing algorithms for registration and change detection, especially in the diagnosis and treatment of diseases of the human retina, is the largest current project; a related project studies the theory and application of robust estimation techniques in computer vision. A second research area focuses on the tracking and segmentation of objects, both in two- and three-dimensional images, using model-based algorithms. The techniques developed are general and may be used in a variety of computer vision tasks; the applications pursued at Rensselaer are mainly focused on biomedical problems, such image-guided radiation therapy. A third track involves the development of stochastic models for the interpretation of video data, for example traffic video.

**Concepts in Software Engineering**
Research in this area focuses on new ways to design and implement computational methods so that they can adapt easily to different problems, providing solutions that are as efficient as programs written especially for each problem. Research interests span many diverse issues: behavioral concept specifications,
language design, compiler optimizations, efficient memory handling, and constructing and using libraries of multipurpose, high-performance software components. Results include the C++ Standard Template Library, which is based on joint research with colleagues in industry; new generic sorting and searching algorithms; and a new memory manager for C++ programs.

Data Mining; Machine and Computational Learning; Algorithms for Massive Data Sets
This research area deals with 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.

Database Systems
This research area deals with the 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 applications such as computer-aided design and manufacturing, bioinformatics, and collaborative engineering.

Pervasive and Network Computing
Pervasive computing foresees a world in the not-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 sent into a collapsed building to locate survivors. Untethered—wireless—communication is constant and, in many cases, so automated that human intervention is unneeded. Wireless, broadband community systems inexpensively bring people together for virtual town meetings, video doctor-patient conferences, and on-line business transactions. Computers in automobiles share information on congestion, quickly computing alternate routes. The promises are immense, but the challenges are formidable.

CS faculty cover the broad area of pervasive networking and computing. This research includes investigation of computer networks and their protocols, security of computers and networks and distributed and parallel system optimization and simulations.

Robotics
Research in robotics is aimed at developing algorithms for motion planning, mobile robotics, and robotic manipulation. Current work focuses on multiple robot coordination and control, mobile manipulators, automated parts feeding for assembly, and motion planning methods that make use of new techniques from topology.

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, such as networking; bioinformatics; visualization; pattern recognition, physics and astronomy; digital library; data mining; distributed computing; and experimental algorithmics.
Faculty*

Professors

Flaherty, J.E.—Ph.D. (Polytechnic Institute of Brooklyn); scientific computation; adaptive and parallel solution techniques; numerical analysis.

Goldberg, M.K.—Ph.D (Institute of Mathematics, Novosibirsk, Russia); experimental design and analysis of algorithms; combinatorial optimization; combinatorics and graph theory.

Hardwick, M.—Ph.D. (Bristol University, U.K.); database systems for engineering and manufacturing applications.

Luk, F.T.—Ph.D (Stanford University); numerical linear algebra; grid computing; signal and image processing.

Musser, D.—Ph.D. (University of Wisconsin); programming methodology; generic software libraries; formal methods of specification and verification.

Spooner, D.—Ph.D. (Pennsylvania State University); database systems, database security, database browsing and visualization, computer science and information technology education.

Stewart, C.—Ph.D. (University of Wisconsin); computer vision; medical applications.

Szymanski, B.K.—Ph.D. (National Academy of Sciences, Warsaw, Poland); computer networks; distributed and parallel computing; distributed and web-based simulation; computational biology.

Trinkle, J.C.—Ph.D. (University of Pennsylvania); robot planning, manufacturing automation, scientific computation, multibody dynamics, computational topology, human-machine interaction.

Clinical Professor

Danchak, M. M.—Ph.D. (Rensselaer Polytechnic Institute); human-computer interaction; intelligent user interfaces; usability; information visualization; techniques for distance learning and human learning models; adaptive hypermedia.

Associate Professors

Adali, S.—Ph.D. (University of Maryland); multimedia database systems, information integration, query optimization.

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.

Yener, B.—Ph.D. (Columbia University); computer networks; biological networks, bioinformatics, security and intelligence; combinatorial optimization.

Zaki, M.—Ph.D. (University of Rochester); data mining and knowledge discovery in databases; bioinformatics; web mining; high performance computing; graph and combinatorial algorithms.

Research Associate Professor

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.

Assistant Professors

Akella, S.—Ph.D. (Carnegie Mellon University); robotics and automation; robotic manipulation and motion planning; geometric algorithms and computer graphics.

Busch, C.—Ph.D. (Brown University); distributed and parallel systems, communications networks.

Carothers, C.—Ph.D. (Georgia Institute of Technology); parallel and distributed systems; simulation; networking and real-time 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 as of the May 2005 Board of Trustees meeting.
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.

Freedman, D.—Ph.D. (Harvard University); computer vision, image processing, computational geometry, computational topology.

Huang, W.—Ph.D. (Carnegie Mellon University); mobile robotics, robotic manipulation, and motion planning.

Magdon-Ismail, M.—Ph.D. (California Institute of Technology); theory, algorithms and applications of computational learning systems; computational finance; bioinformatics; social and communication network analysis.

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); grid computing; middleware; concurrent and distributed systems; programming languages; coordination models; databases and the web.

Instructors
Hollinger, D.L.—M.S. (Rensselaer Polytechnic Institute); machine learning; AI applications for the WWW; genetic algorithms.

Ingalls, R.—Ph.D. (University of Connecticut); operating systems; computer science education.

Kotfila, D. A.—M.Div. (Yale University) Advanced routing and switching protocols; network security.

Professor Emeritus
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.

Rogers, E. H.—Ph.D. (Carnegie Mellon University); collaborative computing; group operating systems; modeling paradigm; software engineering.

Joint Appointments with Mathematical Sciences—Professors
Isaacson, D.—Ph.D. (New York University); mathematical problems 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
Gerhardt, L.A.—Ph.D. (State University of New York at Buffalo); digital voice and image processing; communication systems; integrated inspection; sensing technologies; 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 Electrical, Computer, and Systems Engineering—Associate Professors
Franklin, W.R.—Ph.D. (Harvard University); computational cartography; computational geometry; computer graphics; geographic information science; computer security.

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 Mechanical, Aerospace, and Nuclear Engineering—Associate Professor

**Jansen, K.E.**—Ph.D. (Stanford University); large scale, parallel scientific computing with emphasis on fluid dynamics. Topics include cardiovascular system modeling, turbulence modeling, level set methods, finite element formulations, error estimation, design of software frameworks, and parallel computing.

Joint Appointment with Cognitive Science—Professor

**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).

**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 may 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 should:

- be an expert software developer, with knowledge of several programming paradigms
- have a solid understanding of the mathematical/theoretical underpinnings of computer science
- be able to express himself/herself well both orally and in writing
- understand current computing technologies and be prepared to quickly adapt to new technological developments.

**Baccalaureate Programs**

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 the B.S. in computer science shown below exhibits, flexibility is a hallmark of the Rensselaer computer science program. Students may explore related areas such as mathematics, electrical engineering, computer engineering, management, and psychology.

**Computer Science Curriculum**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td><strong>Spring</strong></td>
<td></td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I ........................................4</td>
<td>MATH-1020</td>
<td>Calculus II ........................................4</td>
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<tr>
<td>CSCI-1100</td>
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<td>CSCI-1200</td>
<td>Computer Science II ..........................4</td>
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<tr>
<td>PHYS-1100</td>
<td>Physics I ...........................................4</td>
<td>MATH-2800</td>
<td>Intro. to Discrete Structures ..........4</td>
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<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective ......................................4</td>
<td></td>
<td>Hum. or Soc. Sci. Elective ..................4</td>
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</table>

1 Students may skip CSCI-1100 and replace it with any other CS course.
Second Year

<table>
<thead>
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<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>CSCI-2300</td>
<td>Data Struct. and Algorithms ........4</td>
<td>CSCI-2400</td>
<td>Mathematics Option ...........4</td>
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<tr>
<td>CSCI-2500</td>
<td>Computer Organization ............4</td>
<td>CSCI-2410</td>
<td>Models of Computation ........4</td>
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<tr>
<td>BIOL-1010</td>
<td>Intro. to Biology ................4</td>
<td>CSCI-2420</td>
<td>Hum. or Soc. Sci. Elective ....4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective ......4</td>
<td></td>
<td>Free Elective ................4</td>
</tr>
<tr>
<td></td>
<td>Science Option ................4</td>
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</table>

Third Year

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<th>Spring</th>
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<td>CSCI-4210</td>
<td>Operating Systems ..........4</td>
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<td>Computer Science Option ..........4</td>
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<td>Free Elective ..........4</td>
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<td></td>
<td>Hum. or Soc. Sci. Elective ....4</td>
<td></td>
<td>Hum. or Soc. Sci. Elective ....4</td>
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<tr>
<td></td>
<td>Science Option ................4</td>
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<td>Free Elective ..........4</td>
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</table>

Fourth Year

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<th>Spring</th>
<th>Credit hours</th>
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</thead>
<tbody>
<tr>
<td>CSCI-4440</td>
<td>Software Design and Doc. ..........4</td>
<td>CSCI-4440</td>
<td>Computer Science Option ..........4</td>
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<td>Computer Science Option ..........4</td>
<td></td>
<td>Free Elective ..........4</td>
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<td>Free Elective ..........4</td>
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<td>Free Elective ..........4</td>
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<td></td>
<td>Free Elective ..........4</td>
<td></td>
<td>Free Elective ..........4</td>
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</table>

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
Eleven additional credit hours of computing courses 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-4720 and reading and independent study courses. ECSE-4490 may also fulfill this requirement. The Pass/No Credit option cannot be used for these courses.

Mathematics
One additional mathematics course at the 2000 level or above. The Pass/No Credit option cannot be used for this course. Independent study courses cannot be used to satisfy this option.

Dual Major Programs
Computer science students can obtain a dual major with any other major offered on the Rensselaer campus. In many cases, students can obtain a dual major within the 128 credits of a single degree, since many courses can be counted twice. Among the popular majors often combined with computer science are philosophy, mathematics, physics, management, Electronic Media, Arts, and Communication, and engineering (the latter requires additional credits hours).

Minor Programs
A computer science minor requires CSCI-1200, CSCI-2300, and three additional four-credit courses at the 2000 level or above. At least two of these must have a CSCI code and at least two must be at the 4000 or 6000 level. One course may be chosen from the ECSE-x6xx or ECSE-x7xx family. Courses required by name for the student’s major cannot be used for the minor.
Accelerated Programs
Students may be admitted to the graduate program in Computer Science when they are within 18 credits of completing their B.S. 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.

Cooperative Education
Numerous opportunities exist for computer science majors, and students are urged to pursue at least one co-op experience during their academic career. More detailed information on this program is available in the School of Science introduction section and the Educational Programs and Resources section of this catalog.

Undergraduate Research Program
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.

Cisco Networking Academy
The Cisco Networking Academy provides extensive hands-on learning in networking. A lab of over 70 routers and switches simulates the backbone of the Internet and is always available for student use. The Academy prepares students for the following certifications: Cisco Certified Network Associate (CCNA), Cisco Certified Network Professional (CCNP), and Cisco Certified Internetwork Expert (CCIE).

Graduate Programs
The Department of Computer Science offers M.S. and Ph.D. degrees in computer science. The department also offers a computer science M.S. and Ph.D. with a specialization in computational science, and a Ph.D. with specialization in computational molecular biology.

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 15 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 two required courses, CSCI-6050 (can be replaced by CSCI-6480) and CSCI-4210 (can be replaced by
CSCI-6140). At least two courses must be taken from the computer systems area, and at least one course must be taken from the computer theory area and one course from the computer applications 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 eight credits in an area of natural science or engineering; 3) at least one course in each of software and hardware systems; and 4) a significant (three to four credit) software project. At least 18 credits must be at the 6000 level and students should attend the computer science colloquium and the 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 below.

**Doctoral Programs**

**Ph.D. in Computer Science**

Students must demonstrate skill using computational tools and high achievement in scholarship and independent research. During the first year, the student focuses on obtaining a breadth of knowledge in computer science. By the end of the first year, the student must pass a doctoral qualifying examination. This examination covers the material of five courses: CSCI-6050, CSCI-4020, CSCI-6140, CSCI-4250, and CSCI-4430.

The second year is devoted to research exploration and selection of a doctoral committee. By the end of the second year, the student must pass a research qualifying exam demonstrating breadth of knowledge in their research area.

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 then is questioned by the committee.

In addition to the above requirements, the student must earn a total of 90 credits beyond the bachelor’s level. Between 45 and 60 credits must be course credits. The remaining credits are for dissertation research. All students must have courses in three of the following four areas on their undergraduate or graduate transcript: database systems, artificial intelligence, numerical computing, and computer graphics/user interfaces. In addition, all doctoral students must have had at least three courses in mathematics at the junior/senior level, and they must demonstrate programming ability on a substantial programming project. The area requirements, the mathematics requirement, and the programming requirement can be satisfied by course work completed prior to entering the Ph.D. program. All doctoral students are expected to have presented at least two public lectures on their research prior to their defense. At least one of the lectures must be for the Graduate Student Seminar. The other may be a conference presentation or invited lecture. Graduate students are expected to attend the Computer Science Colloquium series on a regular basis. The Ph.D. program culminates with the submission of a thesis and the oral dissertation defense.
Ph.D. in Computer Science Specializing in Computational Science and Engineering

Students must complete 90 credits of course work and research beyond the B.S. degree, with at least 45 credits in formal course work. They must take 1) at least 12 credits in an area of natural science or engineering; 2) at least nine credits in numerical analysis and/or scientific computation; and 3) at least one course in software systems, hardware systems, and visualization. They must further demonstrate mathematical sophistication by having taken at least eight credits of 4000- or 6000-level mathematics courses (exclusive of numerical analysis) and programming ability by having done a substantial software project. The mathematical and programming proficiency requirements can be satisfied by work done outside of the Ph.D. degree program. Graduate students are expected to attend the Computer Science Colloquium series on a regular basis.

After one year of study, students must pass a qualifying examination in 1) numerical computing (material equivalent to CSCI-4800), 2) software and hardware systems (material equivalent to CSCI-4020, CSCI-4250, and CSCI-4430), and 3) a scientific or engineering field of specialization.

By the end of the second year the student must pass a research qualifying exam demonstrating breadth of knowledge in their research area. After their third year of graduate study, students are expected to pass an oral candidacy examination that focuses on their research. Subsequent to passing this examination, students must present two public lectures on their research and write and defend a dissertation.

Doctoral course requirements are inclusive of those for the M.S. degree. As with the M.S. degree, applicants apply in the usual manner, but should have backgrounds including 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.

Ph.D. in Computer Science with a Specialization in Computational Molecular Biology

Admission: Students apply to the Computer Science Department in the usual manner. Student backgrounds are expected to include courses in calculus, elementary linear algebra, higher-level computer languages, algorithms & data structures, introductory organic chemistry (CHEM-2210 or equivalent), and introductory biology. 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.

Doctor of Philosophy: Students must complete 90 credits of course work and research beyond the B.S. Degree, with at least 45 credits in formal course work. They must take (1) at least 12 credits in molecular or cell biology / biochemistry, (2) at least nine credits in probability, statistics, machine learning and bioinformatics, and (3) at least 12 credits in Computer Science including at least one course each in software systems, theory of computation, and applications (in addition to courses covered on the qualifying exam, database systems, computational molecular biology, and data mining courses are recommended). They must further demonstrate programming ability by having done a substantial software project. The probability and statistics, programming proficiency, and molecular biology/biochemistry requirement can be satisfied by work done outside of the Ph.D. degree program. Graduate students are expected to attend the Computer Science Colloquium series on a regular basis.

After one year of study, students must pass a qualifying examination in (1) probability and statistics (material equivalent to Course MATP-4600), (2) Computer Science (material equivalent to courses CSCI-4020 Computer Algorithms, and CSCI-4430 Programming Languages, CSCI-6050 Computability, and Complexity), (3) and biochemistry I (BCBP-4760) or molecular biology (BIOL-4620).

By the end of the second year the student must pass a research qualifying exam demonstrating breadth of knowledge in their research area. After their third year of graduate study, students are expected to pass
an oral candidacy examination that focuses on their research. Subsequent to passing this examination, students must present at least two public lectures on their research and write and defend a dissertation.

**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:** Lynn A. DeNoia

### Master of Science in Computer Science

Applicants are assumed to have knowledge of computer concepts and programming in a high-level language. Depending on academic background and professional experience, a student may be required to begin study with one or more of the following prerequisite immigration courses:

- **CISH-4010** Discrete Mathematics and Computer Theory
- **CISH-4020** Object Structures
- **CISH-4030** Structured Computer Architecture

To receive the Master of Science degree in Computer Science, students must earn a minimum of 30 credit hours in Computer and Information Science or approved courses. A student’s Plan of Study will include:

#### CIS Core Courses (6 credits)

- **CISH-4210** Operating Systems
- **CSCI-6050** Computability and Complexity

#### CIS Breadth Requirement (9 credits)

- **ECSE-4670** Computer Communication Networks
- **ECSE-6770** Software Engineering I
- **CISH-4380** Database Systems

#### CIS Electives (6–9 credits)

CIS electives totaling 9 credits, with approval by the student's adviser and such that at least 18 credits of the plan of study are at the advanced graduate level (ECSE-6xxx, ECSE-7xxx CSCI-6xxx, or CISH-6xxx). Most electives are 3-credits, however, 1-credit special topic electives, CSCI-6960 or CISH-6960 (5 weeks) are offered occasionally. Students may take up to three 1-credit electives.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CISH-6220</td>
<td>LANs, MANs, and Internetworking</td>
</tr>
<tr>
<td>ECSE-6660</td>
<td>Broadband &amp; Optical Networking</td>
</tr>
<tr>
<td>ECSE-6780</td>
<td>Software Engineering II</td>
</tr>
<tr>
<td>CISH-6010</td>
<td>Object Oriented Programming and Design</td>
</tr>
<tr>
<td>CISH-6510</td>
<td>Web Application Design and Development</td>
</tr>
<tr>
<td>CSCI-6460</td>
<td>Adv. Database Management Topics</td>
</tr>
<tr>
<td>CISH-6110</td>
<td>OO Database Systems</td>
</tr>
<tr>
<td>CISH-6120</td>
<td>Distributed Database Systems</td>
</tr>
<tr>
<td>CSCI-6150</td>
<td>Artificial Intelligence and Heuristics</td>
</tr>
<tr>
<td>CISH-6050</td>
<td>Software Engineering Management</td>
</tr>
<tr>
<td>CSCI-6210</td>
<td>Design and Analysis of Algorithms</td>
</tr>
<tr>
<td>CISH-6230</td>
<td>Network Management</td>
</tr>
<tr>
<td>CISH-6960</td>
<td>Cryptography and Network Security</td>
</tr>
<tr>
<td>COMM-6420</td>
<td>Foundations of HCI Usability</td>
</tr>
</tbody>
</table>
Completion
Students will complete their program of study via one of two paths:

**Applied Path (6 credits)**
- ECSE-4670 Computer Communication Networks
- COMM-6420 Foundations of HCI Usability
- CISH-4380 Database Systems
- Select one of the following elective courses:
  - ECSE-6770 Software Engineering I
  - CISH-6010 Object Oriented Programming & Design

**Theory Path (9 credits)**
- ECSE-4670 Computer Communication Networks
- Select three of the following elective courses:
  - CISH-6960 Cryptography and Network Security
  - CISH-6220 LANs, MANs & Internetworking
  - CISH-6230 Network Management
  - ECSE-6660 Broadband & Optical Networking

**Computer Science Graduate Certificate Programs**

CIS Graduate Certificate Programs are designed with a selective focus and require that a student successfully complete four graduate courses in a specific area of Computer and Information Science. Credits earned in Graduate Certificates may be subsequently applied toward an M.S. degree as electives with the approval of a student’s adviser.

**Information Systems** *(Program coordinator: Tim Martyn, martyn@rh.edu, 860/548-5354)*

**Required**
- ECSE-4670 Computer Communication Networks
- COMM-6420 Foundations of HCI Usability
- CISH-4380 Database Systems

**Select one of the following elective courses:**
- ECSE-6770 Software Engineering I
- CISH-6010 Object Oriented Programming & Design

**Computer Network Communications** *(Program coordinator: Roger Brown, rhb@rh.edu, 860/548-2462)*

**Required**
- ECSE-4670 Computer Communication Networks

**Select three of the following elective courses:**
- CISH-6960 Cryptography and Network Security
- CISH-6220 LANs, MANs & Internetworking
- CISH-6230 Network Management
- ECSE-6660 Broadband & Optical Networking

**Software Engineering** *(Program coordinator: Heidi Ellis, heidic@rh.edu, 860/548-5387)*

**Required**
- ECSE-6770 Software Engineering I
- CISH-6050 Software Engineering Management

**Select two of the following elective courses:**
- ECSE-6780 Software Engineering II
- CISH-6010 Object Oriented Programming & Design
- CISH-6510 Web Application Design and Development

**Database Systems** *(Program coordinator: Tim Martyn, martyn@rh.edu, 860/548-5354)*

**Any four of the following elective courses:**
- CISH-4380 Database Systems
- CISH-6110 OO Database Systems
- CSCI-6460 Adv. Database Management Topics
- CISH-6120 Distributed Database Systems
- CISH-6960 Data Warehouse Systems
Earth and Environmental Sciences

Chair: Frank Spear

Department Home Page: http://www.rpi.edu/dept/geo

Over the past few decades, the earth sciences have undergone major changes. Primarily stimulating these changes have been the reinterpretation of Earth history and processes with regard to plate tectonics, along with the more recent challenges of local, regional, and global environmental problems. Highly cognizant of these changes, Rensselaer’s instruction in modern earth science is wide ranging and offers many courses and opportunities for individual study.

At Rensselaer, students learn about the 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 geological to field experience and geochemical approaches. The program includes the study of the 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. In addition, students may obtain summer employment with oil, geological engineering, or hydrologic consulting companies, or they may participate in a Rensselaer faculty member’s field-oriented research project.

Research Innovations and Initiatives

The diverse interests of the Earth and Environmental Sciences 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.

Hydrogeology and Environmental Geochemistry
Ongoing research includes investigations of organic pollutant transport, dispersion, and degradation in surface and groundwater. Also under way are studies of heavy-metal-contamination histories of local water bodies, development of methods for tracing and predicting contaminant behavior, and the use of stable isotopes as fingerprints and traces of environmental contamination.

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, 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 with dual microinlet, an elemental analyzer, and gas chromatographic sample introduction systems for continuous flow and compound-specific analyses. PCs, Macs, and Unix workstations in the department are linked to the Institute's computer network.

Faculty*

Institute Professor
Watson, E.B.—Ph.D. (Massachusetts Institute of Technology); experimental geochemistry and petrology.

Professors
Abrajano, T.A.—Ph.D. (Washington University); isotope and environmental geochemistry.
McCaffrey, R.—Ph.D. (University of California, Santa Cruz); tectonics, seismology, geodesy.
Roecker, S.—Ph.D. (Massachusetts Institute of Technology); geophysics, seismology, and geodesy.
Spear, F.S.—Ph.D. (University of California, Los Angeles); petrology, geochemistry.

Associate Professor
Bopp, R.F.—Ph.D. (Columbia University); environmental geochemistry.

Assistant Professor
Sharma, A.—Ph.D. (State University of New York at Binghamton); experimental biogeochemistry, mineral microbial interaction.

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 Professors
Cherniak, D.—Ph.D. (University at Albany); geochemical kinetics.
Wark, D.A.—Ph.D. (University of Texas, Austin); igneous petrology, volcanology.

* 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 2005 Board of Trustees meeting.
Research Scientists
Price, J.—Ph.D. (Oklahoma University); experimental petrology.
Pyle, J.—Ph.D. (Rensselaer Polytechnic Institute); metamorphic petrology, trace element geochemistry.
Thomas, J.—Ph.D. (Virginia Tech); geochemistry.
Tikku, A.—Ph.D. (University of California, San Diego); geophysics.
Williams, C.—Ph.D. (University of Arizona); geophysics, tectonics.

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 their adviser. Students are encouraged to use the flexibility available to their own advantage. 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 third year and that they have maintained satisfactory grades in their first two years.

Baccalaureate Programs
Each of the programs shown below require a total of 124 credit hours. The first program leads to a B.S. in Geology and the second to a B.S. in Hydrogeology.

Geology Curriculum

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I</td>
<td>4</td>
<td>MATH-1020</td>
</tr>
<tr>
<td>CHEM-1100</td>
<td>Chemistry I</td>
<td>4</td>
<td>CHEM-1200</td>
</tr>
<tr>
<td>ERTH-1100</td>
<td>Geology I</td>
<td>4</td>
<td>ERTH-1200</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERTH-2210</td>
<td>Field Methods</td>
<td>2</td>
<td>ERTH-2100</td>
</tr>
<tr>
<td>ERTH-2120</td>
<td>Structural Geology</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>ERTH-4xxx</td>
<td>Geology Group Option</td>
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<td>ERTH-4xxx</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elective</td>
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<table>
<thead>
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<th>Second Year</th>
<th>Credit hours</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>Fall</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>MATH-2010</td>
<td>Multivar. Calc. and Matrix Algebra</td>
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<td>ERTH-2140</td>
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<tr>
<td>PHYS-1100</td>
<td>Physics I</td>
<td>4</td>
<td>PHYS-1200</td>
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<tr>
<td>ERTH-2330</td>
<td>Earth Materials</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
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</table>

<table>
<thead>
<tr>
<th>Third Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERTH-2210</td>
<td>Field Methods</td>
<td>2</td>
<td>ERTH-2100</td>
</tr>
<tr>
<td>ERTH-2120</td>
<td>Structural Geology</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>ERTH-4xxx</td>
<td>Geology Group Option</td>
<td>4</td>
<td>ERTH-4xxx</td>
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<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elective</td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fourth Year</th>
<th>Credit hours</th>
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<td>Fall</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ERTH-xxxx</td>
<td>Electives</td>
<td>16</td>
<td>Culminating Experience</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Electives</td>
</tr>
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</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.
Geology Group options (Two courses from the following group)

ERTH-4190 Environmental Measurements
ERTH-4340 Igneous and Metamorphic Petrology
ERTH-4540 Organic Geochemistry
ERTH-4690 Aqueous Geochemistry
ERTH-4650 Seismology
ERTH-4710 Groundwater Hydrology
ERTH-4750 Geographic Information Systems in the Sciences

Culminating Experience

ERTH-4970 Out of Classroom Experience in Earth Science
ERTH-4980 Senior Field Thesis
Undergraduate Research Program (URP)

Electives

The following are recommended as electives for the geology curriculum:

BIOL-4850 Principles of Ecology
CHEM-2210 Organic Compounds and Reactions
CHEM-4430 Macroscopic Physical Chemistry
CIVL-2630 Introduction to Geotechnical Engineering
CIVL-4150 Soil Mechanics
ENVE-4310 Applied Hydrology and Hydraulics
MATH-2400 Introduction to Differential Equations
MATH-4600 Advanced Calculus
MATH-4700 Foundations of Applied Mathematics
MATH-4800 Numerical Computing
MATH-4820 Introduction to Numerical Methods for Differential Equations
MTLE-2020 Introduction to Ceramic Materials
MTLE-4100 Thermodynamics of Materials
WRIT-4120 Technical and Professional Communication

Hydrogeology Curriculum

First Year

Fall | Credit hours | Spring | Credit hours
---|-------------|--------|-------------
MATH-1010 | Calculus I .........................................4 | MATH-1020 | Calculus II .................................4
CHEM-1100 | Chemistry I ........................................4 | CHEM-1200 | Chemistry II ...............................4
ERTH-1100 | Geology I ...........................................4 | ERTH-1200 | Geology II ...................................4
Hum. or Soc. Sci. Elective ...............4 | Hum. or Soc. Sci. Elective ...............4

Second Year

Fall | Credit hours | Spring | Credit hours
---|-------------|--------|-------------
MATH-2010 | Multivar. Calc. and Matrix Algebra ........4 | MATH-2400 | Differential Equations ..................4
PHYS-1100 | Physics I ..........................................4 | PHYS-1200 | Physics II ...................................4
CSCI-xxxx | Computer Science Elective ..................4 | Biology Requirement 1 ........................4
Hum. or Soc. Sci. Elective ...............4 | Hum. or Soc. Sci. Elective ...............4

1 Biology Requirement: BIOL-1010 if taken in the second year, but may be BIOL-4320 if taken in the third or fourth year.
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 subdiscipline 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 Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH-2100</td>
<td>Introduction to Geophysics</td>
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<tr>
<td>ERTH-4070</td>
<td>Sedimentology</td>
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<tr>
<td>ERTH-4540</td>
<td>Organic Geochemistry</td>
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<tr>
<td>ERTH-4690</td>
<td>Aqueous Geochemistry</td>
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</tr>
<tr>
<td>BIOL-4320</td>
<td>Geomicrobiology</td>
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</tr>
<tr>
<td>BIOL-4620</td>
<td>Molecular Biology</td>
<td></td>
</tr>
<tr>
<td>BIOL-4700</td>
<td>Fresh Water Ecology Laboratory</td>
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</tr>
<tr>
<td>CHEM-2210</td>
<td>Organic Compounds and Reactions</td>
<td></td>
</tr>
<tr>
<td>CHEM-2220</td>
<td>Organic Synthesis</td>
<td></td>
</tr>
<tr>
<td>CHEM-4450</td>
<td>Macroscopic Physical Chemistry</td>
<td></td>
</tr>
<tr>
<td>CHEM-4460</td>
<td>Microscopic Physical Chemistry</td>
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<tr>
<td>CIVL-4240</td>
<td>Finite Element Methods</td>
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<tr>
<td>CHEM-4810</td>
<td>Chemistry of the Environment</td>
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</tr>
<tr>
<td>CSCI-1200</td>
<td>Computer Science II</td>
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<tr>
<td>CHEM-4810</td>
<td>Chemistry of the Environment</td>
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<td>Statistical Analysis I</td>
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<td>DSES-6110</td>
<td>Introduction to Applied Statistics</td>
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<tr>
<td>ECSE-4510</td>
<td>Discrete Time Systems</td>
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<tr>
<td>ENVE-4220</td>
<td>Environmental Law</td>
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<tr>
<td>MATP-4600</td>
<td>Probability Theory and Applications</td>
<td></td>
</tr>
<tr>
<td>PHYS-2350</td>
<td>Experimental Physics</td>
<td></td>
</tr>
</tbody>
</table>

Minor Programs
The department offers opportunities to minor in the following:

Geology
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.

Astrobiology
The Earth and Environmental Sciences Department participates in a multidisciplinary minor in astrobiology for students majoring in geology or other disciplines. To complete this minor, students must take a minimum of 16 credits of course work in this field. These courses include ASTR-4510 and ISCI-4500, four credits each, and two semesters of the one-credit course ISCI-4510. A further two courses outside the major field of study are also required, selected from the following:
The requirement that two selected courses must be outside of the major field of study is reduced to one in the case of a dual major, provided that both majors are in the primary relevant areas of study (i.e., biology, chemistry, geology, and physics).

Hydrogeology
Students not majoring in hydrogeology may take a minor by taking ERTH-4710, ERTH-4180, and electing from the ERTH group at least two additional courses except for ERTH-1030 and ERTH-1040.

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 and Social Sciences portion of this catalog for details.

Accelerated Programs
An accelerated program with emphasis in geophysics 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
The department has several unique educational opportunities that are detailed below.

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.

Environmental Science Concentration
The environmental science degree program is offered to students with an interest in a broad interdisciplinary degree directed toward understanding and finding solutions for the environmental challenges that face modern civilization. The environmental science degree has a core science requirement of 38 credit hours (10 courses). The student then selects from one of several concentration areas, one of which is geology.

Environmental Studies Program
Building on the unusual strength and breadth of Rensselaer’s synthesis of engineering, science, and the humanities and social sciences, the Environmental Studies Program offers students a unique educational opportunity to develop a truly multidisciplinary approach to environmental studies.
Participating students take a broad range of basic courses in their first two years and then choose one of five majors: economics (with a concentration in a specific area of science), hydrogeology, science, technology, and society (with an environmental focus). To complement their major program, students may earn a wide variety of minors. All the majors in the program offer their own environmental minors, and the Schools of Architecture and Management offer special environmental courses as well. Graduates of the Environmental Studies Program will not be narrow specialists; they will receive the kind of multidisciplinary education that is required to address environmental problems.

**Graduate Programs**

Research programs leading to the M.S. and Ph.D. degrees are available in geochemistry, geophysics, hydrogeology, and igneous and metamorphic petrology. 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 Origins of Life initiative. Applicants to degree programs must arrange for their Graduate Record Examination (GRE) general test scores to be sent to the department. Those who cannot take the test because of illness, residence overseas, etc., should attach explanations to their applications.

**Master’s Programs**

The department offers M.S. degrees in geology and hydrogeology and a professional master’s degree in applied groundwater science.

Candidates for the M.S. degrees in geology and hydrogeology 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.

For the professional master’s degree in applied groundwater science, candidates must also complete 30 credit hours of graduate study based on an approved plan of study. However, no thesis is required.

**Doctoral Programs**

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.

**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

Chair: Donald Drew

Chair of the Graduate Committee: Victor Roytburd

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;
- Applications in the physical sciences, biological sciences, and engineering;
- Scientific computing;
- 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 schemes 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 of internal biological, mechanical, electric, or magnetic properties of a system from boundary, spectral, or scattering data. The physical system is modeled by a partial differential or ordinary differential equation with specific unknown terms representing, for example, stiffness in an elastic system or electric permittivity in an electromagnetic system. The goal of this work is to find the unknown properties from indirect measurements. 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 solutions to these problems.

**Dynamical Systems**
This research concentrates on the theory of dynamical systems and its applications in physics and engineering. Dynamical systems arise as mathematical models in various applications such as mechanics, optics, electric circuits, solid-state physics, fluid dynamics, optimal control, neural science and other fields. This research aims to discover and explain new and important phenomena found in experimental and numerical studies. Often involved is modeling a real-life problem by a dynamical system and then applying the ideas and methods of the theory to explain and predict complex behavior. Theoretical research is conducted in chaotic dynamics, Hamiltonian systems (KAM theory and applications, theoretical mechanics), bifurcation theory, and related fields. Mathematical methods used come from analysis, topology, differential geometry, combinatorics, and other fields. Computation may be used as an experimental tool.

**Wave Propagation**
These studies focus on the behavior of acoustic wave propagation. A major area of interest is underwater sound transmissions. Mathematical models are being developed and analyzed to describe the influences of ocean environmental features (such as internal waves and sediment variations) on the study of the propagation of signals in both frequency and time domains, and to improve the accuracy of known numerical methods. Improved numerical and asymptotic methods are derived and tested, providing new ways to extract information from complex propagation environments. Stochastic propagation effects are modeled and analyzed, and results are used to explain variability observed by ocean scientists. Results are extended and applied to 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 genetic algorithms and tabu search. 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 polyelectrolytic 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 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, fluid mechanical models of atmospheric events and the theory of flow in a gas centrifuge. Studies also include the evolution of non-Newtonian (e.g., polymer) fluid flow.

Combustion Theory
Investigations include mathematical modeling of combustion and flame propagation phenomena, and analysis of the resulting systems of nonlinear ordinary and partial differential equations. Topics of current interest are bifurcation and stability of reactive systems, evolution and interaction of waves in reactive gases, combustion and vortex breakdown in swirling flows, and transition from deflagration to detonation in granular explosives.

Applied Geometry
Included are problems dealing with surface design, curve design, robot path planning, packing, tiling, computational geometry, and artificial intelligence as it applies to geometry. Students take advantage of related courses in electrical engineering, mechanical engineering, computer science, and mathematics.

Approximation Theory
This branch of mathematics strives to understand the fundamental limits in optimally representing different signal types. “Signals” here may mean a database of digital audio signal, a collection of digital mammograms, solutions of a class of integral equations, or triangulated compact surfaces acquired by a
3-D scanner. These signals are typically modeled mathematically based on their intrinsic smoothness or oscillatory characteristics. Current research effort involves the design and analysis of various multiresolution techniques that have provable optimality properties for these models. Such optimal representations are invariably the key ingredients to successful data compression, estimation, and computer-aided geometric design. Exploited tools range from mathematical analysis (e.g., Littlewood-Paley theory) to fast numerical algorithms, to information theory, to algebraic and differential geometry, and to spline and subdivision theory.

Complex Systems
This includes an investigation into nonlinear phenomena that arise in such diverse areas as semiconductor laser theory, nonlinear and fiber optics, surface water waves, acoustic waves and gas lasers. Although these topics are seemingly disconnected and have different physical characteristics, they all can be viewed as complex systems composed out of interacting particles or waves. There is a general theoretical framework for their description called weak turbulence theory. The research in this area involves development of weak turbulence theory and how to use this theory to study complex systems.

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

Boyce, W.E.—Ph.D. (Carnegie Institute of Technology); applied mathematics, mathematics education (emeritus).

Cheney, M.—Ph.D. (Indiana University); inverse problems, wave propagation, applications in engineering and biology, partial differential equations.

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.

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).

Handelman, G.H.—Ph.D. (Brown University); applied mathematics, elasticity, wave propagation, mathematical biology (emeritus).

* 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 2005 Board of Trustees meeting.
Herron, I.—Ph.D. (Johns Hopkins University); applied mathematics, fluid mechanics, hydrodynamics, stability.

Holmes, M.—Ph.D. (University of California, Los Angeles); perturbation methods, biomathematics, nonlinear continuum mechanics.

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, combustion, fluid mechanics.

Lim, C.C.—Ph.D. (Brown University); mathematical modeling, vortex dynamics, applications of graph theory.

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); mathematical programming, integer programming, interior point methods, column generation methods, financial optimization, stochastic programming.

Pang, J.S.—Ph.D. (Stanford University); applied and computational mathematics, mathematical programming, variational inequality and complimentarity problems, contact problems, computation of equilibria, financial options pricing, financial optimization, optimal design problems, energy modeling.

Roytburd, V.—Ph.D. (University of California, Berkeley); applied mathematics, combustion theory.

Rubenfeld, L.A.—Ph.D. (New York University); applied mathematics, mathematics, science education.

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

Bennett, K.P.—Ph.D. (University of Wisconsin); mathematical programming, operations research, machine learning, data mining, artificial intelligence.

Kovacic, G.—Ph.D. (California Institute of Technology); applied mathematics, nonlinear dynamics, nonlinear optics.

Piper, B.R.—Ph.D. (University of Utah); computer-aided geometric design, numerical analysis, computer graphics.

Assistant Professors

Giladi, E.—Ph.D. (Stanford University); scientific computing, numerical methods for high frequency wave propagation, finite element methods, iterative methods, numerical analysis.

Kramer, P.R.—Ph.D. (Princeton University); turbulent diffusion, stochastic processes.

Lvov, Y.—Ph.D. (University of Arizona); mathematical physics and nonlinear phenomena.

Clinical Assistant Professors

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 Appointments with Computer Science—Professors

Flaherty, J.E.—Ph.D. (Polytechnic Institute of Brooklyn); scientific computation, numerical analysis, applied mathematics.

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 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 below and is followed by sample junior/senior curricula for each of the department's four undergraduate programs. Additional details and up-to-date descriptions of the mathematics courses, including special topics courses, are available at the department's Web site, http://www.math.rpi.edu/index.html.
The First Two Years

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1010 Calculus I</td>
<td>4</td>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1100 Computer Science I</td>
<td>4</td>
<td>Science Elective</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1100 Physics I</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1900 Art and Science of Math I</td>
<td>1</td>
<td>MATH-1910 Art and Science of Math II</td>
<td>1</td>
</tr>
</tbody>
</table>

Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-2010 Multivar. Calc. and Matrix Algebra</td>
<td>4</td>
<td>MATH-2400 Intro. to Differential Eqns.</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
<td>Science Elective</td>
<td>4</td>
</tr>
<tr>
<td>BIOL-1010 Intro. to Biology</td>
<td>4</td>
<td>Elective (MATH-2700 suggested)</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

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. Also deserving particular attention is MATH-2700, a second semester sophomore course that provides a good background for junior and senior mathematics courses.

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).

Mathematics Curriculum

Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-4200 Mathematical Analysis I</td>
<td>4</td>
<td>MATH-4210 Mathematical Analysis II</td>
<td>4</td>
</tr>
<tr>
<td>Mathematics Option</td>
<td>4</td>
<td>MATH-4010 Abstract Algebra.</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Option</td>
<td>4</td>
<td>Mathematics Option</td>
<td>4</td>
</tr>
<tr>
<td>Mathematics Option</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Culminating Experience</td>
<td>4</td>
<td>Culminating Experience</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

1 The courses BIOL-1010 and PHYS-1100 may be taken in any semester they are offered and in either order.

2 The culminating experience is a course or project to be chosen with the approval of the Mathematical Sciences department.
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. Those planning to go on to graduate work should be sure to take MATH-4100.

Applied Mathematics curriculum

Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-4200</td>
<td>Mathematical Analysis I ...............4</td>
<td>Mathematics Option...............4</td>
<td></td>
</tr>
<tr>
<td>MATH-4800</td>
<td>Numerical Computing .................4</td>
<td>Mathematics Option...............4</td>
<td></td>
</tr>
<tr>
<td>........................</td>
<td>Elective .................4</td>
<td>Elective .........................4</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective ......4</td>
<td>Hum. or Soc. Sci. Elective ...............4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-4700</td>
<td>Foundations of Applied Math I ......4</td>
<td>Mathematics Option...............4</td>
<td></td>
</tr>
<tr>
<td>........................</td>
<td>Mathematics Option...............4</td>
<td>Elective .........................4</td>
<td></td>
</tr>
<tr>
<td>Culminating Experience</td>
<td>Elective .................4</td>
<td>Elective .........................4</td>
<td></td>
</tr>
</tbody>
</table>
| ........................   | ........................................ |\

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. It is recommended that students take PHYS-1100 and PHYS-1200 and those who may continue on to graduate school should consider taking MATH-4210 and MATH-4100.

\* The culminating experience is a course or project to be chosen with the approval of the Mathematical Sciences department.
Mathematics of Computation Curriculum

Third Year

Fall | Credit hours | Spring | Credit hours
---|-------------|--------|-------------
MATH-4200 | Mathematical Analysis I ..................4 | | Computation Option ..................4
MATH-4800 | Numerical Computing .........................4 | CSCI-xxxx | CS Option ....................4
Elective | Elective ..........................4 | Elective ....................4
Hum. or Soc. Sci. Elective | Hum. or Soc. Sci. Elective .............4

Fourth Year

Fall | Credit hours | Spring | Credit hours
---|-------------|--------|-------------
Mathematics Option ..................4 | Elective ..................4
CSCI-xxxx | Elective ..................4
CS Option ..................4
Culminating Experience ¹ .............4
Elective ..................4

Spring Credit hours

Elective ..................4
Hum. or Soc. Sci. Elective .............4
Mathematics Option ..................4
MATP-xxxx OR Option ..................4

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. The computation option is either MATH-4820 or MATP-4820. 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).

It is also recommended that students take PHYS-1200 and CSCI-1200. Those planning to continue on to graduate school should consider taking MATH-4210.

Mathematics of Operations Research Curriculum

Third Year

Fall | Credit hours | Spring | Credit hours
---|-------------|--------|-------------
MATH-4200 | Mathematical Analysis I ..................4 | Elective ..................4
MATP-4700 | Math Models of Operations | Hum. or Soc. Sci. Elective .............4
Research ..................4 | Mathematics Option ..................4
Elective ..................4 | MATP-xxxx OR Option ..................4
Hum. or Soc. Sci. Elective | Hum. or Soc. Sci. Elective .............4

Fourth Year

Fall | Credit hours | Spring | Credit hours
---|-------------|--------|-------------
Mathematics Option ..................4 | Mathematics Option ..................4
Mathematics Option ..................4 | Elective ..................4
Culminating Experience ¹ .............4 | Elective ..................4
Elective ..................4

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.

¹ The culminating experience is a course or project to be chosen with the approval of the Mathematical Sciences department.
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 Decision Science (DSES) or Computer Science (CSCI). In other words, of the four mathematics options, a minimum of two must be coded MATH or MATP.

Also, the OR option in this curriculum is either MATP-4600 or MATP-4820.

**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 Programs
The department offers the M.S. degree in both Applied Mathematics and Mathematics.

Applied Mathematics
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 Office of Graduate Education requirements 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
The student must meet the Office of Graduate Education requirements 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

Chair: Gwo Ching Wang

Associate Chair: Philip A. Casabella

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, or engineering. 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.
Research Innovations and Initiatives

Astronomy and Astrophysics
Research in the astrophysics group includes astrobiology, the chemistry of the interstellar medium, and many areas of galactic and extragalactic astronomy. Research in astrobiology and interstellar chemistry describes how interstellar clouds evolve into new solar systems. Current interest 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 simulations of protostellar collapse, multifluid magnetohydrodynamic shock waves, and shock chemistry. Research in galactic and extragalactic astronomy includes the structure and formation of the galactic halo, metallicity gradients in the galactic thick disk, properties of stars with strong Balmer absorption, optical properties of quasars, and astronomical data mining. The astrophysics group makes use of ground-based telescopes located at world class observing sites in Hawaii, Australia, Chile, and South Africa. Rensselaer also has access to data from major satellite facilities including the Hubble Space Telescope, Chandra, the Infrared Space Observatory, and the Spitzer Space Telescope; and large ground-based astronomy projects, including the Sloan Digital Sky Survey and the Two Micron All Sky Survey (2MASS).

Biophysics
Current research in theoretical and computational aspects related to the dynamics and statistical mechanics of biomolecular systems. The objectives are to understand the folding, dynamics, stability and function of biomolecules from physical principles. Protein folding, 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. Highly parallel computer simulations of the folding and thermodynamics of proteins and peptides in aqueous solutions are being performed. New simulation methods are being applied to study protein folding, binding and aggregation. Other research interests include the hydrophobic effect, enzyme catalysis, and peptide interactions with membranes.

Condensed Matter Physics
This research program concentrates on three areas: surfaces, interfaces, and nanostructures; optical and electronic materials; and electronic transport. New research concepts, materials, and techniques are developed for high technology applications. Many research projects are interdisciplinary. Experimental and theoretical work on surfaces, interfaces, and nanostructures involves the deposition, growth, and characterization of metals, semiconductors, and insulators from monolayers to multilayers to three dimensional nanostructures. The phenomena that are studied include homo- and hetero-epitaxy, initial stages of epitaxy, nucleation of thin films, surface phase transitions, and interface (solid-solid and solid-liquid) structure and bonding. Techniques include Auger electron spectroscopy, X-ray photoelectron spectroscopy, high resolution low-energy electron diffraction, reflection high-energy electron diffraction, atomic force microscopy, scanning tunneling microscopy, X-ray absorptions spectroscopy, X-ray crystallography, and ellipsometry. The department’s major facilities include ultrahigh vacuum evaporation, III–V group IV molecular beam epitaxy, chemical vapor deposition, atomic layer deposition, and the extensive facilities of the Microelectronics Clean Room. Theoretical work also includes applications of statistical physics and large-scale simulations to study the dynamics of natural, artificial, and social systems, including ecological systems, agent-based models, and social networks.

The optical and electronic materials under study include wide bandgap semiconductors, photonic crystals, polymers, semiconductor nanoparticle composites, dielectrics, and magnetic thin films. Optical characterization facilities include Raman, Brillouin, and Rayleigh scattering, photomodulation spectroscopy, photothermal deflection spectroscopy, magneto-optic Kerr effect, and Faraday rotation.
Electron transport in semiconductor and metallic materials are under way. This research is expected to enhance understanding of transport in nanostructures. The experimental work includes studies of ballistic electron transport in ultrathin epitaxial multilayers, electrical resistance of metallic films, and plasma wave electronics in high electron mobility transistors. The electron transport in nanoscale systems (single molecule to atomic wire to carbon nanotube) is studied using the state of the art first principles calculation. The current research includes spin assisted transport (Spintronics) at the nanoscale. The computational facilities in the theory group include in house Linux cluster of about 100 processors and the group has access to National Super Computer facilities.

Other experimental facilities used in these programs include those at the Center for Integrated Electronics, the Focus Center for Interconnects, the Center for Advanced Interconnect Systems Technologies, the electron microprobe and electron microscope facilities, accelerators at the University at Albany, the National Synchrotron Light Source at Brookhaven National Laboratory, and the Stanford Synchrotron Radiation Laboratory.

Educational Research and Development in Physics
Rensselaer’s physics education group pioneered the “studio” approach to physics instruction. The defining characteristics of studio physics classes are integrated lecture/laboratory form, a reduction in lecture time, a technology-enhanced learning environment, collaborative group work, and a high level of faculty-student interaction. The studio physics environment employs activities, computer tools, and multimedia materials that allow students to participate in their own learning and to construct their own scientific knowledge. Allowing students to learn directly from their interactions with the physical world through “hands-on” activities is a high priority. Students may participate in programs of the educational development group to fulfill thesis requirements for the M.S. degree.

Optical Physics
Department research in optical physics is directed towards developing new measurement techniques, new optical materials, and novel devices. Faculty research includes terahertz generation, detection, imaging, and spectroscopy; development of novel light emitting devices; spectroscopy of quantum dots and wells; and ultrafast spectroscopy of semiconductors, magnetic systems, and biological systems. Major facilities include ultrafast laser and terahertz systems associated with the Center for Terahertz Research. Other facilities allow linear and nonlinear optical absorption, luminescence, Raman and Brillouin scattering, and various modulation spectroscopies.

Particle and Nuclear Physics
The structure of matter at distances smaller than the atomic nucleus remains one of Nature’s research frontiers. Our faculty members are engaged in experimental studies of fundamental hadrons and their interactions. We are involved in a search for states of gluonic matter, and new forms of matter as produced in electron-positron annihilation at the CLEO/CESR facility at Cornell University. We also have a longstanding program of experiments at the Thomas Jefferson National Accelerator Facility (JLab) where we are engaged in examining the properties of the proton and its excited states, and also searching for unusual states of baryonic matter.

Faculty*
Professors
Adams, G.S.—Ph.D. (Indiana University); experimental particle physics; photo reactions, hadron structure, exotic hadrons.

* 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 2005 Board of Trustees meeting.
Casabella, P.A.—Ph.D. (Brown University); physics education.

Garcia, A.—Ph.D. (Cornell University); theoretical and computational aspects of biomolecular dynamics.

Hayes, T.M.—Ph.D. (Harvard University); condensed matter physics.

Jackson, S.A.—Ph.D. (Massachusetts Institute of Technology); theoretical physics (Joint appointment with Engineering).

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.

Napolitano, J.J.—Ph.D. (Stanford University); experimental nuclear and particle physics; scientific computation.

Persans, P.D.—Ph.D. (University of Chicago); spectroscopy of semiconductors; thin films; optical materials.

Roberge, W.G.—Ph.D. (Harvard University); theoretical astrophysics.

Schowalter, L.J.—Ph.D. (University of Illinois); material physics.

Schubert, E.F.—Ph.D. (University of Stuttgart); physics of semiconductor devices. (Joint appointment with ECSE).

Schroeder, J.—Ph.D. (Catholic University of America); optical properties of solids at high pressure.

Shur, M.S.—Dr.Sc. (Ioffe Institute); semiconductor physics, ballistic transmission, terahertz radiation (Joint appointment with ECSE).

Stoler, P.—Ph.D. (Rutgers University); particle and nuclear physics; structure of hadrons.

Wang, G.C.—Ph.D. (University of Wisconsin); physics of surfaces, interfaces, and nanostructures.

Whittet, D.C.B.—Ph.D. (St. Andrews University); astrophysics; observational astronomy; interstellar dust; origins of life.

Zhang, X.-C.—Ph.D. (Brown University); ultrafast optics, photonic, optoelectronic and terahertz science and technology (Joint appointment with ECSE).

Associate Professor

Newberg, H.J.—Ph.D. (University of California, Berkeley); astrophysics.

Wetzel, C.M.—Ph.D. (Technical University, Munich); III-V nitride semiconductor physics and technology

Assistant Professors

Korniss, G.—Ph.D. (Virginia Polytechnic Institute); theoretical and computational physics.

Nayak, S.—Ph.D. (Jawaharlal Nehru University); theoretical physics and first principle calculations.

Wilke, I.—Ph.D. (Swiss Federal Institute of Technology); ultrafast optics, photonic, optoelectronic and terahertz science and technology.

Yamaguchi, M.—Ph.D. (Hokkaido University); structural and electronic dynamics in condensed matter, THz spectroscopy of advanced materials, THz science and technology.

Clinical Professor

Washington, M.A.—Ph.D. (New York University); photonics.

Clinical Associate Professor

Bedrosian, G.—Ph.D. (California Institute of Technology, Pasadena); educational physics; electromagnetic analysis.

McIntyre, C.R.—Ph.D. (Massachusetts Institute of Technology); semiconductor materials.

Adjunct Professors

Hauger, S.—Ph.D. (Duke University); educational physics.

LaGraff, J.—Ph.D. (University of Illinois, Urbana-Champaign); educational physics.
Shannon, T.—Ph.D. (Rensselaer Polytechnic Institute); education physics.
Weygand, D.—Ph.D. (Syracuse University); nuclear and particle physics.

Research Professors
Lee, S.—Ph.D. (University of Michigan); condensed matter.

Research Associate Professor
Lu, J.—Ph.D. (Technical University of Munich); electronic materials.
Xu, J.—Ph.D. (Institute of Physics, China); ultrafast optics, terahertz science and technology.

Research Assistant Professors
Cummings, J.—Ph.D. (Rice University); experimental nuclear and particle physics.
Liu, X.-Y.—Ph.D. (University of Illinois, Urbana-Champaign); atomistic modeling of materials.

Visiting Scientists
Cho, S.—Ph.D. (University of California at Los Angeles); ultrafast optics, photonics, optoelectronic and terahertz science and technology.
Edelstein, W.—Ph.D. (Harvard University); magnetic resonance imaging basic sciences and applications.
Kersting, R.—Ph.D. (University of Aachen); optical physics and terahertz radiation.
Kubarovsky, V.—Ph.D. (Institute for High Energy Physics, Russia); experimental nuclear physics.
Wagner, D.J.—Ph.D. (Vanderbilt University); educational physics.

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>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1010 Calculus I</td>
<td>4</td>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1100 Chemistry I</td>
<td>4</td>
<td>BIOL-1010 Intro. To Biology</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1100 Physics I</td>
<td>4</td>
<td>PHYS-1200 Physics II</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci.</td>
<td>4</td>
<td>Hum. or Soc. Sci.</td>
<td>4</td>
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Second Year

<table>
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<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-2100 Intro. to Theoretical Phys.</td>
<td>4</td>
<td>PHYS-2350 Experimental Physics</td>
<td>4</td>
</tr>
<tr>
<td>MATH-2010 Multivariate Calculus and Matrix Algebra</td>
<td>4</td>
<td>MATH-2400 Intro. to Differential Eqns.</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1100 Computer Science I</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci.</td>
<td>4</td>
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</tbody>
</table>

1 CHEM-1300 may be substituted for CHEM-1100 Chemistry I.
2 Humanities and Social Sciences courses shall total 24 credits and meet distribution requirements in the catalog.
3 Students with little or no electronics experience should take ENGR-1310, a one-credit laboratory course in addition to this four-credit elective.
### Third Year

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
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</thead>
<tbody>
<tr>
<td>PHYS-2330 Intermediate Mechanics ...................4</td>
<td>PHYS-4210 Electromagnetic Theory .......................4</td>
</tr>
<tr>
<td>PHYS-2510 Intro. to Quantum ...........................4</td>
<td>PHYS-4100 Intro. to Quantum Mechanics .................4</td>
</tr>
<tr>
<td>MATH-4600 Advanced Calculus...........................4</td>
<td>PHYS-4420 Thermodynamics and Statistical Mechanics ........4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci.1 ......................................4</td>
<td>Elective ..................................................4</td>
</tr>
</tbody>
</table>

<table>
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<th>Spring Credit hours</th>
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<tr>
<td>PHYS-4210 Electromagnetic Theory .......................4</td>
<td>Elective ..................................................4</td>
</tr>
<tr>
<td>PHYS-4420 Thermodynamics and Statistical Mechanics ........4</td>
<td>Hum. or Soc. Sci.1 ......................................4</td>
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</table>

### Fourth Year

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<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
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<tbody>
<tr>
<td>PHYS-4370 Research Part................................4</td>
<td>Elective ..................................................4</td>
</tr>
<tr>
<td>Elective .................4</td>
<td>Elective ..................................................4</td>
</tr>
<tr>
<td>Elective .................4</td>
<td>Hum. or Soc. Sci.1 ......................................4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci.1 ......................................4</td>
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</table>

### Fourth Year

<table>
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<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
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<tr>
<td>TECH-1300 may be substituted for CHEM-1100 Chemistry 1.</td>
<td></td>
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<tr>
<td>Humanities and Social Sciences courses shall total 24 credits and meet distribution requirements in the catalog.</td>
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</tr>
<tr>
<td>Students with little or no electronics experience should take ENGR-1310, a one-credit laboratory course in addition to this four-credit elective.</td>
<td></td>
</tr>
<tr>
<td>Technical Electives are to be selected with the aid of an adviser in order to create a concentration in an appropriate applied physics field.</td>
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</tbody>
</table>
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, and environmental physics. Two such concentrations are illustrated below:

Optical Physics—A concentration in optical physics might include four courses from the following list:
- PHYS-2620 Fundamentals of Optics
- PHYS-4640 Optical Communications and Integrated Optics
- PHYS-4720 Solid-State Physics
- PHYS-2370 Research Participation

Microelectronics—A concentration in microelectronics might include courses from the following list:
- ECSE-2050 Analog Electronics and Circuits
- ECSE-4220 VLSI Design
- ECSE-2210 Microelectronics Technology
- ECSE-4250 Integrated Circuit Processes and Design *

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:
- PHYS-2620 Solid-State Physics
- PHYS-4720 Solid-State Physics
- PHYS-4630 Lasers and Optical Systems
- PHYS-4620 Particles and Nuclei
- ASTR-4220 Astrophysics
- PHYS-6510 Quantum Mechanics I
- PHYS-6520 Quantum Mechanics II
- PHYS-6310 Advanced Mechanics
- PHYS-6110 Methods in Theoretical Physics
- ASTR-4240 Gravitation and Cosmology

Students planning on graduate work in astronomy or astrophysics are urged to choose electives from the above list, as well as include the following:
- ASTR-2050 Intro. to Astr. and Astrophysics
- ASTR-4120 Observational Astronomy
- ASTR-4220 Astrophysics
- ASTR-4240 Gravitation and Cosmology

Minor Programs
The Department of Physics, Applied Physics, and Astronomy offers the following minors:

Physics
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.

Astronomy
To complete an astronomy minor, a student should take PHYS-2510, ASTR-2050, and two of the following courses: ASTR-4120, ASTR-4510, or ASTR-4960.

Astrophysics
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-2510, ASTR-4220, at least one four-credit research project in astrophysics, and at least three semesters of the one-credit ASTR-4900.

* Students cannot receive credit for ECSE-4250 and MTLE-4160
Astrobiology
This multidisciplinary minor is open to students majoring in physics or in other disciplines. To complete this minor, a student must take a minimum of 16 credits of course work in this field. These courses must include four credits each of ASTR-4510 and ISCI-4500, and two semesters of the one-credit ISCI-4510. Two additional courses outside the major field of study must also be selected from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>ENVE-2110</td>
<td>Intro. to Environmental Engineering</td>
</tr>
<tr>
<td>BIOL-4320</td>
<td>Geomicrobiology</td>
</tr>
<tr>
<td>BIOL-4440</td>
<td>Microbial Ecology</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>BCBP-4810</td>
<td>Biological Spectroscopy</td>
</tr>
<tr>
<td>BCBP-4860</td>
<td>Protein and Nucleic Acid Structure</td>
</tr>
</tbody>
</table>

The requirement that two selected courses must be outside the major is reduced to one in the case of a double major, provided that both majors are in the primary relevant areas of study (i.e., biology, chemistry, geology, and physics).

Dual Major Programs
Students may form a dual major in physics and any other degree program within the School of Science. In these cases, the program will satisfy the requirements of both degrees. In addition, a dual major in physics and philosophy is available by satisfying the physics requirements and pursuing 10 philosophy courses.

Accelerated Programs
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.

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.

Master’s Programs
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 four courses: PHYS-6520, PHYS-6310, PHYS-6110, and PHYS-6410. 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
Ninety credits beyond the bachelor’s degree or 60 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 at 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 Introduction to 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 six courses including PHYS-6310, PHYS-6510 and PHYS-6520, PHYS-6590, PHYS-6110, and PHYS-6410. 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: 1) one graduate 6000-level course in the area of research specialization; 2) three courses related to the student’s educational needs as authorized by the student’s research adviser. 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. After all, the successful pursuit of almost any Institute 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 Institute 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 program.

Applied Science

Chair: Samuel C. Wait, Jr.

The School of Science offers a Master of Science in Applied Science, which is a professional degree with no thesis requirement that prepares graduates who have traditional discipline-oriented backgrounds to function more effectively in industrial, governmental, or other interdisciplinary occupations. Its intention is to help working professionals upgrade their technical expertise and cross boundaries among disciplines. No financial aid from Rensselaer is available for this program. In addition to extensive science offerings, students may take applicable courses in other schools such as Management, Engineering, or Humanities and Social Sciences.

Students entering the Master of Science in Applied Science program are subject to Rensselaer’s general admission requirements. All programs require 30 credit hours for completion of the degree. At least half of those courses must be at the 6000 level. Within these 30 hours, a number of concentration options are also available. At least 15 hours must be in courses within the School of Science, and include some 6000 level courses.
Some concentration examples include: analytical and environmental chemistry, applied groundwater science, biochemistry/biophysics, bioinformatics, chemistry and entrepreneurship, database management systems, microelectronics manufacturing, optimization and statistics, parallel and scientific computation, photonics, polymer science and engineering, and software engineering. In addition, further combinations of courses leading to the Master of Science in Applied Science are developed as additional needs for interdisciplinary education are identified.

A typical Master of Science in Applied Science curriculum consists of:

- Two to four core courses that establish the basis for advanced study in an area of specialization
- Two to four specialization courses that are fundamental to an area of specialization
- Two to six elective courses that allow students to focus in a particular area within their specialization and gain skills intersecting their technical field with other disciplines.

**Biochemistry and Biophysics**

**Director, Undergraduate Degree Program:** Joyce J. Diwan

**Director, Graduate Degree Program:** Jane F. Koretz

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 frontiers of research in 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 has increasingly depended 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, many of which are jointly taught by biology and chemistry faculty, impart knowledge and training in cutting-edge research approaches. Students following this curriculum are thus exceptionally well prepared for graduate school and to become desirable prospective employees in various sectors of 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. Many 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 primarily prepares students for jobs in biotechnology, pharmaceuticals, and other related industry sectors. It is also 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.
Research Innovations and Initiatives
Biophysical research at Rensselaer includes the study of areas as diverse as focusing processes of the eye, electrical impedance assays of cell motility, photosynthesis, bioenergetics of Na+ transport, myosin mechanics, cellular bioengineering, biofluid mechanics. A variety of approaches, including molecular modeling, spectroscopic probes, nuclear magnetic resonance, de novo design and chemical synthesis of unnatural proteins, 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, bioanalytical chemistry, glycobiology, DNA aptamers, and the catalysis and mechanisms of protein folding.

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: R. Bizios, N. DePaola, D. Vashishth


Mathematical Sciences: M.H. Holmes, D. Isaacson, M. Zuker

Chemical and Biological Engineering: G. Belfort, S.M. Cramer, J.S. Dordick

Physics: I. Wilke, X.-C. Zhang

Earth and Environmental Sciences: A. Sharma

School of Science: I. Giaever
## Undergraduate Program
### Biochemistry and Biophysics Curriculum

#### First Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
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#### Molecular Biophysics Modules (Choose 2)

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#### Laboratory Option (Choose 1)

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<td>BCBP-4710</td>
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<tr>
<td>BIOL-4720</td>
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</table>

1 Humanites and Social Science (HSS) 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-4450 and CHEM-4460.
Recommended Electives

<table>
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<td>Mathematics in Medicine and Biology</td>
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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**

<table>
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<th>Semester Code</th>
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<td>Protein and Nucleic Acid Structures</td>
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**Graduate School—Biophysics**

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### Bioinformatics

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### Minor Programs

Students majoring in chemistry, biology, bioinformatics, or chemical engineering may obtain a minor in either biochemistry or 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.

#### Biochemistry Minor for Chemistry Majors

Students must complete BCBP-4760, BCBP-4770, and two of the following: BCBP-4710, BIOL-4260, BIOL-4620, BCBP-4860, BCBP-4310, BCBP-4780, BCBP-4790, CHEM-4310.

#### Biophysics Minor for Chemistry Majors

Students must complete BCBP-4760, BCBP-4770, and two of the following: MATH-2400, MATH-4720, BIOL-4270, BCBP-4210, BCBP-4810, BCBP-4870, PHYS-2510.

#### Biochemistry Minor for Biology and Bioinformatics Majors

Students must complete BCBP-4770, CHEM-2440, and two of the following: BCBP-4710, BIOL-4260, BCBP-4860, BCBP-4780, BCBP-4790, BCBP-4310, CHEM-4310.

#### Biophysics Minor for Biology and Bioinformatics Majors

Students must complete BCBP-4770, CHEM-2440, and two of the following: MATH-2400, MATH-4720, BIOL-4270, BCBP-4210, BCBP-4810, BCBP-4870, PHYS-2510.
Biochemistry Minor for Chemical Engineering Majors
Students must complete BIOL-1010, BCBP-4760, BCBP-4770, and one of the following: BCBP-4710, BIOL-4260, BIOL-4620, BCBP-4790, BCBP-4780, BCBP-4860, BCBP-4310, CHEM-4310.

Biophysics Minor for Chemical Engineering Majors
Students must complete BIOL-1010, BCBP-4760, BCBP-4770, and one of the following: MATH-4720, BIOL-4270, BCBP-4210, BCBP-4810, BCBP-4870.

Graduate Programs
Both the Master of Science and Master of Science in 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 Science in Applied Science degree program features the possibility of combining master’s level cooperative education participation or equivalent industrial experience, with course work for the degree in biochemistry and biophysics.

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: Robert Palazzo

Program Home Page: http://j2ee.rpi.edu/biology/update.do

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. Previously, growing sequence databases had been compiled one gene at a time by individual research laboratories. This cottage industry approach is still part of the effort, but numerous genome-sequencing projects have produced the entire sequences of viruses, bacteria, and increasingly complex eukaryotic organisms. The complete human genome with its $10^9$ base pairs is now complete.

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.

Bioinformatics approaches incorporate expertise from the biological sciences, computer science, and mathematics. Allied computational approaches using chemical and physical methods are also of widespread interest. Rensselaer’s bioinformatics and molecular biology undergraduate curriculum includes training in mathematics, chemistry, and physics. At the program’s core are courses in the theory and
practice of bioinformatics that deal with topics such as database design and search algorithms, sequence alignment, sequence analysis, and molecular modeling. The core includes a molecular biology sequence and training in drug discovery.

The curriculum is extremely flexible, allowing for dual majors with several other disciplines including computer science. 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 planning careers as molecular biologists with a computational background or as fully trained computer scientists with a knowledge of biological sciences can adapt the program to their needs.

There are extensive opportunities to pursue undergraduate research in faculty laboratories. The bioinformatics and molecular biology program also serves as an excellent premedical curriculum.

**Research Innovations and Initiatives**
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. A diverse group of agencies including NIH, NSF, the American Diabetes Association, and NASA fund this work. Research projects range from drug discovery, enzymology, signal transduction, protein structure, and protein folding to studies on environmental adaptations of microorganisms.

**Faculty**

**Biology:** C. Bystroff, J. Diwan, J.F. Koretz, J.C. Salerno, S.M.E. Smith

**Chemistry and Chemical Biology:** C.M. Breneman, W. Colon, M. Wentland

**Computer and Information Science at Hartford:** T. O. Martyn

**Computer Science:** B.K. Szymanski, M. Zaki

**Decision Sciences and Engineering Systems:** M.J. Embrechts

**Mathematical Sciences:** M. Zuker

**Undergraduate Programs**

**Bioinformatics and Molecular Biology Undergraduate 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.
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#### Elective Recommendations

**Biochemistry**
- BCBP-4310 Genetic Engineering
- BCBP-4810 Biological Spectroscopy
- BCBP-4210 Biophysical Methods
- BCBP-4860 Protein and Nucleic Acid Structure
- BCBP-4710 Biochemistry Laboratory
- BCBP-2900 Research in Biochemistry and Biophysics
- BCBP-2830 Out of Class Exp. in Biochemistry and Biophysics
- BCBP-2940 Readings in Biochemistry and Biophysics
- BCBP-2990 Research Thesis
- BCBP-4210 Biophysical Methods

**Biology**
- BIOL-1010 Introduction to Biology
- BIOL-2310 Microbiology
- BIOL-2500 Genetics and Evolution
- BIOL-4270 Human Physiology I
- BIOL-4280 Human Physiology II
- BIOL-4420 Introductory Immunology
- BIOL-4510 Molecular Genetics
- BIOL-4740 Cell and Developmental Biology Laboratory

### Second Year

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<td>Culminating Exp.1 ..................................3</td>
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This curriculum requires a minimum of 128 credit hours.

1 Chosen from one of the following courses: BIOL-4070 or BIOL-4990.
Chemistry
CHEM-2440 Physical Chemistry for Life Sciences
CHEM-4300 Medicinal Chemistry
CHEM-4310 Bioorganic Mechanisms
CHEM-4450 Macroscopic Physical Chemistry
CHEM-4460 Microscopic Physical Chemistry

Chemical Information
Introduction to Polymer Chemistry
Polymer Science Laboratory
Chemistry of the Environment

Computer Science
CSCI-1100 Computer Science *
CSCI-1200 Computer Science II
CSCI-2200 Programming in C++
CSCI-2300 Data Structures and Algorithms
CSCI-4020 Computer Algorithms
CSCI-4260 Graph Theory
CSCI-4380 Database Systems

Mathematics
MATH-2010 Multivariable Calculus and Matrix Algebra
MATH-2400 Differential Equations
MATH-4720 Mathematics in Medicine and Biology

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.

* Required if lacking computer science skills.
Environmental Science

Director: Teofilo Abrajano, Jr.

Program Home Page: http://www.rpi.edu/dept/envsci

Environmental issues continue to be prominent in the lives of everyone. Essentially no place on the planet has escaped perturbation resulting from activities of an ever-growing human population. The challenge is to maintain those attributes of the Earth that make it habitable while at the same time providing for human needs. Science will play an absolutely critical role in enabling technological civilizations to move toward sustainable interactions with the natural world.

While effective environmental scientists must be rigorously educated in one area of science, they must have a perspective far broader than any single science discipline affords. In fact, cognizance of considerations beyond just the sciences is also required. Rensselaer’s environmental science degree addresses these challenges with a multifaceted program.

The Environmental Seminar considers topical environmental issues from numerous perspectives. Through it, students receive a broad overview of environmental challenges in preparation both for their major and for leadership roles in environmental science.

A guided selection of courses in the Humanities and Social Sciences broadens perspective and understanding of the human approach to and interactions with the natural world. Two courses, IENV-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 requirement for an intensive environmental experience is an overt acknowledgement that environmental science is a discipline concerned with the natural world.

The science core of 38 credit hours gives each student a common core of 10 courses that introduces important approaches for understanding the natural world. The student-elected concentration in one of the traditional scientific disciplines gives depth in one area of science. With judicious use of the 28 credit hours of electives, 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 the impact of acid rain on the Adirondacks, characterization of subsurface microorganisms with the potential for bioremediation, PCB and other contaminant analysis in the Hudson River, 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.

Faculty Committee

Undergraduate Program

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>
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<tr>
<th>Fall</th>
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<th>Spring</th>
<th>Credit hours</th>
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<td>Chemistry I</td>
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<td>IENV-1920</td>
<td>Environmental Seminar</td>
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### Fourth Year

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<td>Concentration and Elective</td>
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</table>

### Concentrations

The environmental science degree program requires one concentration. Concentration options and the associated courses are shown below.

### Biology

(all of the following)  
- BIOL-2310  Microbiology
- BIOL-2500  Genetics and Evolution
- BIOL-4620  Molecular Biology
- BIOL-4760  Molecular Biochemistry I
- CHEM-2260  Organic Chemistry II

(one of the following)  
- BIOL-4320  Geomicrobiology
- BIOL-4700  Freshwater Ecology Laboratory
- BIOL-4850  Principles of Ecology

---

1. Hum. and Soc. Sci 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. Each student is required to elect one of the concentrations listed below.

4. Each student is required to engage in an activity that qualifies as an intensive environmental experience as described below.

5. This course is offered every other year in the fall term of odd-numbered years and therefore is a junior year course for some students.
**Chemistry**

(all of the following)

- CHEM-2030 Inorganic Chemistry I
- CHEM-2150 Equilibrium Chemistry and Quantitative Analysis
- CHEM-4450 Macroscopic Physical Chemistry
- CHEM-4810 Chemistry of the Environment

(one of the following)

- CHEM-2260 Organic Chemistry II
- CHEM-4460 Microscopic Physical Chemistry
- CHEM-2950 Undergraduate Research (3 credits)
- CHEM-4xxx Chemistry Elective
- CHEM-4990 Senior Thesis

**Computer Science—students may choose from two options:**

**Option A (Computer Science)**

(all of the following)

- CSCI-1100 Computer Science I
- CSCI-1200 Computer Science II
- CSCI-2300 Data Structures and Algorithms
- CSCI-2400 Models of Computation
- CSCI-2500 Computer Organization

One course from the series CSCI-4xxx

**Option B (Scientific Computation)**

(all of the following)

- MATH-2010 Multivariable Calculus and Matrix Algebra
- MATH-2400 Introduction to Differential Equations
- CSCI-1100 Computer Science I
- CSCI-1200 Computer Science II
- CSCI-2300 Data Structures and Algorithms
- CSCI-4800 Numerical Computing

**Geology**

(Six of the following courses, four of which must be at the 4000 level)

- ERTH-2100 Introduction to Geophysics
- ERTH-2140 Introduction to Geochemistry
- ERTH-2330 Earth Materials
- ERTH-2610 Oceanography

**Mathematics**

(both of the following)

- MATH-2010 Multivariable Calculus and Matrix Algebra
- MATH-2400 Introduction to Differential Equations

(one of the following)

- MATH-4200 Mathematical Analysis I
- MATH-4600 Advanced Calculus

(one of the following sequences)

- MATH-4700 Foundation of Applied Mathematics
- MATP-4700 Mathematical Methods of Operations Research

**Physics**

(all of the following)

- MATH-2400 Introduction to Differential Equations
- PHYS-1200 Physics II
- PHYS-2100 Introduction to Theoretical Physics

- PHYS-2330 Intermediate Mechanics I
- PHYS-2510 Quantum Physics I
- PHYS-4210 Electromagnetic Theory
Minor Programs
Sustainable stewardship of the environment is the single most important challenge facing the world, and this minor is ideal for students wishing to develop a multidisciplinary background in environmental science. The program of study requires a minimum of four courses of which three are required. These required courses include: BIOL-4850, CHEM-4810, and ERTH-4180. A minimum of one additional course must be selected from the list below. At the discretion of the adviser and the environmental science program director, the student may take an alternative not on the list, or complete a four-credit research project. At least three of the four courses required for the minor must be at the 4000 level.

ENVE-4310 Applied Hydrology and Hydraulics  BIOL-4700 Fresh Water Ecology Laboratory
MANE-4700 Solar Devices and Renewable Energy  BIOL-4870 Environmental Toxicology
BIOL-4310 Industrial Microbiology  ERTH-4710 Groundwater Hydrology
BIOL-4320 Geomicrobiology  ERTH-4690 Aqueous Geochemistry
BIOL-4440 Microbial Ecology  ERTH-4180 Environmental Geology
ERTH-4690 Aqueous Geochemistry  ERTH-4540 Organic Geochemistry
ERTH-4500 Global Environmental change

Students interested in developing a broad, multidisciplinary background in energy to complement their more focused major program may also consider another minor option—the Interschool Minor in Energy. See Interdisciplinary Programs and Research in the Humanities and Social Sciences section of this catalog for details on this program.

Special Opportunities in Environmental Science
Environmental Studies Program
Building on the unusual strength and breadth of Rensselaer’s synthesis of engineering, science, and the humanities and social sciences, the Environmental Studies Program offers students a unique educational opportunity to develop a truly multidisciplinary approach to environmental studies.

Students who enter Rensselaer in the Environmental Studies Program will take a broad range of basic courses in their first two years. They then choose one of five majors: economics (with an ecological economics focus), environmental engineering, environmental science (with a concentration in a specific area of science), hydrogeology, or science, technology, and society (with an environmental focus). To complement their major programs, students may earn a wide variety of minors. All the majors in the program offer their own environmental minors, and the Schools of Architecture and Management offer special environmental courses as well. Rather than becoming narrow specialists, students participating in the Environmental Studies Program will receive a multidisciplinary education that prepares them to address a variety of environmental problems.

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. They may do so either directly (as in “natural world” experience) or indirectly through temporary employment (e.g., as a co-op or intern) or through participation in an environmental research monitoring or assessment program. The environmental experience, envisioned typically as a summer activity occurring after the sophomore or junior year, must last at least a month and, in some cases, may be associated with earning academic credit. To successfully fulfill this requirement, students must document the experience and obtain approval for it from the Environmental Science Faculty Director.
Interdisciplinary Science

Chair: Samuel C. Wait, Jr.

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 more humanistic studies 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 sciences, geology, mathematical sciences (course codes MATH and MATP) and physics. 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 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

**Fall**

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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. (i) Eight courses from a single discipline; (ii) Four courses from a second discipline; (iii) Four courses from a third discipline; and (iv) One course from each of the three disciplines not represented in (i), (ii), or (iii). Two or more of the courses in the eight course sequence must be at the 4000 level.

3. Humanities and Social Sciences courses shall total 24 and meet distribution requirements in the catalog.

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.

5. 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.
Multidisciplinary Science

Chair: Samuel A. Wait, Jr.

Traditionally, graduate degrees have focused on a single subject matter such as chemistry, physics, or mathematics. However, current and expected future trends in the working environment show that jobs will increasingly bridge more than one area of specialization. Biochemistry, for example, which is of major importance in today’s society, now spans two or three disciplines. Practitioners must have a thorough knowledge of several areas of chemistry and biology. The same is true of bioinformatics, a new multidisciplinary field that depends on expertise in biology and computational sciences. Information Technology is another example that combines expertise in computing and information systems with knowledge from other areas such as management, human-computer interacting, social sciences, and an application problem domain. See the IT web site (www.it.rpi.edu) for more details. These are just three in a growing number of fields that cross specialization. Rensselaer’s M.S. and Ph.D. in Multidisciplinary Science meet the need of graduates who anticipate careers in such occupations.

Rensselaer strongly emphasizes interdisciplinary research programs that bridge disciplines within the School of Science and between the School of Science and the School of Engineering. The George M. Low Center for Industrial Innovation was specifically constructed to house research centers such as the Center for Integrated Electronics, the Center for Composite Materials and Structures, the Center for Automation Technologies, the Center for Multiphase Research, and the Scientific Computation Research Center.

Students within multidisciplinary graduate programs are under the tutelage of faculty from more than one discipline. This highly knowledgeable faculty will determine which courses the student needs, develop appropriate examinations, and supervise research activities. The dean of science appoints the doctoral committee and supervises the student’s overall progress.

Students interested in pursuing such multidisciplinary graduate programs must follow Rensselaer’s standard graduate admission guidelines and must seek approval from faculty representing all disciplines related to their individual programs.

Prior to admission to the program, the student must demonstrate that there has been previous contact with a faculty member at Rensselaer concerning the proposed multidisciplinary research, that financial aid is available and, with the help of the faculty member who is to be the principal research adviser, the student should prepare a preliminary plan of study and a preliminary research proposal that clearly indicates why this research is suited for the multidisciplinary program instead of a department program.
Interdisciplinary Research Centers

Darrin Fresh Water Institute

Director: Sandra A. Nierzwicki-Bauer

Associate Directors: Richard F. Bopp, Charles W. Boylen

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 Adirondack lodge (which houses a multi-computing facility and provides housing for students studying at the Institute during the academic year), several small cottages, a boathouse, and a 7,500-square-foot teaching and research facility.

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 acid rain on the Adirondacks, 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. Other university laboratories and field stations also join in cooperative studies.

The Darrin Fresh Water Institute also has facilities on campus with the W.M. Keck Foundation Water Quality Laboratory. This laboratory is equipped with state-of-the-art instrumentation to conduct sophisticated studies of water quality and the fate of pollutants. Analytical equipment to examine the chemistry and microscopy equipment to study interactions between organisms and substrates are components of this interdisciplinary research laboratory, which is located in the Materials Research Center.

Additionally, on-campus facilities include the iEAR/Darrin Fresh Water Institute Environmental Multimedia Studio. Environment-related multimedia resources are produced in this studio. Such projects include the production and cablecasting of the Darrin Fresh Water Institute summer lecture series and the production of the DFWI home page, which includes a “virtual tour” of research facilities at the Bolton Landing field station. Visit the site at http://www.rpi.edu/dept/dfwi/.

The Darrin Fresh Water Institute is an integral part of Rensselaer’s environmental initiative. Summer courses involving both classroom instruction and intensive field studies are held at the Lake George site. Student participation in research activities at the Institute is encouraged through the participation with individual faculty and student internships available each summer.
Inverse Problems at RPI (IPRPI)

Director: Joyce R. McLaughlin

Center Home Page: 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 computing 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, 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. Some approaches are based on effective use of a mathematical model in order to make optimal use of the data; other approaches involve model-blind “data mining” methods. Since inverse problems are concerned with the processing of data and extraction of relevant information, the field is a part of Information Technology.

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: J. McLaughlin, M. Cheney, D. Isaacson

Earth and Environmental Sciences: S. Roecker, R. McCaffrey, C. Williams

Mechanical, Aerospace and Nuclear Engineering: A. Maniatty

Civil Engineering: M. Zeghal

Electrical, Computing and Systems Engineering: B. Yazici
New York Center for Studies on the Origins of Life

**Director:** James P. Ferris, Department of Chemistry and Chemical Biology

**Associate Directors:** Douglas C.B. Whittet, Department of Physics, Applied Physics, and Astronomy, and John W. Delano, Department of Earth and Atmospheric Sciences, and Department of Chemistry, University at Albany

**Assistant Director:** Ann Marie Strack

**Program Home Page:** [http://www.origins.rpi.edu](http://www.origins.rpi.edu)

The New York Center for Studies on the Origins of Life involves faculty, postdoctorals, graduate students, and undergraduate students from Rensselaer Polytechnic Institute, the State University of New York at Albany, and the College of Saint Rose in education and research programs seeking to understand how life originated and evolved. Some of the major research areas are listed below.

**Research Innovations and Initiatives**

**Sources of Organics on the Primitive Earth**

Two major hypotheses for the origins of organics on the early Earth are being evaluated in the proposed research. First is the idea that the organic precursors to life were initially formed in the interstellar medium and, after processing during the formation of the solar system, were delivered to the Earth's surface. The second hypothesis is that a reducing atmosphere formed by volcanic outgassing from a reduced mantle on the primitive Earth was the source of the organic precursors for life.

**Interstellar Sources**

The organics present in the interstellar medium are investigated by ground-based and orbiting observatories in the two–25 microns wavelength range of the infrared by Douglas C.B. Whittet. These measurements have been made on the Infrared Space Observatory and on ground-based observatories in Hawaii and Chile. The high resolving power of these telescopes allows the detection of infrared frequencies characteristic of functional groups in organic molecules.

**Shock Processing of Prebiotic Materials**

Organic molecules formed in the interstellar medium are brought to the solar nebula in the icy coatings on dust grains. Wayne Roberge is simulating the processing of ices by the accretion shock where infalling dust enters the solar nebula, by shocks inside the solar nebula, and by external wind shocks where the bipolar outflow strikes infalling material. We find that nebular and accretion shocks can anneal the ices, greatly altering the ices' capacity to retain volatile organics. The efficiency of annealing depends strongly on heliocentric distance, with important consequences for the relative volatile content of Jupiter family versus Kuiper Belt comets.

**Reactions During Planet Formation**

An important stage of organics processing is in the planetesimals created in the early stages of the planets, moons, asteroids, and comets. When radioactive decay heated these bodies, the frozen water in them liquefied. The reaction with water and the radiation from radioactive elements further altered the organics. Meteorites are fragments from asteroids which, together with comets, are believed to have brought these organics with them when they impacted the primitive Earth. These organics are believed to be the major source of starting materials for the origins of life. Michael J. Gaffey is using infrared spectroscopic measurements to investigate the structures of the organics on the outer belt asteroids.
The Oxidation State of the Earth’s Crust and Mantle
John W. Delano has determined the original oxidation state of ancient volcanic rocks up to 3.96 billion years ago using the geochemistries of Cr and V. The results of that investigation were published in late 2001 and indicate that high-temperature volcanic gases were not a likely source of chemically reduced gases at any time during the last 3.96 billion years. Work is proceeding in an effort to determine the Earth’s oxidation state of high-temperature volcanic gases prior to 3.96 billion years ago to see if they might have served as a source of gas species useful for the formation of prebiotic molecules.

Atmospheres of Titan and Jupiter
James P. Ferris is investigating through laboratory experiments the photochemical processes in the atmospheres of Titan and Jupiter. Using a flow chemical reactor where it is possible to irradiate the low-mixing ratios of atmospheric organics, the photochemical transformations in proposed primitive atmospheres are being investigated. With a flow reactor, it is possible to obtain sufficient amounts of reactants for their identification and quantification by nuclear magnetic resonance (NMR) and mass spectrometry.

The RNA World
Ribonucleic acid (RNA) was the most important biopolymer for the first life on Earth. The emphasis in this research is the prebiotic synthesis of RNA and the search for evidence of the RNA world in the introns of primitive life on Earth today.

Thioacids as Phosphorylating Reagents
William J. Hagan is investigating the thermal and photochemical formation of thioacids, which represent precursors of high-energy phosphate donors that might have promoted the phosphorylation of sugars, such as ribose. The latter is a possible step in the conversion of nucleosides to nucleotides, the building blocks of RNA.

Prebiotic RNA Synthesis
James P. Ferris is investigating the mineral-catalyzed formation of RNA from activated mononucleotides. The research will center on the origin of the RNA world, where RNA or RNA-like molecules have been proposed to be the most important biopolymers in the first life on Earth.

Search for Catalytic RNA Sequences
The third research emphasis is Sandra A. Nierzwicki-Bauer’s search for evidence of the postulated RNA world in the extant life on the Earth today. If RNA was the basis for the first life on Earth, vestiges of the sequences of ancient catalytic RNA in the RNA sequences of slow-growing, deep subsurface microorganisms may be found. The presence of the nucleotide sequence of the Group I intron, which catalyzes the splicing of RNA, is the object of the search in the introns of the subsurface bacteria.

The Impact History of the Primitive Earth
John W. Delano is determining the timing of large impact events on the Moon, and by analogy on the Earth, and the implications for the sustainability of life on the early Earth. Impact-produced glasses from three Apollo landing sites are being chemically and isotopically analyzed individually to determine the ages of impact events on the Moon. This dating makes it possible to determine whether the impact flux was simple (e.g., monotonic decrease through time) or complex (e.g., late cataclysm).
Minor Programs
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. Students must take a minimum of 16 credits of course work in this field. These courses include ASTR-4510, and ISCI-4500, four credits each, and two semesters of the one-credit course ISCI-4510. A further two courses outside the major field of study are also required, selected from the following:

- ENVE-2110 Introduction to Environmental Engineering
- BCBP-4860 Protein and Nucleic Acid Structure
- CHEM-2250 Organic Chemistry I
- BIOL-4320 Geomicrobiology
- CHEM-4810 Chemistry of the Environment
- BIOL-4440 Microbial Ecology
- ERTH-4070 Sedimentology
- BIOL-4620 Molecular Biology
- ERTH-4540 Organic Geochemistry
- BIOL-4760 Molecular Biochemistry I
- BCBP-4810 Biological Spectroscopy
- ASTR-2050 Introduction to Astronomy and Astrophysics

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).

Affiliated Faculty
Earth and Environmental Sciences: J. Abrajano, M.J. Gaffey, A. Sharma, B. Watson

Natural Sciences, the College of Saint Rose: W.J. Hagan

Biology: S.A. Nierzwicki-Bauer

Physics, Applied Physics, and Astronomy: W. Roberge

New York State Center for Polymer Synthesis
Director: Brian Benicewicz, Department of Chemistry

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, S. Kumar, B. Nauman

**Chemistry:** Y. Akpalu, T. Apple, B. Benicewicz, C. Choma, W. Colon, J. Crivello, L.V. Interrante, S. Krause, J. Moore, C. Ryu

**Materials Science and Engineering:** P.M. Ajayan, C. Chung, R. Ozisik, L. Schadler, S. Sternstein

**Pervasive Computing and Networking**

**Director:** Boleslaw K. Szymanski, Computer Science

**Associate Directors:** Shivkumar Kalyanaraman, Electrical, Computer and System Engineering, and Bulent Yener, Computer Science

**Program Home Page:** [http://www.rpi.edu/cpcn](http://www.rpi.edu/cpcn)

A multidisciplinary group of researchers from the Schools of Engineering and Science has come together in Rensselaer’s Center for Pervasive Computing and Networking to collaborate on projects that contribute to the goal of pervasive computing. This vision foresees a world in the not-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 sent into a collapsed building to locate survivors. Untethered—wireless—communication is pervasive and, in many cases, so automated that human intervention is unneeded. Wireless, broadband community systems inexpensively bring people together for virtual town meetings, video doctor-patient conferences, and on-line business transactions. Computers in automobiles share information on congestion, quickly computing alternate routes. The promises are immense, but the challenges are formidable. Some of the major research areas currently pursued by the researcher in the Center are listed below.

**Research Innovations and Initiatives**

**Grids and Worldwide Computing**

As workstations and desktop computers gain power and increasing numbers are connected to the Internet 24 hours a day, a movement has arisen to create both formal and ad hoc networks in which users combine their computing power, utilizing idle time on machines ranging from individual desktops and PCs to clusters of PCs to supercomputers to form parallel processors capable of tackling very large problems. To achieve these goals, advances are needed in many areas, including programming and protocols for parallel processing, tracking and accessing widely distributed pieces of data, and routing messages over a constantly changing and sometimes unreliable network. Although grid computing has made a lot of progress in recent years through projects such as Globus, the focus in Rensselaer’s Center is on more dynamic and autonomous environments in which task allocation, migration, and fault tolerance are supported automatically.

**Cybersecurity**

Without serious attention to security issues, the world of pervasive computing could turn rapidly from dream to nightmare, in which on-line criminals and terrorists steal private information, destructively attack individual computers and entire networks, and send damaged and dangerous programs to unprotected systems. Center researchers are investigating use of data mining systems, finite state finite automata
augmented with probabilities, bioinformatics techniques, normally used to match DNA sequences, and recursive data mining to detect variations from the user’s normal behavior. They are also exploring the use of generic code-carrying proofs as a secure and memory-stingy method of sending programming code. Another group is working on security for an ad hoc wireless system and identifying security gaps and designing protection against specific attacks in the Border Gateway Protocol.

**Networking**

Center researchers have developed very efficient methods to run simulations to detect problems on computer networks and then to apply traffic management techniques to solve these problems. Their goals are to reduce congestion, automate many management tasks, and improve quality of service. They use these simulations to optimize very complex systems. They are developing BANANAS, an Internet architectural framework, that gives messages more flexibility in the routes they choose, and working on overlay systems that can deliver very reliable broadband services to groups of users. Another team developed Genesis (The General Network Simulation Integration System), which divides a large network or even the entire Internet into domains and runs a simulation of each over a given time interval on a separate processor. The processors then exchange information and run new simulations for the time interval until they converge on a solution.

**Wireless Networks**

Unlike cell phone systems, in which messages travel by way of fixed towers, devices in ad hoc wireless systems communicate directly with each other. They pass messages from node to node as needed, even as some devices move around and others unpredictably come on- or off-line, creating a constant need to find new routes for messages. Rensselaer researchers are working on all levels of the technology to make such networks efficient and reliable. The new approaches include using microelectronics techniques to create a multi-hop optical wireless system and using radio frequency (RF) and optical techniques to build an inexpensive and easily accessible community network around the Rensselaer campus. Centers teams are also working on distributed networks of sensors and actuators, developing methods through which groups of cameras can exchange information and work together, and developing techniques for distributed groups of robots to communicate and cooperate.

**Center for Terahertz Research**

**Director:** Xi-Cheng Zhang  
**Center Home Page:** [www.rpi.edu/terahertz](http://www.rpi.edu/terahertz)

The faculty members of the Center for Terahertz Research are among the world’s first scientists to exploit the unique advantages of terahertz (THz) radiation. Using the relatively unexplored terahertz portion of the electromagnetic spectrum, they are creating innovative imaging and sensing technologies that hold enormous potential in biomedical imaging, genetics diagnostics, microelectronics and the chemical and biological materials identification fields that support homeland defense initiatives.

The promise of terahertz wave radiation, known as “T-rays,” is being realized through ongoing research at the THz Center’s state-of-the-art laboratories: Dr. Xi-Cheng Zhang’s THz Optics lab, Dr. Michael Shur’s THz Electronics lab, the THz Quantum Optics Lab, Dr. Yamaguchi’s THz spectroscopy and control lab, and Dr. Ingrid Wilke’s THz lab and Dr. Gwo-Ching Wang’s Studio lab. Together, these researchers are overcoming significant challenges posed by the fundamental physics that underlie this large and historically inaccessible portion of the electromagnetic spectrum.
Rensselaer’s THz research team has become the established leader in the development and application of terahertz technology. Their breakthroughs in microscopy, imaging, and development of electro-optic THz emitters and detectors have opened the door to tremendous opportunities for THz radiation throughout major industries.

Research at the center is currently focused on the generation and detection of free-space THz beams using ultra-fast optics and electro-optic crystals. A primary goal is to develop and refine the instrumentation finding higher dynamic ranges, achieving faster data acquisition, and increasing sensitivities to enable the detection of monomolecular layers that will move THz technology beyond its current niche applications to support wider use in biomedicine. During the last several years, scientists and engineers from more than 75 universities, companies, and clinics have visited the labs, and Rensselaer’s THz team has helped scientists from 18 countries learn how to use THz sensors.

Rensselaer’s terahertz research group has received more than $14 million in grants from the National Science Foundation, Army Research Office, Army Research Laboratory, Air Force Office of Scientific Research, Department of Energy, Defense Advanced Research Projects Agency, W.M. Keck Foundation, Research Corporation, IMRA America Incorporated, Molecular OptoElectronic Corporation, 3-D Digital Corp., Zomega Technology Corporation, NASA, Lockheed Martin, Intelligent Optical System, Corning, and INEEL.

The center’s labs are equipped with the most advanced photonic and opto-electronic instrumentation for generating, measuring and recording picosecond and femtosecond terahertz radiation waves. Rensselaer’s Center for Terahertz Research stands at the forefront of terahertz technology, a science still in its infancy yet expected to become one of the most promising research areas for transformational imaging in the 21st century.

**Affiliated Faculty**

**Roland Kersting**, Research Assistant Professor of Physics

**Michael Shur**, Patricia W. and C. Sheldon Roberts Professor, Professor of ECSE & Physics, Director, Center for Broadband Data Transport Science and Technology

**Ingrid Wilke**, Assistant Professor of Physics

**Gwo-Ching Wang**, Professor and Chair of Physics

**Jing Zhou Xu**, Research Assistant Professor of Physics

**Masashi Yamaguchi**, Assistant Professor of Physics

**X.-C. Zhang**, J. Erik Jonsson Distinguished Professor of Science, Professor of Physics and ECSE
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**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 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** Col. Thomas D. Bell

The Department of Air and Space Studies offers an elective program to eligible male and female students who are U.S. citizens wishing to pursue commissioning as future Air Force officers. The program has two phases, a General Military Course and a Professional Officer Course. The General Military Course may be taken during the first two years or during a special six-week summer course. After the General Military Course, students compete for entry into the two-year Professional Officer Course.

Admission to the Professional Officer Course is based on demonstrated proficiency in the General Military Course, medical qualifications, academic standing, physical conditioning requirements, the successful completion of field training, aptitude for further officer training, and citizenship.

Air Force scholarships are awarded on a merit basis to high school seniors and full-time college students who meet specific program requirements. 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.
Faculty*
Professor: T. D. Bell
Assistant Professors: B.C. Deary, J.L. Gilpin, C.P. Hughes

Air Force Reserve Officers Training Corps

General Military Course
First Year

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Second Year

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Professional Officer Course
Third Year

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Fourth Year

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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.

Military Science

Chairman: Lt. Col. Michael Papadopoulos
The Office of Military Science offers an elective program to qualify male and female students for commissions as officers in the U.S. Army. The Army ROTC program has two phases: a basic course, normally taken during the freshman and sophomore years, and an advanced course, normally taken during the junior and senior years.

Army ROTC scholarships are awarded to high school seniors and first- and second-year Army ROTC students.

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All Army ROTC instruction is provided on campus. To register, the student should visit the Office of Military Science, Room 407, AS & RC Building. For further information call collect (518) 276-6254.

Faculty*
Adjunct Professors
Joseph C. Cansler, Chris Irwin

Army Reserve Officers Training Corps Program

Basic Course
First Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAR-1010</td>
<td>Fundamentals of Military Science I</td>
<td>1</td>
</tr>
<tr>
<td>USAR-1020</td>
<td>Fundamentals of Military Science II</td>
<td>1</td>
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Second Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>USAR-2010</td>
<td>Applied Leadership I</td>
<td>1</td>
</tr>
<tr>
<td>USAR-2020</td>
<td>Applied Leadership II</td>
<td>1</td>
</tr>
</tbody>
</table>

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; compass; military ceremonies; communications techniques; nuclear, biological, chemical defense, and first aid. Leadership laboratories occur monthly and are outside the normal class schedules. Only contracted and scholarship cadets are required to attend.

Advanced Course

Third Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>USAR-2060</td>
<td>Applied Military Leadership I</td>
<td>2</td>
</tr>
<tr>
<td>USAR-2070</td>
<td>Applied Military Leadership II</td>
<td>2</td>
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Fourth Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAR-4010</td>
<td>Advanced Military Management and Leadership I</td>
<td>2</td>
</tr>
<tr>
<td>USAR-4020</td>
<td>Advanced Military Management and Leadership II</td>
<td>2</td>
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</tbody>
</table>

Supplemental Courses All students who intend to progress through the advanced course must take a course in American History subject to the approval of the Military Science adviser.

Naval Science

Chairman: Capt. Steven Kremer

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.

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**Faculty***

**Professor:** S.R. Kremer  
**Associate Professor:** A.G. Hendrickson  
**Assistant Professors:** M. Bird, J.M. Hekel, J.K. Lyon, D.A. Zallnick

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**Naval Reserve Officers Training Corps Program**

**Basic Course**

**First Year**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>USNA-1010</td>
<td>The Military and Its Place in Society</td>
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<tr>
<td>USNA-0010</td>
<td>Drill/Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USNA-2020</td>
<td>Seapower and Maritime Affairs</td>
<td>3</td>
</tr>
<tr>
<td>USNA-0020</td>
<td>Drill/Laboratory</td>
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**Second Year**

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<tr>
<td>USNA-2030</td>
<td>Naval Leadership &amp; Management I</td>
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<tr>
<td>USNA-0030</td>
<td>Drill/Laboratory</td>
<td>0</td>
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<tr>
<td>USNA-2040</td>
<td>Naval Ships Systems</td>
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</tr>
<tr>
<td>USNA-0040</td>
<td>Drill/Laboratory</td>
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**Advanced Course**

**Third Year**

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<tr>
<td>USNA-2050</td>
<td>Navigation</td>
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<tr>
<td>USNA-0050</td>
<td>Drill/Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USNA-2060</td>
<td>Naval Operations (Navy only)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-2150</td>
<td>Evolution of Warfare (Marines only)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-0060</td>
<td>Drill/Laboratory</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>USNA-2070</td>
<td>Naval Ships Systems II</td>
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</tr>
<tr>
<td>USNA-0070</td>
<td>Drill/Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USNA-4190</td>
<td>Naval Leadership and Ethics (Navy only)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-2170</td>
<td>Amphibious Warfare (Marines only)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-0080</td>
<td>Drill/Laboratory</td>
<td>0</td>
</tr>
</tbody>
</table>

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1 Not required of two-year students; covered in summer institute.  
2 Not required of Marine Corps option students.  
3 Marine Corps option only.
Supplemental Courses

In addition, the NROTC midshipman must complete the following courses to ensure minimum acceptable standards for commissioning:

- MATH-1010 Calculus
- MATH-1020 Calculus
- PHYS-1100 Physics
- PHYS-1200 Physics
- One course in computer science.
- One approved course in political science/international affairs.
- Two approved courses in English and writing assessment.

Course Descriptions

For course descriptions see the Course Descriptions section of this catalog under the designation USAF, USAR, USNA.

\(^2\) Not required of Marine Corps option students.
Course Descriptions

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
DSES Decision Sciences and Engineering Systems
ECSE Electrical, Computer, and Systems Engineering
ENGR General Engineering
EPOW Electrical Power Engineering
ENVE Environmental Engineering
ESCI Engineering Science
MANE Mechanical, Aerospace, and Nuclear Engineering
MTLE Materials Science and Engineering

Humanities and Social Sciences (Humanities Courses) (HSSH)
ARTS Arts
COMM Communication
IHSS Interdisciplinary Humanities and Social Sciences
LANG Foreign Languages and Literature
LITR Literature
PHIL Philosophy
STSH Science and Technology Studies (Humanities Courses)
WRIT Writing

Humanities and Social Sciences (Social Sciences Courses) (HSSS)
ECON Economics
PSYC Psychology
STSS Science and Technology Studies (Social Sciences Courses)
Information Technology (IT)
ITEC Information Technology

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
ARCH Architecture (SOA)

ARCH-1200 Summer Design Institute
A four-week intensive introductory course for high school students and students considering a major or minor in architecture or design. The program focuses on the design studio and a series of projects, with lectures, labs, and field trips. Topics include theory, history, construction, structures, urban design, contemporary design approaches, environmental issues, electronic media, multidisciplinary studies, and professional practice. Summer term annually. 3 credit hours

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. 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. Prerequisites ARCH-2110. 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. 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. 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. Fall and summer terms. 4 credit hours

ARCH-2210 Architecture Design 1
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. Fall and summer terms. 4 credit hours

ARCH-2230 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. 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. 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. 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. Prerequisites: ARCH-2510 except M.Arch students. 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. Prerequisites: ARCH-2510 except M.Arch students. Fall term annually. 4 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. Spring term annually. 2 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. 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. Summer and fall terms annually.

6 credit hours each

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. Spring and summer terms.

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. Fall and summer terms.

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. Spring and summer terms annually.

6 credit hours each

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-4010 History of Greek and Roman Architecture
A focus on ancient architecture: houses, temples, public buildings, water systems, roads, city walls; methods and elements of city planning, architectural practice, and building methodology; styles and their functional and decorative uses; the influence of Greek and Roman architecture on later periods. A lecture course illustrated with slides. Tests and a research project. Prerequisite: ARCH-2120 or permission of instructor. 4 credit hours

ARCH-4020 Architecture of Early Christian, Byzantine, Romanesque, and Gothic Europe
A focus on European architecture from 330 to 1450 A.D., with a brief look at 19th and 20th century derivatives. Emphasis is on churches, but castles, palaces, monasteries, and town planning are also considered. An illustrated lecture course. Tests and a research project. Prerequisite: ARCH-2120 or permission of instructor. 4 credit hours

ARCH-4030 Architecture and Urban Design of the Italian Renaissance
Organized according to patterns of patronage, architecture and urban design of the 15th and 16th centuries in Italy are studied as a manifestation of the theoretical ideas, sociopolitical context, and historical circumstance of the period. Fall term alternate years. 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. 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 requestioning 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. 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 as well as facilities for the public realm. Prerequisite: ARCH-2230. Fall and summer terms. 6 credit hours

ARCH-4250, ARCH-4260 Architecture Design 5, 6
A series of upper-level design studios that focus on significant concerns in architecture. Prerequisites: ARCH-4240 for ARCH-4250, ARCH-4250 for ARCH-4260. ARCH-4300 may be taken after ARCH-4250. Fall and spring terms annually. 6 credit hours each

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 2-credit course that introduces codes, the regulatory process, agreements, contract documents, building design cost control, and administration. This course may be taken anytime 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. Fall and spring terms annually. 6 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. 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.
Fall and summer terms. 6 credit hours.

ARCH-4420 Digital Media Seminar
This course will explore advanced topics in computer-
mediated design processes through both theoretical
investigation and hands-on application. Students will
investigate the application of video, animation, and/or
multimedia technologies to design conceptualization
through processes which engage the inherent logics of
digital media. Rather than simply employ these
technologies, the course will strive to critically examine
their implications for architectural designers. Students will
complete projects based on past or current design studio
work. Prerequisite: ARCH-4240. 4 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.
Spring term annually. Limited enrollment. 4 credit hours

ARCH-4510 Construction Industry Seminar
Introduction to the construction industry as an essential
course for realizing architecture. A survey of the people,
organizations, and professional and industry groups
involved in design, construction, finance, insurance,
and regulation of building. Current issues influencing design
quality are identified by the class and are explored in a
series of student-organized in-depth seminars with
industry participants. Spring term annually. 2 credit hours

ARCH-4520 Seminar on Architectural Practice
An examination of contemporary American
architectural practice, including an examination of
architects, their firms, and professional institutions.
Introduction to firm management issues including
strategic planning, human resources, marketing and
financing, project and risk management. Exploration of the
nature of a profession including rights, obligations, and
standards of performance. 4 credit hours

ARCH-4530 Systems Building Seminar
The course focuses on the underlying principles of systems,
building system design, and the ways and means by which the
building industry and society use resources to
condition environments for human habitation, enterprise,
and comfort. It concentrates on the hardware side of the
building design process, including conventional methods
as well as emerging possibilities for responsive and
intelligent system design and implementation. With an
emphasis on integration within the ethic of
environmentally responsible approaches, the seminar
addresses the analysis of environmental conditions, the
development of appropriate design criteria, architectural
and systems responses. The course provides an overview of
building systems and subsystem approaches, innovative
assembly techniques, and inventions and innovations,
including technology transfers from other industries. Full
term annually. 4 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. Fall and spring terms annually.

2 credit hours

ARCH-4550 Building Economics
An introduction to the economics of building: where the money comes from and where it is spent, factors influencing design and building costs, and approaches to managing costs from initial project definition through construction and use. Techniques for project budgeting, cost estimating, and life cycle cost analysis are included.

4 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. Spring annually.

2 credit hours

ARCH-4610 Building Conservation 1
Investigates the history and use of building materials with special focus on the diagnosis and repair of masonry, wood, metal, and traditional finishes in architecture. Nineteenth century materials will be stressed. Course will involve fieldwork and materials testing laboratory. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually.

2 credit hours

ARCH-4620 Introduction to Computation-Based Design and Programming
This course offers project-centered training in at least three different design-based programming tool kits. 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-4630 Building Conservation 2
Investigates the history and use of 20th century building materials with special emphasis on “modern age” materials such as glass, steel, reinforced concrete, plastic, and other synthetic products. Course will involve fieldwork and materials testing laboratory. Prerequisite: ARCH-4610. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually.

2 credit hours

ARCH-4640 American Building—17th–19th Centuries
Examines the particular forces that have influenced 20th century architecture in America in a worldwide context with emphasis on structural types, materials, and building techniques unknown a century ago. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Prerequisite: ARCH-4640. Spring term annually.

2 credit hours

ARCH-4650 American Building—20th Century
Examines the particular forces that have shaped American Architecture including European antecedents, social mores, settlement patterns, materials’ availability, technological innovations, stylistic evolution, and prominent practitioners. Significant engineering advances and development of the American landscape will also be discussed. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Prerequisite: ARCH-4650. Spring term annually.

2 credit hours

ARCH-4660 Historical Archeology
Current archeological techniques and approaches to the investigation of historic sites will be taught including historical research and on-site analysis. Course will require fieldwork. Prerequisites: ARCH-6700, ARCH-6680. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually.

1 credit hour

ARCH-4670 Industrial Archeology
Introduction to America’s great wealth of the 19th and 20th century. Engineering landmarks, particularly those in the Hudson and Mohawk River valleys—their typology and potential for continued and adaptive use, are investigated. Historic bridges and transportation corridors will also be studied. Prerequisite: ARCH-4660. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually.

1 credit hour

ARCH-4680 Traditional Trades and Craftsmanship
Through hands-on application, students will work with historic building materials to learn traditional construction techniques and crafts. Course will involve fieldwork. Prerequisites: ARCH-4610, ARCH-4630. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually.

2 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-4560, ARCH-4140, ARCH-4330 and ARCH-4560; A pre-or co-requisite to ARCH-4300. Fall term annually. 4 credit hours

ARCH-4700 Advanced Structures and Construction Systems
The development of a working knowledge of building systems comprised primarily of composites, including reinforced, high-strength, and pre-cast concrete, reinforced masonry, and emerging composites. Arches, shells, and plates are analyzed. Advanced computer applications assist the student in developing an understanding of the relationships among concept, material, form, and structural implications. Prerequisites: ARCH-2330. 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. 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. 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. 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 Architecture Acoustics 1 and 2, the student should be prepared for a basic entry-level position in either acoustics in architecture or in acoustical consulting. 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. Spring term annually. 4 credit hours

ARCH-4860 Applied Psychoacoustics
This course introduces students to the concepts and methods of applied psychoacoustics as used for architectural acoustics and for audio engineering. These concepts include fundamental hearing phenomena, basic hearing models, spatial hearing, psychoacoustical experimental techniques, and statistical analysis. Experimental techniques include pair comparisons, ABX-testing, multidimensional scaling, parametric and non-parametric statistics, among others. Spring term annually. 2 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
An individually initiated, planned, and developed comprehensive project that creatively engages the material inhabited world. The semester begins with a 5-week architecture competition and includes a research/methods seminar that is common to all students. The competition is followed by an integrated design research phase under the guidance of a final project adviser and two reviewers. In that phase, each student initiates, prepares, and develops a project for completion in ARCH-4990. For students in the B.Arch. program only. Fall and spring terms annually. 6 credit hours

ARCH-4990 B.Arch. Final Project 2
The final phase of B.Arch. students, final project—a comprehensive investigation that engages the material inhabited world. The students continue and complete the integrated design research phase of an approved project that was initiated in B.Arch. Final Project 1 (ARCH-4980) under the guidance of a final project adviser and two reviewers. For students in the B.Arch. program only. Prerequisite: ARCH-4980. Fall and spring terms 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. 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. 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. Fall term annually. 4 credit hours

ARCH-6210, ARCH-6220 Graduate Studio 1, 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-6400 Philosophies of Space in a Digital Culture
The focus of the course will be on establishing an intellectual means to comprehend the cultural context of electronic media. The course will examine relevant philosophies, psychologies, and cultural ephemera to situate the ‘information revolution’ into a meaningful context. The motivations of the class are very political; architecture (via an expanded definition) is seen as a means of comprehending the powers of space and nonspace. Electronic media and its related technologies will be examined through the filter of a theory of architecture—a theory that will be designed throughout the course. Fall terms annually. Limited enrollment. 4 credit hours

ARCH-6420 Experimental Research Lab
This course is offered primarily to familiarize students in the Informatics and Architecture post-professional master’s program with facilities and technologies significantly relevant to a technologized practice of architectural design. The course is composed of introductory training sessions in a variety of laboratories and studios to expose students to the techniques available to them in their design pursuits. Offered once annually. 2 credit hours

ARCH-6440 Simulation
Covering first the theoretical ground for visual and performative architectural simulations, this course will introduce students to the methods of three primary types of simulation: visual simulation or visualization, interactive simulation, and performative or mathematical simulation. The course will stress the simultaneous critical investigation into and application of simulation tools and techniques to conceptual problems of architecture and urbanism. Offered once annually. Limited enrollment. 4 credit hours

ARCH-6460 Stagecraft and Theater Design
This course introduces students to the elements of theater
design and construction. The course will discuss the physical structures in which live performances occur, as well as the economic and social forces (e.g., trade unions, production, financing, and organizational structures of play production). Particular emphasis is given to understanding historical methods of stagecraft and their relation to modern construction techniques and use of materials. In addition, the course will discuss acoustical considerations for theater and stage shell design. The graduate-level course will require an extensive individual project. Fall term annually.

ARCH-6610 Preservation Theory
Examines the historical foundation of the roughly 200-year-old historic preservation movement and the various philosophies which presently motivate it. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually.

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. Spring term annually.

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. Fall term annually.

ARCH-6620 Contemporary Preservation Practice
Visits to and from architectural firms. Investors, developers, government officials, and not-for-profit executives will introduce students to opportunities in contemporary preservation practice and what potential employers are seeking. An extensive range of disciplines will be explored including urban planning and landscape design. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually.

ARCH-6630 Economics of Historic Preservation
Discusses the impact of preservation projects in a community and the tools for funding them. Investigation into private sources, i.e., foundation and not-for-profit grants; public grants, incentive, and loan programs; impact on tourism and business revitalization; and instructions on how to approach funding sources and measure economic strides. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually.

ARCH-6640 Historic Preservation Law
Analysis of federal, state, and local laws affecting historic resources—from implementation of the National Historic Preservation Act to enactment of local legislation. Included will be related federal and state regulations on land use and environmental protection. Code, public health, and zoning issues will also be investigated. Prerequisites: ARCH-6630 and ARCH-6610. Meets on alternate Friday and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually.

ARCH-6650 Architectural Materials Testing
A course in conjunction with Building Conservation 1 and 2 to provide in-depth laboratory work on the performance and durability of historical architectural building materials. Strength, fire resistance, and other code-related properties will be tested and judged against contemporary standards. Course will involve materials testing laboratory. Prerequisites: ARCH-4630 and ARCH-6670. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually.

ARCH-6660 Structural and Mechanical Systems
Historical structural and mechanical systems will be studied. Building code issues will be explored along with innovative and discrete methods of heating, cooling, ventilating, and lighting historic buildings. Prerequisite: ARCH-4610. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually.

ARCH-6670 Researching Historic Structures
How to investigate an historic structure based on public and private archival records and published sources that include written, graphic, photographic, and oral materials. In conjunction with Recording Historic Structures, this course will teach students how to “read” a building and
produce an historic structures report. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually.

ARCH-6690 Drawing Historic Structures
An introduction or remedial course in free-hand drawing as a way of looking at, imagining, and presenting historic buildings. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually.

ARCH-6700 Recording Historic Structures
How to record and interpret according to current standards of architectural documentation the physical structure, condition, and historical changes to existing buildings using non-destructive traditional methods and newly adopted probes. Architectural photography, photogrammetry, and computer realization will be studied. Course will involve fieldwork, will meet on alternate Fridays, and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually.

ARCH-6710 Preservation Design Studio 1
Working in teams of four to six, students will take on the complete documentation and analysis of a particular building or discrete group of historic structures. Included will be preparation of an historic structures report and feasibility plans for the continued or renewed vitality of the structure. Retrofitting and adaptive use will be part of the discussion. Prerequisites: ARCH-4640, ARCH-6610, ARCH-6700. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually.

ARCH-6720 Preservation Design Studio 2
Serving as a cumulative project each student will undertake a community/neighborhood preservation project working with local partners and sponsors including public officials, not-for-profit organizations, historical societies, business improvement districts, owners, and advocacy groups among others. Projects will be approved by the faculty adviser and program director. Recording, research, legal and economic analysis, proposal preparation, and fund-raising skills will all be brought to bear on the project. Prerequisites: ARCH-6710. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually.

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. Fall term annually.

ARCH-6860 Applied Psychoacoustics
This course introduces students to the concepts and methods of applied psychoacoustics as used for architectural acoustics and for audio engineering. These concepts include fundamental hearing phenomena, basic hearing models, spatial hearing, psychoacoustical experimental techniques, and statistical analysis. Experimental techniques include pair comparisons, ABX-testing, multidimensional scaling, parametric and non-parametric statistics, among others. The graduate-level course will require an extensive individual project and more advanced data analysis. Spring term annually.

ARCH-6870 Sonics Research Laboratory I
The Sonics Research Lab is completely research based. First, we will develop an understanding of the measurement equipment and analysis required in order to quantify qualitative aspects of various sonic environments. In addition, we 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. Co-requisite: ARCH-4840 or instructor approval. Fall term annually.

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. Spring term annually.

ARCH-6900 Graduate Thesis Seminar
Readings and discussion of topical materials that are selected to place graduate projects and theses in a comprehensive context. Fall and spring terms.

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.
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 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 Graduate School 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 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. 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-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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. Fall and spring terms annually.

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. Fall and Spring term annually.

Variable credit hours

ARTS Arts (HSSH)

ARTS-1010 Media Studio: Video/Audio
This course introduces students to basic recording and editing techniques, and develops critical listening and viewing skills by experiencing and discussing historic and contemporary examples of time based media. Individual and group projects are created and critiqued in class sections. Each student will come away with a basic understanding of film and video making language, media literacy, basic production skills, and a historical overview. Fall and spring terms annually.

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. Fall and spring terms annually.

ARTS-1100 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. Fall and spring terms annually.

ARTS-1200 Intermediate Video
This course explores contemporary video practice, concentrating on creating, presenting, and analyzing video art. It is an introduction to the Arts Department production facilities and equipment, and a prerequisite for 4000-level video classes. Prerequisite: ARTS-1010 or permission of instructor. Fall and spring terms annually.

ARTS-1400 Music Fundamentals
A creative approach for students with no previous experience to the concepts of music theory (rhythm, scales, keys, intervals, chords, etc.) and elementary harmony. Also an introduction to some of the monuments of Western repertory through listening, reading, and discussion. Spring term annually.

ARTS-2010 Professional Project
A creative approach for students with no previous experience to the concepts of music theory (rhythm, scales, keys, intervals, chords, etc.) and elementary harmony. Also an introduction to some of the monuments of Western repertory through listening, reading, and discussion. Spring term annually.

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. Fall and spring terms annually.

ARTS-2030 Net Art
Net Art is a hands-on studio course that uses the examination of the historical and theoretical aspects of Web-based art and virtual social spaces as a launching pad for individual student work. Considerable work at the
conceptual level and a survey of Web-oriented software and programming enable students to create new works in net-based art. Prerequisite: ARTS-1020 or permission of instructor. 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. Fall and spring terms 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. 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. Fall and spring terms 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. 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. Fall and spring terms annually. 1 credit hour

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. Fall and spring terms annually. 1 credit hour

ARTS-2330 Ghanaian Drumming Ensemble
Further developing hand drumming technique, as well as stick drumming technique and bell and shaker patterns, this course concentrates on the performance of intermediate level Ghanaian polyrhythms that are played in ensemble form. Instructor also conveys much information regarding the cultural context from which this music arises. Prerequisite: Intro. to Ghanaian Drumming or audition. Fall and spring terms annually. 1 credit hour

ARTS-2400 Music Theory I
A course that explores the fundamental concepts of music theory, for the students with at least some musical background. Rhythm, scales, keys, intervals, chords, and elementary harmony will be covered as well as an introduction to counterpoint and analysis. Correlative studies in ear-training and keyboard skills. Fall 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. 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. 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. Spring. 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. Fall term 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. Fall term annually.  4 credit hours

ARTS-2560 The American Musical
This course surveys the American Musical, introducing students to its basic components and concepts. Since the musical integrates different media, it is studied through the contribution of major artists as well as in historical, social, and cultural contexts. The course also analyzes music and musical theater genres, which influenced the musical, including European opera and operetta; American blues, ragtime, and jazz; and Latin-American rhythms. Fall term annually.  4 credit hours

ARTS-2600 Acting I
This course introduces students to the principles of acting. Students participate in theatre games and improvisations; explore the stage environment; study dramatic conflict and transformation into different characters; and learn stage terminology and blocking. The emphasis is on individual and group projects that develop students' creativity and imagination. The culmination of the course is the presentation of monologues and scenes from international plays. Fall term annually.  4 credit hours

ARTS-2940 Studies in the Arts
Projects adapted to the needs of individual students.  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: Computer Music or Video Art and Installation or permission of the Instructor. Spring term annually.  4 credit hours

ARTS-4020 Advanced Digital 3-D Projects
Advanced Digital 3-D Projects is a studio/seminar in the arts concentrating on individual student projects in advanced digital 3-D research. Topics covered include issues in virtual environment creation, human interface to 3-D data, digital sculpture, advanced animation research, and others. Newly emerging issues in digital 3-D as they apply to art theory and practice will be addressed. Prerequisites: ARTS-2030, or ARTS-4060, ARTS-4070, or permission of instructor. Spring term annually.  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 vérité, propaganda films, "home movies," reality TV, tabloid news, autobiographic and activist videos. Prerequisite: ARTS-2010 or permission of instructor. Based on availability of instructor.  4 credit hours

ARTS-4050 Arts Practicum
Arts Practicum 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. 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: 2000-level electronic arts course or permission of instructor. 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 and particle animation, scene description and story building. Prerequisite: 2000-level electronic arts course or permission of instructor. Fall and spring 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. Fall and spring terms annually.  4 credit hours
ARTS-4120 Radio: Theory and Practice
This course is an investigation of radio as a unique artistic form. To provide a context for student’s own production work (which will be aired over WRPI) the class incorporates readings on aesthetics, culture, history, politics, and economics of the world’s first electronic broadcast technology. Prerequisite: ARTS-1010, COMM-1510. Fall and spring terms annually. 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 2
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 on 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. 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. Fall and spring terms 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. Fall and spring terms annually. 4 credit hours

ARTS-4620 Theatre Performance
This course gives students a practical background in the field of theatre, introducing them to all aspects of a theatre production. Students rehearse a play in the classroom and then give performances on the RPI campus. Students also participate in directing, stage managing, writing press releases, and designing set, costumes, lighting, and sound for the show. Auditions take place on the first day of class. Fall term annually. 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. Spring term annually. 4 credit hours

ARTS-4710 Technical Production and Documentation
This course teaches the skills needed to produce and document professional electronic arts events, including live concerts, installations, and multimedia presentations. It is an intensive, hands-on course designed to give students direct experience with sound, video, and lighting equipment in live performance environments. Students will learn technical and creative skills essential for artistic practice in the field of electronic arts. Prerequisite: limited to upper class B.S. EARTS, EMAC, IT ARTS students, MFA students, or by permission of instructor. Fall and spring terms annually. 4 credit hours

ARTS-4910 Honors Capstone Design
Honors Capstone Design is a two-semester sequence offered in Fall and Spring and is an option for fulfilling the Culminating Experience/Capstone requirement for graduating seniors majoring in EMAC. Through a series of production and writing assignments, breakout seminars, group critiques, and public exhibition, the goal is to develop a work-in-progress in the Fall semester and a final version in the Spring semester of the capstone project and senior thesis paper. Students must submit proposals for their project in the Spring semester of the previous academic year. Permission of instructor is required. Students cannot receive credit for both this course and
COMM-4910, Honors Capstone Design. Fall and spring terms annually.  
ARTS-4940 Studies in the Arts  1 to 4 credit hours
ARTS-4960 Topics in the Arts  3 to 4 credit hours
ARTS-6010 Computer Music Studio  
An introduction to the history, theory, techniques, and practice of computer music composition with an emphasis on hands-on creative work. This course functions as an orientation for incoming MFA students to the musical resources of the iEAR Studios. Students use the studio facilities to produce directed creative projects. Prerequisite: limited to MFA students or permission of instructor. Fall term annually.  
ARTS-6020 Video Art Studio  
An introduction to techniques and principles of video art preproduction, production, and post-production, with an emphasis on hands-on creative work in the iEAR Studios. Studies include historical and theoretical analysis of important works and techniques of video art, practical technical instruction, performance, and directed creative projects. Prerequisite: enrollment in the MFA program or permission of instructor. Studio course. Fall term annually.  
ARTS-6030 Digital Imaging Studio  
This graduate studio course embarks on the exploration of the computer as an agent to augment and expand conceptualization and expression in art-making. The techniques and principals of digital imaging are developed with an emphasis on conceptual, aesthetic, and critical issues relating to content. Prerequisite: limited to MFA students or permission of instructor. Studio course. Fall term annually.  
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 MFA students in electronic arts.  
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 Creative Seminar I. 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 MFA students or permission of instructor. Fall term annually.  
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. Spring term annually.  
ARTS-6940 Studies in Electronic Arts  
Individual and collaborative projects and readings adapted to the needs of individual students at the advanced level. Fall and spring terms annually.  
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 IP are assigned until the thesis has been approved by the faculty adviser 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.  
ASTRONOMY  
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 1-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 2-credit course, it will be graded in the conventional manner. If ASTR-1510 and ASTR-1530 are both taken as graded 2-credit courses, they may be counted together as one 4-credit elective for nonscience majors. Fall term annually.  
ARTS-6990 Master’s Thesis  
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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 or 2 credit hours
planets, comets, and the search for life in the solar system. If ASTR-1530 is taken as a 1-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 2-credit course, it will be graded in the conventional manner. If ASTR-1510 and ASTR-1530 are both taken as graded 2-credit courses, they may be counted together as one 4-credit elective for non-science majors. Spring 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. Prerequisites: MATH-1020. Corequisite: PHYS-1200. 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 non-physics and non-science majors as well as those committed to specialization in Astronomy. Includes evening laboratory sessions. 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. Fall and spring terms annually.

3 credit hours

**ASTR-4120 Observational Astronomy**


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. Prerequisites: PHYS-2510 and PHYS-4420 or equivalent. 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-2330 or permission of instructor. Spring term annually.

4 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. Spring term annually.

4 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. 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. Fall and spring terms annually.

4 credit hours

**ASTR-4960 Topics in Astronomy and Astrophysics**

2 credit hours
both this course and ASTR-4250. Prerequisite: ASTR-4220. Consult department about when offered.

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. Fall and spring terms annually.

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 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 each term. 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 each term. 1 to 4 credit hours

BCBP-4210 Biophysical Methods
Topics covered will include electron microscopy of ordered samples, structural databases, hydrodynamics of biological macromolecules, viscosity, sedimentation, translational and rotational diffusion, chromatography, conductance, dielectrophoresis, dynamic light scattering, flow and electric birefringence, and electrophoresis. Also water as a solvent, polyelectrolytes, and Debye-Hückel theory. (Students cannot obtain credit for both this course and BCBP-6210.) Prerequisites: CSCI-1100, BIOL-2120, CHEM-2440, and PHYS-1100 or equivalents. Spring term odd-numbered years. 4 credit hours

BCBP-4310 Genetic Engineering
Case studies on the effect of genetic engineering on medicine, agriculture, biology, forensics, and various other areas of technology. Each week a set of assigned readings will be discussed. Some of the topics to be covered are vaccines, biomolecular computing and electronics, paleontology, ecology, bioremediation, and polymers. (Students cannot obtain credit for both this course and BCBP-6310.) Prerequisites or corequisites: BCBP-4760 and BIOL-4620, or permission of instructor. Fall term, odd-numbered years. 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 tissue extraction, 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.) Prerequisite: BIOL-2120. 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. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BIOL-4760 or CHEM-4760.) Prerequisites: CHEM-2250 or CHEM-2210 and BIOL-2120 or equivalent. Fall term annually. 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. Spring term annually. 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. Spring term even-numbered years. Prerequisite: BCBP-4760 or equivalent. (Students may not receive credit for both this course and BCBP-6780, CHEM-4780, or CHEM-6780.) 4 credit hours

BCBP-4790 Protein Chemistry
The ability to design synthetic proteins from first principles (de novo design) is a new area of protein chemistry with exciting potential applications in medicine and industry. This course will review the present understanding of chemistry and physics of protein structure and stability and show how this understanding can be applied to the design of unnatural proteins. The course will also cover the computer modeling and chemical synthesis of proteins, how to impart new characteristics to natural proteins via chemical modification, and the generation of protein ‘chimera’ using semisynthesis. (Students cannot receive credit for this course and BCBP-6790 or CHEM-4790.) Prerequisite: CHEM-4760 or BCBP-4760 or BIOL-4760 or equivalent; CHEM-6190 or BCBP-4810 is an asset. Recommended for seniors; juniors should talk to the instructor before registering. Spring term, odd-numbered years. 4 credit hours

BCBP-4810 Biological Spectroscopy
Explores the use of spectroscopic methods to study biological systems. Theory and application of techniques including UV-visible absorbance spectroscopy, IR spectroscopy, fluorescence, electron paramagnetic resonance and nuclear magnetic resonance, and their application to the study of the structure of macromolecules, enzyme mechanism, and other important biological problems covered. (Students cannot obtain credit for both this course and BCBP-4810.) Prerequisite: BCBP-4760 or equivalent. Fall term even-numbered years. 4 credit hours

BCBP-4860 Protein and Nucleic Acid Structure
The three-dimensional structure of these biological macromolecules is explored in detail, with special attention to the relationship of structure and function. Other topics include methods used to determine structure, the thermodynamics of structure formation, structure prediction from primary sequence, and computer-based molecular modeling. (Students cannot obtain credit for both this course and BCBP-6860.) Prerequisite: BCBP-4760 or equivalent. Spring term even-numbered years. 4 credit hours

BCBP-4870 Crystallographic Analysis of Protein Structure
X-ray crystallography is the method of choice for determining the three-dimensional structure of biological macromolecules. The course will cover the crystallographic method, its theory and practice, followed by a detailed exploration of selected protein structures. Other topics include the thermodynamics of structure formation, structure prediction from primary sequence, and molecular dynamics. (Students cannot obtain credit for both this course and BCBP-6870.) Prerequisites: BCBP-4760, MATH-1020, and PHYS-1200 or equivalents. Fall term odd 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. Prerequisite: permission of instructor. Limited to students with senior status. Offered each term. 4 credit hours

BCBP-6210 Biophysical Methods
Topics covered will include electron microscopy of ordered samples, structural databases, hydrodynamics of biological macromolecules, viscosity, sedimentation, translational and rotational diffusion, chromatography, conductance, dielectrophoresis, dynamic light scattering, flow and electric birefringence, and electrophoresis. Also water as a solvent, polyelectrolytes, and Debye-Huckel theory. (Students cannot obtain credit for both this course and BCBP-4210.) Prerequisites: CSCI-1100, BIOL-2120, CHEM-2440, and PHYS-1100 or equivalents. Spring term odd-numbered years. 4 credit hours

BCBP-6310 Genetic Engineering
Case studies on the effect of genetic engineering on medicine, agriculture, biology, forensics, and various other areas of technology. Each week a set of assigned readings will be discussed. Some of the topics to be covered are vaccines, biomolecular computing and electronics, paleontology, ecology, bioremediation, and polymers. (Students cannot obtain credit for both this course and BCBP-4310.) Prerequisites or corequisites: BCBP-4760 and BIOL-4620, or permission of instructor. Fall term, odd-numbered years. 4 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. Spring term even-numbered years. 4 credit hours

BCBP-6790 Protein Chemistry
The ability to design synthetic proteins from first principles (de novo design) is a new area of protein chemistry with exciting potential applications in medicine and industry. This course will review our present understanding of chemistry and physics of protein structure and stability and show how this understanding can be applied to the design of unnatural proteins. The course will also cover the computer modeling and chemical synthesis of proteins, how to impart new characteristics to natural proteins via chemical modification, and the generation of protein 'chimeras' using semisynthesis. (Students cannot receive credit for this course and BCBP-4790 or CHEM-4790.) Prerequisite: CHEM-4760 or BCBP-4760 or BIOL-4760 or equivalent; CHEM-6190 or BCBP-4810 is an asset. Spring term, odd numbered years. 3 credit hours

BCBP-6810 Biological Spectroscopy
Explores the use of spectroscopic methods to study biological systems. Theory and application of techniques including UV-visible absorbance spectroscopy, IR spectroscopy, fluorescence, electron paramagnetic resonance and nuclear magnetic resonance, and their application to the study of the structure of macromolecules, enzyme mechanism, and other important biological problems covered. (Students cannot obtain credit for both this course and BCBP-4810.) Prerequisite: BCBP-4760 or equivalent. Fall term even-numbered years. 4 credit hours

BCBP-6860 Protein and Nucleic Acid Structure
The three-dimensional structure of these biological macromolecules is explored in detail, with special attention to the relationship of structure and function. Other topics include methods used to determine structure, the thermodynamics of structure formation, structure prediction from primary sequence, and computer-based molecular modeling. (Students cannot obtain credit for both this course and BCBP-4860.) Prerequisite: BCBP-4760 or equivalent. Spring term even-numbered years. 4 credit hours

BCBP-6870 Crystallographic Analysis of Protein Structure
X-ray crystallography is the method of choice for determining the three-dimensional structure of biological macromolecules. We will cover the crystallographic method, its theory and practice, followed by a detailed exploration of selected protein structures. Other topics include the thermodynamics of structure formation, structure prediction from primary sequence, and molecular dynamics. (Students cannot obtain credit for both this course and BCBP-4870.) Prerequisites: BCBP-4760, MATH-1020, and PHYS-1200 or equivalents. Fall term odd-numbered years. 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 each term. 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 Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned until the dissertation has been approved 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. 1-9 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 IP are assigned until the thesis has been approved by the faculty adviser 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. 1-9 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. Fall and spring terms annually. 4 credit hours

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. Spring term annually. 4 credit hours, 6 contact hours

BIOL-2160 Introductory Biotechnology
The application of biological principles and materials in the production of commercially important products. Fermentation, biocatalysis, hybridization technology, and plant cell culture are treated in the history and development of modern biotechnology, including social aspects. Prerequisite: BIOL-1010 or BIOL-2120. Spring term even-numbered years. 3 credit hours

BIOL-2310 Microbiology
The morphology and the physical and chemical activities of bacteria, yeasts, molds, and viruses. Laboratory work in techniques of microbiology. Quantitative aspects. Spring term annually. 4 credit hours, 6 contact hours

BIOL-2410 Embryology
Anatomical, cellular, and molecular aspects of germ cell formation, fertilization, early development, morphogenesis, induction, and differentiation. Extra-embryonic adaptation and hormonal controls are also discussed, concluding with a summary of current concepts on eucaryotic gene expression and regulation. Prerequisite: BIOL-2120. Spring term annually. 4 credit hours, 6 contact 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. Fall, spring, summer session 2 annually. 3 credit hours

BIOL-2520 Genetics Laboratory
Laboratory teaches how science is done by students making observations and then developing and experimentally testing student formulated hypotheses. Fall term annually. 1 credit hour, 3 contact 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. 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. Fall, spring, and summer terms annually. 1 to 4 credit hours

BIOL-2980 Biomedical Research
Independent research in health sciences, supervised by a faculty member, for the purpose of developing research skills. Open to students in the accelerated physician-scientist curriculum only. Prerequisite: permission of instructor. Spring term annually. 4 credit hours

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. Prerequisite: BIOL-4260 or BIOL-4740 and permission of instructor. Offered each term. 3 credit hours

BIOL-4070 Principles of Research Culminating Experience
This course is an introduction to research methods. It will provide a basis for understanding the fundamental steps required to develop and pursue a research project, and to develop critical thinking skills in the context of modern biological research. This course shares the format with BIOL-4080 Principles of Research and serves as a culminating experience in the Biology curriculum with the addition of a semester long literature review culminating in a written review-type manuscript of a significant aspect of biological science. Offered spring term annually. 3 credit hours
BIO-4080 Principles of Research
This course is an introduction to research methods. It will provide a basis for understanding the fundamental steps required to develop and pursue a research project, and to develop critical thinking skills in the context of modern biomedical research. Open to students in the accelerated physician-scientist program only. Spring term only. 
2 credit hours

BIO-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. Spring semester annually. 
2 credit hours

BIO-4260 Cell Biology
Biochemical and morphological evidence underlying current models of cell structure and function. Topics covered include roles of membranes in cell compartmentation, organelle structure and biogenesis, vesicle transport, secretion, cytoskeleton, motility, signaling, mitosis, and cell cycle regulation. Distinctive characteristics of differentiated mammalian cells are examined. The format includes faculty lectures, computer-based tutorials, and student presentations. Prerequisite: BIOL-4760 or permission of instructor. Spring term annually. 
4 credit hours

BIO-4270 Human Physiology I
Introduction to fundamental physiological processes and their mechanism of action in human organismal systems. Membrane structure and function, transport mechanisms, action potentials, and synaptic transmission. Skeletal, cardiac, and smooth muscle structure, function, and control. Sensory receptors and neural coding. The nervous system. Fall term annually. 
4 credit hours

BIO-4280 Human Physiology II
Study of basic physiological principles in human and higher mammalian organisms. Emphasis on interaction and control of physiological systems, their control and interaction. Introduction to circulatory, renal, respiratory, digestive, reproductive, and hormonal systems. Prerequisite: BIOL-4270. Spring term annually. 
4 credit hours

BIO-4290 Human Physiological Systems
Study of basic physiological principles in human and higher mammalian organisms. Emphasis on interaction and control of physiological systems. Introduction to neural, motor, sensory, circulatory, renal, respiratory, reproductive, and hormonal systems. Non-majors only. Fall term annually. 
4 credit hours

BIO-4310 Industrial Microbiology
A survey of the uses of microorganisms in production of commercially important products, decomposition of wastes, and control of nuisance microorganisms. Development of fermentation processes, types of fermentation equipment, product recovery, and fermentation economics are discussed. Prerequisites: BIOL-2310 and BIOL-4760 or CHEM-2250, or permission of instructor. Spring term odd-numbered years. 
3 credit hours

BIO-4320 Geomicrobiology
Microbial activities on rock and minerals; in soils and sediments. Microbial relationships to fossil fuels. Pertinent topics in limnology and marine microbiology. Prerequisite: BIOL-2310 or BIOL-6310 or ERTH-1010, or permission of instructor. Spring term annually. 
3 credit hours

BIO-4360 Introductory Virology
Natural history of virus diseases. In vitro virus-cell interactions. Physical and chemical properties of viruses and their nucleic acids. Prerequisite or corequisite: BIOL-2310 or BIOL-2500. Fall term annually. 
4 credit hours

BIO-4370 Introduction to Microbial Physiology
Unique aspects of the physiology of bacteria and blue-green algae are considered. Fine structure and function, metabolism and reproduction are integrated into a common framework at the molecular and cellular level. Specific topics include microbial transport, heterotrophy, fermentation, autotrophy, nitrogen, sulfur and carbon metabolism, microbial growth and morphogenesis in the prokaryotes. Prerequisites: BIOL-2310 and BIOL-4760. Spring term odd years. 
3 credit hours

BIO-4380 Introduction to Microbial Genetics
An introduction to mechanisms of gene transfer in bacteria. Mutant selection and genetic manipulations using classical and recombinant DNA techniques will be discussed. Life cycles of bacteriophage are studied. Discussion of original journal articles will be used to supplement other course material. Prerequisites: BIOL-2310 or BIOL-6310 or ERTH-1010, or permission of instructor. Fall term even-numbered years. 
3 credit hours

BIO-4390 Introductory Medical Microbiology
A discussion of pathogenic bacteria. Major topics are the biology, mechanisms of pathogenicity, laboratory identification of these organisms, and the various mechanisms of host defense. Organisms pathogenic for man are stressed. Fall term odd-numbered years. 
4 credit hours

BIO-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. Fall term annually.

**BIOL-4410 Plagues, Politics, and People**
The origin of plagues old and new are the main theme of this course. Through such sources as the Bible and Shakespeare we also see how previous societies have responded to epidemics in ways that are very similar to current experience with AIDS, a disease that has and will impact the civilized world like none other in history. An overview of the basic principles of microbiology are woven into the story. Spring term annually.

**BIOL-4420 Introductory Immunology**
An introduction to immune responses, antigen-antibody reactions, antibody structure and formation, blood groups, and antibody-mediated and cell-mediated hypersensitivity. Prerequisites: BIOL-2120 and BIOL-2310. Fall term annually.

**BIOL-4430 AIDS: Paradise Lost**
AIDS, with its combination of sex, death, and celebrities, holds a strong fascination for our society. The AIDS story is a complex one, shaped by a number of forces. While the primary focus is on the biology of the HIV virus and its interface with the immune system, we do not neglect how social, technical, administrative, political, legal, and economic factors mold the AIDS story. Student presentations of current topics in the AIDS epidemic will be an integral part of the course. (Cross listed as PSYC-4630.) Prerequisite: BIOL-2120. Spring term annually.

**BIOL-4440 Microbial Ecology**
A study of the interactions between microbes and their environments. Discussion includes the physiological ecology of microorganisms (effects of physical parameters on microbial distribution and activities in nature), dispersal mechanisms in nature, associations with higher organisms, and the role of man in manipulating microbial activities. Prerequisite: BIOL-2310 or permission of instructor. Fall term annually.

**BIOL-4450 Environmental Biology**
Central in the myriad environmental challenges modern civilization faces is the maintenance of life-support functions provided by biological diversity or biodiversity. The course considers biodiversity; origins, patterns of change, importance, and current status, especially in the United States. In addition to developing this knowledge base, student term projects will consider and establish the influence of various human mediated activities and processes on biodiversity and the life-support functions it provides. Spring term annually.

**BIOL-4510 Molecular Genetics**

**BIOL-4540 Bioinformatics I**
The course covers concepts and methods related to information processing in biological systems. Concepts covered include homology, identity and similarity; mechanisms and measures of molecular evolution; introduction to data bases (e.g., GenBank, PDB); search algorithms (BLAST); pairwise sequence alignment using dynamic programming (GAP, BestFit); progressive methods for multiple alignment (CLUSTAL, PILEUP). Selected topics include molecular biology applications (shotgun sequencing analysis, PCR primer design). Prerequisites: MATH-1020, BIOL-4620, BIOL-4760. Fall term annually.

**BIOL-4550 Bioinformatics II**
The course covers use of homology to extract information about structure and function from amino acid sequences. Concepts covered include structural homology, structural motifs and data bases, homology modeling of macromolecules, energy minimization and relaxation, molecular docking, and introduction to molecular dynamics. Prerequisite: BIOL-4540. Spring term annually.

**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 concurrent). Spring term annually.

**BIOL-4630 Molecular Biology II**
This course will provide students with an in-depth examination of the molecular mechanisms involved with gene regulation. The goal of this course will be to expose students to the complexity of regulation of specific biological phenomena, emphasizing current areas of research interest. Examples of semester topics include aspects of immunity, the cell cycle and oncogenes, phage replication and infection, and cellular growth and development. Prerequisite: BIOL-4760. Fall term annually.
BIOL-4700 Freshwater Ecology
Quantitative examination of major biological fresh water communities. Delineation of 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. Microcosm stimulation experiments delineate nutrient and food chain perturbations. Laboratory is taught at the Darrin Fresh Water Institute at Lake George and various field locations in the Adirondacks for two weeks during August. Prerequisite: BIOL-1010 or equivalent or permission of instructor. Summer term annually.

BIOL-4710 Biochemistry Laboratory
Major principles of biochemistry are illustrated, as students purify and analyze specific proteins. Experience is obtained with various techniques including tissue extraction, chromatography, ultracentrifugation, spectrophotometric analysis, and electrophoresis. The course includes extensive hands-on laboratory work, as well as the writing of in-depth reports, and is qualified as a writing-intensive course. (Students cannot obtain credit for both this course and BCBP-4710.) Prerequisite: BIOL-2120. Spring term annually.

BIOL-4720 Molecular Biology Laboratory
The techniques of gel electrophoresis, restriction enzyme mapping, and molecular hybridization are applied to the study of bacterial plasmids and mammalian genes. This is a writing-intensive course. Prerequisite: BIOL-2120. Fall term annually.

BIOL-4740 Cell and Developmental Biology Laboratory
This course examines the biological roles of the extracellular matrix and cytoskeletal proteins in human normal and cancer cells. Experimental techniques include cell culture, immunofluorescence microscopy, computer image analysis, and various biochemical methods. This is a writing-intensive course. Prerequisite: BIOL-2120. Spring term annually.

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 synthesis, enzymology, mechanisms of catalysis, regulation, lipids and membranes, carbohydrates, bioenergetics, and carbohydrate metabolism. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BCBP-4770 or CHEM-4770.) Prerequisites: CHEM-2250 or CHEM-2210 and BIOL-2120 or equivalent. Fall term annually.

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. Spring term annually.

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. Fall term annually.

BIOL-4870 Environmental Toxicology
A study of the origins, transport, fate, and effects of toxic chemicals in the environment. Includes discussion of selective toxicity, biochemical modification, and tissue interactions for several classes of toxic chemicals. Prerequisites: BIOL-1010 and BIOL-2120. Spring term even-numbered years.

BIOL-4940 Readings in Biology
Selected readings in the biological literature to supplement the scientific background of undergraduate students. Cannot be used as a biology elective. Prerequisite: permission of instructor. Fall, spring, and summer terms annually.

BIOL-4990 Senior Research Thesis
Thesis independent research, supervised by a faculty member, culminating in a written thesis. Prerequisite: permission of instructor. Fall, spring, and summer terms annually.

BIOL-6310 Microbiology
An intensive review of the basic concepts of cellular organization, intermediary metabolism, and respiration in microorganisms. Particular emphasis is placed on the relationship between microorganisms and man. Spring term annually.

BIOL-6330 Bacterial Physiology
Discussion of the physiology of microorganisms. Emphasis placed upon bacteria with pertinent aspects of yeasts, molds, and viruses. Topics cover cell anatomy, growth and reproduction, general metabolism, and microbial enzyme systems. Prerequisite: BIOL-2310. Spring term odd-numbered years.
BIOL-6360 Microbial Genetics
A survey of the current status of microbial genetics (bacteria, viruses, and fungi), including discussions of methods and findings in the areas of mutation, adaptation, transformation, transduction, conversion, and recombination. Prerequisites: BIOL-2500 and BIOL-6330. Fall term even-numbered years. 3 credit hours

BIOL-6370 General Virology
Morphology, physiology, and genetics of viruses affecting bacterial, plant, and animal hosts. Some animal diseases of viral etiology considered. Experimental approach is stressed. Fall term annually. 3 credit hours

BIOL-6390 Medical Microbiology
Conducted in conjunction with BIOL-4390, with extra readings, etc. Fall term odd-numbered years. 3 credit hours

BIOL-6410 Bioinformatics I: Sequence Analysis
This studio course covers concepts and methods related to information processing in biological systems. Concepts covered include homology, identity, and similarity; mechanisms and measures of molecular evolution; introduction to databases (e.g., GenBank, PDB); search algorithms (BLAST and FASTA); pairwise sequence alignment using dynamic programming (Gap, BestFit); progressive methods for multiple alignment (Pileup, ClustalW); and special topics in sequence analysis. Prerequisites: BIOL-1010, college-level math, or permission of the instructor. Fall term annually. 3 credit hours

BIOL-6420 Bioinformatics II: Molecular Modeling
This studio course covers use of homology to extract information about structure and function from amino acid sequences. Concepts covered include structural homology, structural motifs and databases, homology modeling of macromolecules, energy minimization and relaxation, water considerations, molecular docking and molecular dynamics. Prerequisites: BIOL-6410 and BIOL-4760 or BCBP-4760 or CHEM-4760 or equivalent, or permission of instructor. Spring term annually. 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-2310 or permission of instructor. Spring term even-numbered years. 3 credit hours

BIOL-6690 Advanced Molecular Biology
Replication, transcription, and translation of genetic information in both prokaryotic and eukaryotic organisms. Molecular cloning, sequencing, and reassociation of nucleic acids. Current topics in the literature, based on original research papers. Spring term annually. 3 credit hours

BIOL-6720 Molecular Biology of Plants
The course will cover several topics that are currently at the forefront of study of the molecular biology of flowering plants. These include: 1) the organization of DNA sequences in nuclear chromosomes and in those of mitochondria and chloroplasts; 2) the regulation of transcription and translation of tissue-specific and environmentally-sensitive genes; 3) gene expression in the development and functioning of chloroplasts and mitochondria; 4) methods of transformation of plants and the use of transgenic plants to answer questions of basic plant molecular biology and development; and 5) the engineering of new traits in plants. The course assumes a familiarity with basic biochemistry and molecular biology. Taught jointly with the State University of New York at Albany. Fall term even-numbered years. 3 credit hours

BIOL-6900 Seminar in Biology
Weekly discussion of selected topics in biology by graduate students and staff. Fall and spring terms annually. 1 credit hour

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. 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 original research papers. Spring term annually. 3 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 IP are assigned until the thesis has been approved by the
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.

BMED Biomedical Engineering (SOE)

BMED-1330 Introduction to Biomedical Engineering
This is a course for first and second year engineering students which provides an overview and introduction to the field of Biomedical Engineering. It will present the many aspects of the discipline, with information about the state of the art, current practices and challenges confronting the field. Career opportunities will be identified, and the education and training needed to qualify for different jobs will be outlined. Fall term annually.

BMED-2200 Dynamic Systems for Biomedical Engineering

BMED-2940 Studies in Biomedical Engineering
Each term. 1 to 4 credit hours

BMED-2960 Topics in Biomedical Engineering
Each term. 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, biomechanical and biomaterial properties, using invasive and noninvasive techniques. Transducers studied include strain gauge, differential transformer, spectrometer, blood gas electrodes, bipotential electrodes, microscope with camera, mechanical testing machine, piezoelectric transducer (or sensor). Also studied are instruments for determination of material properties. Prerequisites: BMED-2200, BMED-4500 or permission of instructor. Fall term annually.

BMED-4240 Tissue-Biomasier 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. An introduction to biocompatibility with special emphasis on the interaction of biomaterials with cells and tissues. Detailed review of blood-material interactions. Case studies of implants are discussed to illustrate biomaterials selection as a key part of implant design. Prerequisites: ENGR-1600, BIOL-4290, or permission of instructor. Spring term annually.

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 cardiac, respiratory, renal, and gastrointestinal systems. Includes laboratory on the application of engineering techniques in the study of physiological systems. Prerequisite: BIOL-4290 or equivalent. Spring term annually.

BMED-4540 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; prerequisite: BMED-2200. Fall term annually.

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 writing-intensive course. Prerequisite: senior standing. Spring term annually.

BMED-4650 Introduction to Cell and Tissue Engineering
This course teaches the use of engineering principles to describe cellular processes of biological, chemical, and physical nature. A quantitative approach will be used to explain the behavior of cells under various physical stimuli through the application of the laws of physics, mathematics, and physical biochemistry. The transduction of these physical stimuli into modified behavior and their impact on organ level performance/function and tissue
engineering will be discussed in the case of mammalian cells. Prerequisites: A basic course in mechanics (ENGR-2530 or BMED-4540, and a basic course in transport phenomena or fluid dynamics (ENGR-2250 or equivalent), or permission of instructor. Fall semester annually. 3 credit hours

BMED-4940 Studies in Biomedical Engineering Each term. 1 to 4 credit hours

BMED-4960 Topics in Biomedical Engineering Each term. 1 to 4 credit hours

BMED-6240 Tissue-Implant Interfaces An examination of biomaterial and biomechanical factors affecting events at tissue-implant interfaces, with emphasis on biomaterial surface properties as well as cell and molecular interactions. Prerequisites: BIOL-4290 and BMED-4500 or permission of instructor. Fall term annually. 3 credit hours

BMED-6280 Biomechanics of Soft Tissues Application of continuum mechanics in modeling the biomechanical behavior of nonmineralized tissues such as tendons, ligaments, skin, cartilage, blood vessels, etc. Topics include structure of collagen, elastin, proteoglycans, and other tissue components, nonlinear elastic models (including Fung’s pseudoeosticity approach as well as strain energy functions), linear viscoelasticity, Fung’s quasilinear viscoelasticity, hereditary integral formulation of constitutive equations, and introduction to mixture theory. Fall term odd-numbered years. 3 credit hours

BMED-6290 Biomechanics of Hard Tissues Structure-property relationships for mineralized connective tissues of the human body. Discussion centers on various types of bone (e.g., lamellar, woven) with an emphasis on models for biomechanical behavior. Topics include elastic models for bone (isotropic and anisotropic), theories of yielding and fatigue, strength properties, composite and hierarchical models, and models of bone remodeling/modeling. Fall term even-numbered years. 3 credit hours

BMED-6350 Fluid Dynamics and Transport in the Vascular Circulation The principles of convective diffusion in liquids are discussed as applied to the vascular circulation. Topics include: convective and diffusion boundary layers in internal flows with reacting and/or permeable walls, Taylor dispersion, microhydrodynamics of macromolecules and particles, Brownian motion, mass transport to arterial walls and across cell membranes. This course is intended for first year graduate students in Biomedical Engineering and undergraduate seniors with permission of the instructor. Spring term, even-numbered years. 3 credit hours

BMED-6480 Adaptive Systems This course contains the fundamental theory required to design adaptive systems. Topics include parameter identification, ARMA modeling, model reference systems, model algorithmic control, self-tuning systems, and adaptive filtering. Applications to physical and physiological systems are introduced. (Cross listed as ECSE-6480). Prerequisite: ECSE-6400 or equivalent. Spring term odd-numbered years. 3 credit hours

BMED-6500 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-4540 or ENGR-2530 with permission from the instructor. Graduate Course; spring semester. 3 credit hours

BMED-6550 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-4540 or ENGR-2530 with permission from the instructor. Spring alternate years. 3 credit hours

BMED-6940 Studies in Biomedical Engineering Each term. 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-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-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 Graduate School 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-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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

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, CHEM-1200 Chemistry I, II
Laws and theories of modern chemistry. Relationship between structure and properties of materials. The dynamics of chemical changes are stressed in terms of chemical equilibrium, thermodynamics, and kinetics. Laboratory work includes preparative and analytical experiments. Credit cannot be obtained for both CHEM-1100 and CHEM-1300. Prerequisite for CHEM-1200: either CHEM-1100 or CHEM-1300. A fall-spring sequence annually.

CHEM-1300 Chemical Principles for Engineers
An introduction into the basic principles of chemistry with an emphasis on applications in everyday scientific and engineering practice. Topics covered include atomic and molecular structure, particle and wave behavior of light and matter, periodic properties of elements, oxidation-reduction, stoichiometry, molecular bonding, introduction to organic and biochemistry, thermodynamics, phases of matter including gas laws, intermolecular forces, chemical equilibrium, simple one and two component phase diagrams, acids-bases-buffers, and chemical kinetics. Laboratory is integrated into the course. Students cannot obtain credit for both this course and CHEM-1100. Fall term. 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. 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-1300. 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. Co-requisite: CHEM-2110. Fall term annually 2 credit hours

CHEM-2210 Organic Compounds and Reactions
Structural aspects of organic chemistry and the relation between structure and reactivity of organic compounds. Extensive use is made of information derived from infrared, ultraviolet, and nuclear magnetic resonance spectroscopy. Recommended for chemistry and chemical engineering majors. Students cannot receive credit for both CHEM-2250 and CHEM-2210. Prerequisite: CHEM-1200 or CHEM-1300 or ENGR-1600 or equivalent. Fall term annually. 4 credit hours

CHEM-2220 Organic Synthesis
A continuation of CHEM-2210 with a focus on synthetic methods in organic chemistry. Prerequisite: CHEM-2210. Spring 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. CHEM-2210 or a similar course in organic chemistry is a co- or prerequisite. Fall term annually. 1 credit hour

CHEM-2240 Organic Chemistry Laboratory II
A continuation of CHEM-2230, which is a prerequisite. CHEM-2220 or a similar course in organic chemistry should be taken with or prior to this course. Spring term annually. 1 credit hour
CHEM-2250 Organic Chemistry I
Structure, chemical behavior, occurrence and uses of organic compounds. Compounds of biological, environmental and industrial importance are specifically addressed. Recommended for students in biology and health related areas. Students cannot obtain credit for both CHEM-2250 and CHEM-2210. Prerequisite: CHEM-1200 or CHEM-1300 or equivalent. Fall term annually. 3 credit hours

CHEM-2260 Organic Chemistry II
A continuation of CHEM-2250, which is a prerequisite. Students cannot obtain credit for both CHEM-2250 and CHEM-2210. Prerequisite: CHEM-1200 or CHEM-1300 or equivalent. 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. Corequisite: CHEM-2220 Organic Synthesis. 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. Fall and spring terms annually. Credit hours arranged

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. 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. (Cross listed as ERTH-2140. Students cannot receive credit for both this course and ERTH-2140.) Prerequisites: ERTH-1100 and/or ERTH-1200 or permission of instructor. Spring term annually. 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. 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 each term. 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, which is writing intensive. CHEM-4010 and CHEM-4410 are corequisites. 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. 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, and the interpretation and discussion of the results obtained from them. This is a writing-intensive course. Experiments depend on the theoretical material in CHEM-4110 and CHEM-4460, which are corequisites. Spring semester.

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. Students cannot get credit for both this course and CHEM-6160. Spring even numbered years.

3 credit hours

CHEM-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. (Cross listed as ERTH-4190. Students cannot obtain credit for both this course and ERTH-4190.) Prerequisite: permission of the instructor required. Fall term odd-numbered years.

4 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-2220 or 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-2220 or CHEM-2260 or permission of instructor. Fall term.

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-2220 or CHEM-2260 or permission of instructor. 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. 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 and transport properties. Fall term annually.

3 credit hours

CHEM-4460 Microscopic Physical Chemistry
A course dealing primarily with physicochemical properties of substances on a molecular basis. Chemical kinetics, quantum chemistry, spectroscopy, statistical mechanics, surfaces and colloid chemistry. Prerequisite:
CHEM-4410 or a thermodynamics background above a 1000-level course. Spring term annually. 4 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. Fall term annually. 3 credit hours

CHEM-4520 Chemical Information
An introduction to the discipline of chemical information science, including a survey of the printed and electronic sources for chemical information. Prerequisites: CHEM-2210 or CHEM-2250 and CHEM-2030 or permission of instructor. Spring term annually. 1 credit hour

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-2210. Fall and spring terms annually. 4 credit hours

CHEM-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 geochemistry of natural organic compounds in oceans, lakes, sediments, and soils and the transport and fate of organic pollutants. (Cross listed as ERTH-4540. Students cannot obtain credit for both this course and ERTH-4540.) Prerequisites: CHEM-2210, ERTH-1200, or permission of instructor. Spring term odd-numbered years. 4 credit hours

CHEM-4550 Introduction to Polymer Chemistry
Measurement of molecular weight and distribution, other characterization methods, organic and kinetic aspects of polymerization, chemical properties and uses of polymers, solution properties. Prerequisites: CHEM-4460. Spring term annually. 4 credit hours

CHEM-4570 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. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BIOL-4760 or BCBP-4760.) Prerequisites: CHEM-2250 or CHEM-2210, and BIOL-2120 or equivalent. Fall term annually. 4 credit hours

CHEM-4590 Protein Folding
Introduction to protein folding. The biophysical mechanism of protein folding and the role of misfolding in human disease 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 or corequisite: CHEM-4760 or BCBP-4760 or equivalent. Students may not receive credit for both this course and BCBP-4780 or BCBP/ CHEM-6780. Fall term odd-numbered years. 4 credit hours

CHEM-4620 Introduction to Polymer 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. Meets with CHEM-6640; both courses cannot be taken for credit. Corequisite: CHEM-4620 or equivalent. Spring term annually. 3 credit hours, 6 contact hours

CHEM-4640 Experimental Techniques in Macromolecular Chemistry
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 process) settings. Students learn theory, computation methods, and the use of computer programs for calculation of speciation and mass balance. (Cross listed as ENVE-4110 and ERTH-4690. Students cannot receive credit for both this course and either ERTH-4690 or ENVE-4110.) Prerequisite: permission of instructor. Fall term annually. 4 credit hours
CHEM-4790 Protein Chemistry
The ability to design synthetic proteins from first principles (de novo design) is a new area of protein chemistry with exciting potential applications in medicine and industry. This course will review our present understanding of chemistry and physics of protein structure and stability and show how this understanding can be applied to the design of unnatural proteins. The course will also cover the computer modeling and chemical synthesis of proteins, how to impart new characteristics to natural proteins via chemical modification, and the generation of protein ‘chimera’ using semi-synthesis. Prerequisite: CHEM-4760 or BCBP-4760 or BIOL-4760 or equivalent; CHEM-6190 or BCBP-4810 is an asset. Students cannot receive credit for this course and BCBP-6790 or CHEM-6790. Recommended for seniors; juniors should talk to the instructor before registering. Spring term, odd-numbered years. 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 photo-chemistry; chemistry of natural water systems; chemistry of pesticides, fertilizers, and other important environmental contaminants; aspects of the carbon, nitrogen, and sulfur cycles. (Cross listed as ERTH-4810. Students cannot obtain credit for both this course and ERTH-4810.) Prerequisites: CHEM-1200 and one prior or concurrent course in organic chemistry or permission of instructor. Spring term annually. 4 credit hours

CHEM-4900 Senior 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. Fall term annually. 1 credit hour

CHEM-4910 Laboratory Glassblowing
Demonstrations and laboratory practice in the construction and repair of glass apparatus used in chemistry. The entire course is graded pass/fail, with no students allowed to take the course on any other basis. In addition, upper-class students may take four other courses pass/fail. Fall term annually. 1 credit hour, 3 contact hours

CHEM-4950 Senior Research
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. Chemistry seniors only. To be graded S/U. 3 credit hours

CHEM-4960 Selected Topics in Chemistry
1 to 4 credit hours

CHEM-4990 Senior Thesis
2 credit hours first term, 3 credit hours second term

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. Fall term annually. 3 credit hours

CHEM-6030 Advanced Inorganic Chemistry II
Transition metal chemistry, emphasizing structural and bonding interpretations of magnetic and spectral data (ligand field theory); stabilities and reaction mechanisms of complexes; polynuclear complexes, naturally occurring transition metal complexes and their importance in environmental and biological systems. Spring term annually. 3 credit hours

CHEM-6160 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. Students cannot get credit for both this course and CHEM-4160. Spring even numbered years. 3 credit hours

CHEM-6190 Molecular Spectroscopy
Introduction of interaction of light with molecules; theory of molecular energies and applications to rotational, vibrational, and electronic spectroscopy. Prerequisites: CHEM-4410 and CHEM-4460 or permission of instructor. Fall term odd-numbered years. 3 credit hours
CHEM-6210, CHEM-6220 Advanced Organic Chemistry I, II
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. A fall-spring sequence annually. 3 credit hours each

CHEM-6280 Natural Products Chemistry
A survey of modern synthetic methods used in the construction of the major groups of secondary metabolites and related natural products. The essentials of retrosynthetic analysis are presented and instruction in the development of strategies for organic synthesis are offered. Prerequisites: CHEM-6210 and CHEM-6220. Fall term odd-numbered years. 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 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-4310; both courses cannot be taken for credit. Prerequisite: permission of instructor. 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 bioassays, phage-display, combinatorial chemistry and parallel synthesis. Students cannot receive credit for both this course and CHEM-4330. 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. Spring term odd-numbered years. 3 credit hours

CHEM-6470 Photochemistry
Physical and chemical consequences of interaction of visible and ultraviolet radiation with matter; laws of photochemistry; quantum mechanical description of light absorption; dynamics of excited state decay and energy transfer; organic photochemistry; experimental techniques and state-of-the-art applications. Spring term even-numbered years. 3 credit hours

CHEM-6480 Chemical Kinetics
Kinetics of thermochemical and photochemical reactions. Mathematical and mechanistic descriptions of the phenomenological approach to rate process; theoretical treatments of kinetically simple reactions; principles of light absorption and photochemistry; organic photochemistry. Prerequisite: permission of instructor. 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 on 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. 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. 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. Full 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. Fall term odd-numbered years. 3 credit hours

CHEM-6620 Physical Chemistry of Macromolecules
Thermodynamic properties of synthetic and natural macromolecules. The application of classical and statistical thermodynamics, configuration and conformation of isolated polymer chains, the rotational isomeric state model, scaling theory, single chain dynamics, phase equilibria, osmotic pressure, translational diffusion, intrinsic viscosity and scattering (light, x-ray, neutron) to understanding the structure and properties of proteins, nucleic acids, rod-like polymers, polymer blends and polymer nanocomposites. Prerequisite: CHEM-6620 or permission of instructor. 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. Full term alternate years. 3 credit hours

CHEM-6640 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. Prerequisite: CHEM-4620 or permission of instructor. Spring term annually. 3 credit hours, 6 contact 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. Fall term alternate 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. Spring term even-numbered years. 3 credit hours

CHEM-6780 Protein Folding
The biophysical mechanism of protein folding and the role of misfolding in human disease 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 or corequisite: CHEM-4760 or BCBP-4760 or equivalent. Students may not receive credit for this course and BCP-6780 or BCBP/CHEM-4780. Fall term odd-numbered years. 4 credit hours

CHEM-6790 Protein Chemistry, Design and Modification
The ability to design synthetic proteins from first principles (de novo design) is a new area of protein chemistry with exciting potential applications in medicine and industry. This course will review our present understanding of the chemistry and physics of protein structure and stability, and show how this understanding can be applied to the design of unnatural proteins. The course will also cover the computer modeling and chemical synthesis of proteins, how to impart new characteristics to natural proteins via chemical modification, and the generation of protein ‘chimera’ using semisynthesis. Prerequisite: CHEM-4760 or BCBP-4760 or BIOL-4760 or equivalent; CHEM-6190 or BCBP-4810 is an asset. Cannot be taken for credit with BCBP-6790, CHEM-4790 or BCBP-4790. Spring term, odd-numbered years. 3 credit hours
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. Fall term annually.  
1 credit hour

CHEM-6940 Readings in Chemistry  
1 to 3 credit hours

CHEM-6960 Selected Topics in Chemistry  
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 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 3 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 IP are assigned until the thesis has been approved by the faculty adviser 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 9 credit hours can be used in place of CHEM-6990 for students submitting a master’s thesis.  
Variable credit hours

CHME Chemical Engineering (SOE)

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. 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. 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 Fluid Mechanics and Heat Transfer  
An introductory course in fluid mechanics and heat transfer covering fluid statics, laminar and turbulent flow and heat transfer in pipes and boundary layers, dimensional analysis, friction in valves and fittings, flowmeters, and heat conduction. Prerequisite: MATH-2400. Fall term annually.  
4 credit hours

CHME-4020 Heat and Mass Transfer  
An introductory course in heat and mass transfer covering radiation heat transfer, conduction and diffusion, heat exchanger design, packed towers, convective mass transfer, free convection, and change-of-phase heat transfer. Prerequisite: CHME-4010. 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 multivariable control, numerical analysis and simulation. Prerequisite: MATH-2400. Spring term annually.

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. Fall term annually.

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. 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 writing-intensive course. Prerequisites: CHME-4040 and CHME-4500. Spring term annually.

CHME-4150, CHME-4160 Chemical Engineering Laboratory I, 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 for CHME-4150: CHME-4010, CHME-4020, and CHME-2020. Prerequisites for CHME-4160: CHME-4150, CHME-4040, and CHME-4500. Fall and spring terms annually.

CHME-4400 Chromatographic Separation Processes
Theory and practice of chromatographic separation processes. Dynamics of zone migration, diffusion, and kinetics. Multicomponent adsorption, nonequilibrium adsorption, zone spreading, and control of separation. Modern analytical and preparative bioseparation techniques of liquid chromatography. Prerequisite: senior or graduate standing in chemical engineering or permission of instructor. Spring term annually.

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. Fall term annually.

CHME-4440 Advanced Membrane Concepts

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. Fall term annually.

CHME-4600 Introduction to Semiconductor Processing
The basic processes used for 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. Fall term annually.

CHME-4940 Readings in Chemical Engineering
1 to 3 credit hours

CHME-4960 Topics in Chemical Engineering
3 credit hours

Graduate courses with Biochemical Engineering emphasis

CHME-6410 Advanced Membrane Concepts

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. 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. Fall 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. Summer term annually. 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. Fall term odd-numbered years. 3 credit hours

Graduate courses with Chemical Engineering emphasis

CHME-6510 Advanced Fluid Mechanics I
Continuity, momentum, and energy equations for continuous fluids; constitutive relations. Kinematics of fluid motion; vorticity and circulation. Potential flow. Navier-Stokes equations. Boundary layer theory. Turbulence. Multicomponent reacting systems. Selected applications. Prerequisite: CHME-4010. Spring term annually. 3 credit hours

CHME-6520 Advanced Fluid Mechanics 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. 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. 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. 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 series solutions, special function representations, boundary-value problems, and operational calculus. Prerequisite: MATH-2400. 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. 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. Spring term annually.

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 on sufficient demand.

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 on sufficient demand.

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, detonations, droplet combustion, and turbulent jet flames. (Cross listed as MANE-6830. Students cannot receive credit for both this course and MANE-6830.) Prerequisite: permission of instructor. Spring term odd-numbered years.

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. (Cross listed as MANE-6840. Students cannot obtain credit for both this course and MANE-6840.) Prerequisite: a working knowledge of fluid mechanics and heat transfer. Fall term annually.

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. (Cross listed as MANE-6850. Students cannot obtain credit for this course and MANE-6850.) Prerequisite: CHME-6840 or MANE-6840. Spring term annually.

CHME-6940 Readings in Chemical Engineering
1 to 3 credit hours

CHME-6950 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. Fall and spring terms annually.

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 Graduate School 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 IP are assigned until the thesis has been approved by the faculty adviser 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

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,

* 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.
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. H and G, fall term annually; H, spring and summer term. 3 credit hours

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

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. 3 credit hours

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. 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. 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 multidatabase 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-4380. H, spring, even years; G, on sufficient demand.

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

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. 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. 1 credit hour

CISH-6940 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. 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-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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

CIVL Civil Engineering (SOE)

CIVL-2030 Introduction to Transportation Engineering
Introduction to the planning, design, and analysis of transportation problems. Studies of costs of providing transportation, level of service offered to travelers, and demand for transportation services. Evaluation of various service strategies and the policy implications of each alternative. Various modes of travel and their physical facilities. Prerequisite: MATH-2400. Corequisite: ENGR-2600. 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. Fall term alternate years.

3 credit hours

CIVL-2130 Surveying
The organization, planning, instrumentation, and execution of surveys for engineering projects including precise control systems for both horizontal and vertical control, astronomic observations for the establishment of precise directions, terrestrial and photogrammetric mapping, statewide plane coordinate systems, and the legal aspects of boundary surveys. Fall term alternate 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. Fall term annually.

4 credit hours

CIVL-2670 Introduction to Structural Engineering

4 credit hours, 6 contact 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, coreflection, bridge piers and abutments, and underpinnings. Prerequisites: ENGR-2530 and CIVL-2630 or equivalent. Fall term annually.

3 credit hours

CIVL-4020 Computer-Aided Design in Civil Engineering
The course introduces concepts in computer automation in civil engineering analysis and design. Topics include geometric modeling, optimization, symbolic computations and numerical techniques for civil engineering problems. Various software tools involved in computer-aided design process are introduced. Application to civil engineering problems is emphasized. Prerequisites: ENGR-2530, CSCI-1100, and ENGR-1200 or equivalent. Fall term annually.

3 credit hours

CIVL-4070 Steel Design

3 credit hours

CIVL-4080 Concrete Design
Analysis and design of reinforced concrete structures using ultimate strength methods. Design for flexure and shear, column design, development of reinforcing bars. Footing design. Prerequisite: CIVL-2670. Spring term annually.

3 credit hours

CIVL-4120 Civil Engineering Instrumentation and Sensors
Various experimental techniques for the collection and analysis of laboratory and field data. Theory and application of electrical resistance strain gages and other data gathering equipment are introduced. Students are also introduced to the concepts involved with the interfacing of personal computers to machines for data acquisition and control. Prerequisite: ENGR-2530 and ENGR-2600. Fall term annually.

4 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.) 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. 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. (Cross listed as MANE-4240. Students cannot obtain
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. Spring term annually. 3 credit hours

CIVL-4440 Structural Analysis
Computer analysis of structures. Advanced topics in the behavior of structural components. Bending of plates, buckling of columns and frames. Beam-columns. Torsion in structural members. Inelastic behavior and limit analysis of structures. Prerequisite: CIVL-2670. Fall term annually. 3 credit hours

CIVL-4570 Analytical Methods in Infrastructure Engineering
Analysis methods and software used to manage highway and transit systems, pipeline systems, building campuses, and other large networks of civil engineering structures. Topics include: performance evaluation and forecasting, life-cycle cost analysis, capital programming and budget allocation, optimization, databases and management systems, information and knowledge modeling, expert systems, decision analysis techniques, and uncertainty in decision making. Prerequisite: CIVL-4580 or equivalent professional experience. Spring term annually. 3 credit hours

CIVL-4580 Infrastructure Engineering
Principles and fundamental analytical methods required for the preservation of the civil engineering infrastructure. Included are determination of condition of existing structures, deterioration models, data analysis and management, system-level analysis. Methodologies are synthesized in the form of modern infrastructure management systems. Emphasis is placed on pavements and bridges. Fall term annually. 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. Spring term odd-numbered years. 3 credit hours

CIVL-4640 Transportation Facility Design and Planning
Approaches to the planning, design, and engineering of airports, rail yards, and marine terminals. Special attention is paid to the operational requirements of each mode of transportation and the impact these have on facility design. Innovative designs are encouraged through a series of design projects. Prerequisite: CIVL-2030. Spring term odd-numbered years. 3 credit hours

CIVL-4660 Traffic Engineering
Basic characteristics of traffic, including driver, vehicle, volume, speed delay, capacity, and accidents; traffic surveys, administration, laws and ordinances; traffic regulation and control, signs, markings, signals, and signal systems. Prerequisite: CIVL-2030. Fall 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. Spring term even-numbered years. 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 alternatives considered, design assumptions, cost, safety, and feasibility. This is a writing-intensive course. Prerequisites: senior status and CIVL-4070 and CIVL-4080, or CIVL-4010 and CIVL-4150, or CIVL-2030 and CIVL-4660 or CIVL-4640 or ENVE-2110 and either ENVE-4200, ENVE-4350, ENVE-4310 or ENVE-4340. 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. (Cross listed as MANE-6170. Students cannot obtain credit for both this course and MANE-6170.) Spring term annually. 3 credit hours
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Description</th>
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<tbody>
<tr>
<td>CIVL-6230</td>
<td>Transportation Economics</td>
<td>Economic concepts, drawn from micro- and macro-economic theory, as they apply to transportation. Location theory, demand analysis, cost analysis, pricing, regulation, pertinent current problem areas, cost/benefit analysis. Prerequisite: CIVL-2030, ECON-2010, and DSES-4140 or their equivalents. Fall term even-numbered years.</td>
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<tr>
<td>CIVL-6240</td>
<td>Intelligent Transportation Systems</td>
<td>This course covers concepts and models applicable to intelligent transportation systems (ITS). ITS uses information system technology to create seamless multi-modal transportation systems with enhanced performance and productivity. Term projects focus on assessment and evaluation of candidate ITS treatments for site-specific locations based on network models that capture real-time phenomena. Simulation and other modeling techniques are employed heavily. Prerequisites: CIVL-2030 and CIVL-4660. Fall term even-numbered years.</td>
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<tr>
<td>CIVL-6250</td>
<td>Transportation Systems Planning</td>
<td>The analysis and planning of transportation systems. Study of the basic interaction between transportation supply and demand. Modeling these relationships for a variety of transportation problems. Role of transportation systems analysis in the social, environmental, and political framework of policy decision making. Prerequisite: CIVL-2030. Spring term even-numbered years.</td>
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<tr>
<td>CIVL-6260</td>
<td>Transportation Algorithms</td>
<td>Quantitative techniques applied in transportation analysis. Included are shortest path algorithms, equilibrium traffic assignment, routing and scheduling heuristics, demand forecasting techniques. Computer applications stressed. GIS-based packages employed. Prerequisites: CIVL-2030, MATH-2400. Spring term annually.</td>
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<tr>
<td>CIVL-6270</td>
<td>Traffic Control Systems</td>
<td>Detailed exploration of advanced traffic control systems with emphasis on design and analysis. Topics include control system functions, hardware and software technology; isolated, arterial, and network applications. Several sessions focus on state-of-the-art software packages including CORSIM, TRANSYT-7F, HCS, VISIM, and SimTraffic. An ITS perspective maintained and stressed. Prerequisite: CIVL-4660. Spring term odd-numbered years.</td>
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<tr>
<td>CIVL-6280</td>
<td>Infrastructure Asset Management Systems</td>
<td>Engineering methods and decision processes for managing engineered facilities and related assets. Topics include: engineering asset types; integrated asset management; traditional infrastructure management systems; development and implementation issues; key issues during design, construction, maintenance, and rehabilitation phases of ownership; strategic planning and budgeting decision processes; analysis of tradeoffs, economic consequences of decisions; and benchmarking of system performance. Prerequisite: CIVL-4570. Fall term alternate years.</td>
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<tr>
<td>CIVL-6320</td>
<td>Advanced Steel Design</td>
<td>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. Spring term annually.</td>
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<tr>
<td>CIVL-6450</td>
<td>Structural Dynamics</td>
<td>Analysis of elastic and inelastic single and multiple degree-of-freedom structural systems under time-dependent loads including harmonic, impulse, earthquake, and other general dynamic loads. Development of equations of motion. Analytical and numerical evaluation of free and forced vibration response. Identification of dynamic system properties. Modal analysis. Vibration...</td>
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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. Spring term alternate years.  
3 credit hours

CIVL-6480 Designing with Geosynthetics
Civil Engineering applications of geosynthetics including geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geopipe 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. Spring term alternate years.  
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. Spring term alternate years.  
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. Fall term annually.  
3 credit hours

CIVL-6520 Advanced Foundations and Earth Structures
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. Spring term alternate years.  
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. 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.) 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. (Cross listed as MANE-6660. Students cannot obtain credit for both this course and MANE-6660.) Prerequisite: differential equations. Fall term annually.  
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. (Cross listed as MANE-6670. Students cannot obtain credit for both this course and MANE-6670.) Prerequisite: CIVL-6660 or MANE-6660. Fall term odd-numbered years.

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. (Cross listed as MANE-6680. Students cannot obtain credit for both this course and MANE-6680.) Prerequisite: CIVL-6660, MANE-6660, CSCI-6860 or MATH-6860. Spring term odd-numbered years.

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. (Cross listed as MANE-6690. Students cannot obtain credit for both this course and MANE-6690.) Prerequisite: CIVL-6660 or MANE-6660. Spring term even-numbered years.

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. (Cross listed as MANE-6700. Students cannot obtain credit for both this course and MANE-6700.) Prerequisite: CIVL-6660 or MANE-6660. Fall term odd-numbered years.

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. (Cross listed as MANE-6780.) Prerequisite: CIVL-6660 or MANE-6660. Spring term even-numbered years.

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 master’s students and twice by Ph.D. students. 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. Fall and spring terms.

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 Graduate School 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. Students cannot obtain credit for both this course and MANE-6700.) Prerequisite: CIVL-6660 or MANE-6660. Fall term odd-numbered years.

3 credit hours

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
CIVL-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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.

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.

COGS - Cognitive Science (HSSH)

COGS-6100 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. Fall and spring terms annually.

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. Spring term annually.

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. Fall term annually.

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. Spring term annually.

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. Fall and spring terms annually.

COGS-6960 - Topics in Cognitive Science
An advanced course concerned with selected topics in cognitive science. Prerequisite: permission of instructor. Fall and spring terms annually.

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 then be listed as S. Fall and spring terms annually.

COGS-6990 - Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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. Fall and spring terms annually.

COGS-9990 - Doctoral 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. Fall and spring terms annually.
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. Spring term annually. 4 credit hours

COMM-1610 Introduction to Communication and Information Technology
Introduces the terms, theories, and issues associated with the use of the Internet in personal and social contexts. The lectures and labs focus on helping students understand how computer-mediated communication (CMC) is used in contemporary society, providing different ways to understand how CMC is used to build interpersonal relationships, develop group communication, and support public communication while exploring social issues facing those who communicate via the computer. Fall and spring terms annually. 4 credit hours

COMM-2100 Creating Electronic Portfolios
Students create an electronic portfolio that displays examples of their work to track their development and eventually to show others for advising, employment, co-op placement, or graduate school admission. In this portfolio-building process, students do guided self-assessment of their knowledge, abilities, and skills. Based on availability of instructor. 2 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. Fall and spring terms 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 annually. 4 credit hours

COMM-2460 Media and Popular Culture
A general survey of contemporary media, their historical origins and social impact, with a focus on TV, newspapers, magazines, radio, film, and personal computers. 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. Fall and spring terms annually. 4 credit hours

COMM-2880 Interpersonal Communication
A course examining communication processes between two individuals in a variety of contexts including friendships, families, and work relationships. Considers both scientific and humanistic approaches to interpersonal communication. Topics discussed include development of the self, interpersonal attraction, social exchange theory, family communication systems, conflict, and communication skills. Fall term alternate 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-4170 Electronic Coaching Systems
This course is based on theoretical work in cognition and motor behavior and on applied research in computing, sports, and arts. This course analyzes how designers think about human performance systems. Support systems analyzed include online tutorials, wizards, agents, and Web-based systems. Prerequisite: COMM-4750 or another LL&C 4000-level graphics or document design course, or graduate standing. Spring term annually. 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. Cross-listed with COMM-6810; students
cannot obtain credit for both courses. Additional assignments required for students at the 6000 level. Prerequisite: COMM-4170, COMM-4420, COMM-4770, or COMM-4710. Spring term annually.

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. Cross listed with COMM-4310 and COMM-6300. Fall and spring terms annually.

COMM-4310 EMAC 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: Senior status. Cross-listed with COMM-4300 and COMM-6300. Fall and spring terms annually.

COMM-4340 Communication in Cyberspace
This course involves students from multiple locations in the study of issues pertaining to forms and social effects of computer-mediated communication (CMC). Through both study and significant “hands-on” use of such systems, students learn to manage various network-based communication systems through collaborative projects in virtual teams through electronic partnership. Theories and illustrations regarding the impacts of CMC in relation to organizational communication and structure, group communication and decision making, and interpersonal effects are explored. Prerequisite: IHSS-196X or equivalent. Offered spring semester, alternate years.

COMM-4400 Publication Practicum
This is an advanced design studio course about how to integrate type and image when creating social communications for and with an audience. Students are guided step-by-step through the communication design process from conception to production. In a participatory manner and through readings they learn how to communicate visually to a multicultural audience. Fall term annually. Prerequisite: COMM-4570. Cross listed with COMM-6400. Students cannot obtain credit for both courses.

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. Cross-listed with COMM-6420; an additional assignment is required for COMM-6420. Students cannot obtain credit for both courses. Prerequisite: one H&SS course. Fall term annually.

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. Cross-listed with COMM-6560. Students cannot obtain credit for both courses.) Fall term annually.

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. Fall term annually.

COMM-4550 Religion, Culture, and Media
How are religious fundamentalists using new media? Can religious conversion take place in a theme park? How do religious "crossover" 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 "return of religion" within the secular consensus of modernity. Prerequisite: COMM 1510 or permission of instructor. Fall term annually.

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. Spring term annually.  

**COMM-4570 Typography**
Text that isn’t noticed isn’t read. Typography is a studio course in graphic design that teaches students the fundamentals of how to choose appropriate fonts, design with type, and integrate text with graphics in any given composition. Designing emotive, aesthetically pleasing, and persuasive typographic compositions is the focus of the course. (Cross listed with COMM-6570. Students cannot obtain credit for both courses.) Prerequisite: COMM-2610. Spring term annually.  

**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 our experience and identity? How has it shaped our culture? Who pays for it and why? These are the types of questions this course will address. Prerequisite: any COMM or LITR course or permission of instructor. Fall term annually.  

**COMM-4590 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.  

**COMM-4600 Rhetoric of Nature and the Environment**
A seminar course focusing on how attitudes are formed and people mobilized to action on environmental issues. Topics will include traditions of nature writing and art, the symbolic/conceptual formation of “nature” and “the environment,” and methods for analysis and development of discursive formations and persuasive strategies. Prerequisites: junior or senior status, two environmentally focused H&SS courses, and two courses in biology and/or geology, or permission of the instructor. Spring term annually.  

**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 on availability of instructor.  

**COMM-4640 Language and Power**
Language plays a key role in the creation and reproduction of social inequalities across groups and between individuals. This course explores the linguistic dimensions of colonialism; race, ethnic, gender, and class differences in communicative style; access to institutional resources such as jobs, justice, health care, and education; media manipulation; and the uses of religious rhetoric for political ends. Students learn how to gather and analyze real-life conversations. Prerequisite: permission of instructor. Spring term annually.  

**COMM-4650 Intermediate Visual Communication**
This is a studio course that grapples with advanced applications of the basic principles of design in print and electronic media. The focus of the course is on developing the student’s ability to derive viable concepts in the creation of meaningful, communicable, and aesthetically pleasing communication forms. Situated in a computer lab, students complete hands-on projects, thumbnail sketching by hand and using the computer as a tool. Prerequisite: COMM-2610. Spring term annually.  

**COMM-4660 Visual Literacy**
This is an intermediate design studio course about visual literacy theory and its practical application to the creation of graphic designs that communicate to an audience. Students hone their conceptual and creative skills through rigorous visual problems that they solve individually and then analyze in group critiques. Fall term annually. Prerequisite: COMM-2610 and COMM-4570. Cross listed with COMM-6660. Students cannot obtain credit for both courses.  

**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. Fall term annually.  

**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 World Wide Web, CD, and DVD. 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. 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 requirements, through design, development, and evaluation of a site's graphic and textual content and the assessment of customer satisfaction with the site. Cross-listed with COMM-6750. Students cannot obtain credit for both courses. Prerequisite: COMM-4420. Fall term annually.

4 credit hours

COMM-4720 Web Designing for Community Networking
This course emphasizes participatory design and the development of functional communication products for real-world clients. Students create Web-based graphic, interactive, or multimedia information resources for arts and cultural organizations, city and county government, and social-service organizations in Troy, New York. These resources may be used by the Troy Coalition for Community Networking and TroyNet. Prerequisite: at least one course in database, multimedia, or Web design. Spring term annually.

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. Prerequisite: COMM-2610 or permission of instructor. 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. Prerequisite: COMM-2610 and permission of instructor. Fall term annually.

4 credit hours

COMM-4750 Electronic User Interfaces
Application of research on computer usability to the design of Web sites, graphic user interfaces (GUIs), personal digital assistants (PDAs), persuasive computing, and electronic performance support systems. Prerequisite: an introductory course in communication or another social science. Fall term annually.

4 credit hours

COMM-4760 Task-Oriented Communication
Teaches the practices of developing instructions for people performing mental and physical tasks. This course covers evaluating task performance, choosing instructional media, developing instructional objectives, and producing procedural information. Attention is given to graphic media and to nonverbal tasks and skills. Prerequisite: an introductory course in communication or another social science. Spring term, alternate years.

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. We will gather requirements, design to meet those requirements, and evaluate our success. Cross-listed with COMM-6770; students taking COMM-6770 will be assigned an additional project. Students cannot obtain credit for both courses. Prerequisites: COMM-4420 or permission of instructor. Spring term annually.

4 credit hours

COMM-4780 Hypermedia Art and Fiction: Theory and Design
This course is a seminar for students with some experience designing interactive multimedia computer programs (or Web sites). The seminar will explore new directions in interactive electronic art, in particular, audiovisual artworks and hypertext fiction. Students will evaluate how interactive electronic media can be used for creative expression and present their findings in oral presentations and written reports. For final projects, students will have the option of completing either a research paper or an interactive electronic project. Prerequisite: previous experience designing interactive multimedia computer programs (or Web sites). Fall term annually.

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 on 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. Cross listed with COMM-6800. Students cannot obtain credit for both courses. Prerequisites: COMM-2610 or WRIT-1110. Fall term annually. 4 credit hours

COMM-4810 Electronic Media and Society
Electronic media such as the Internet, cable television, movies, and pop music are both producers of information and large organizational structures. The course analyzes the interplay between media organizations and society at large. Offered on availability of instructor. 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. Cross-listed with COMM-6820. For COMM-6820, additional statistical analysis and a literature-based paper on a usability topic are required. Prerequisite: COMM-4420, COMM-4770 or ITEC-2210. Offered on availability of instructor. 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 scientific study of interpersonal communication. Five general theoretical perspectives are reviewed: symbolic interactionism, social exchange theory, psychodynamic theory, social biology, and systems theory. Each perspective attributes different powers to actors and envisions human motivation quite differently. Each has also had major impact on popular and scholarly thought. Spring term annually. 4 credit hours

COMM-4910 Honors Capstone Design
Honors Capstone Design is a two-semester sequence offered in Fall and Spring and is an option for fulfilling the Culminating Experience/Capstone requirement for graduating seniors majoring in EMAC. Through a series of production and writing assignments, breakout seminars, group critiques, and public exhibition, the goal is to develop a work-in-progress in the Fall semester and a final version in the spring semester of the capstone project and senior thesis paper. Students must submit proposals for their project in the spring semester of the previous academic year. Permission of instructor is required. Students cannot receive credit for both this course and ARTS-4910. Fall and spring terms 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-6240 Rhetorical Theory I
Introduces classical rhetoric and emphasizes the use of language as a means of winning the assent, sympathy, or cooperation of an audience. It examines the rhetorical theories of figures such as Gorgias, Isocrates, Plato, Aristotle, Cicero, Quintilian, and Saint Augustine. Spring term annually. 3 credit hours

COMM-6250 Rhetorical Theory II
An introduction to modern rhetoric, with an emphasis upon the use of language as a means of generating knowledge and understanding and establishing and maintaining human communities. A study of the rhetorical theories of figures such as Francis Bacon, George Campbell, Richard Whately, Kenneth Burke, C. Perelman, L. Olbrechts-Tyteca, and Michel Foucault. Fall term annually. 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. Prerequisite: COMM-6240. Offered on 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. Cross-listed with COMM-4300 and COMM-4310. Fall and spring terms annually. 3 credit hours

COMM-6310 Seminar in Interpersonal Communication
This graduate seminar introduces major organizing concepts in the social scientific study of interpersonal communication. Five general theoretical perspectives are reviewed: symbolic interactionism, social exchange theory, psychodynamic theory, social biology, and systems theory. Each perspective attributes different powers to actors and envisions human motivation quite differently. Each has also had major impact on popular and scholarly thought. Spring term alternate years. 3 credit hours
COMM-6340 Techniques for Verbal Analysis
This course introduces students to techniques for seeing the underlying patterns in verbal data, including conversations, texts, interviews, and protocols. Topics include: conversation analysis; content analysis; activity analysis; narrative analysis; protocol analysis; theme analysis; and discourse analysis. Students will have a chance to read a range of studies, discuss issues relevant to research in the field, practice analytic techniques, and conduct preliminary field research. Spring term alternate years. 3 credit hours

COMM-6350 Literacy Seminar
In this seminar, we examine new communication technologies that depend upon reading and writing in counterpoint to four concepts in literacy studies: literacy as practice, literacy as control, literacy as mediation, and vernacular literacy. Our goal is to understand the scope and limits of these concepts for new technologically mediated environments — to see, in what sense, literate technologies challenge, extend or modulate the ways we use texts. Fall term alternate years. 3 credit hours

COMM-6360 Rhetorical Invention: A Social Perspective
This seminar explores contemporary perspectives on rhetorical invention and their implications for research and teaching in rhetoric, composition, literary studies, and inquiry in all disciplines. Social perspectives that question or complement traditional individualistic views of invention are emphasized. The relationship of rhetorical invention to creativity and to invention in its generic sense is also explored. Offered on availability of instructor. 3 credit hours

COMM-6400 Publication Practicum
This is an advanced design studio course about how to integrate type and image when creating social communications for and with an audience. Students are guided step-by-step through the communication design process from conception to production. In a participatory manner and through readings they learn how to communicate visually to a multicultural audience. Prerequisite: COMM-6570. Cross listed with COMM-4420. Students cannot obtain credit for both courses. Additional assignments at higher level required for graduate students. Fall term annually. 3 credit hours

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. Spring 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. Fall term annually. 3 credit hours

COMM-6520 Seminar in Communication Theory
This course is based on the assumption that, because humans are symbol-using creatures, an intensive study of their use of symbols will illuminate human nature and behavior. This investigation relies on such thinkers as Aristotle, G. H. Mead, Richard McKeon, Ernst Cassirer, Ludwig Wittgenstein, and Martin Heidegger. Topics in the course usually include the relationship between symbols and thought, symbols as a vehicle of analyzing behavior, and the use of symbols to coordinate social action. Offered on availability of instructor. 3 credit hours

COMM-6530, COMM-6540 Communication Research I, 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. A fall-spring sequence annually. 3 credit hours each

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. (Cross-listed with COMM-4460. Students cannot obtain credit for both
COMM-6570 Typography
Text that isn't noticed isn't read. Typography is a studio course in graphic design that teaches students the fundamentals of how to choose appropriate fonts, design with type, and integrate text with graphics in any given composition. Designing emotive, aesthetically pleasing, and persuasive typographic compositions is the focus of the course. (Cross listed with COMM-4570. Students cannot obtain credit for both courses.) Prerequisite: COMM-2610. Spring term annually. 3 credit hours

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-6660 Visual Literacy
This is an intermediate design studio course about visual literacy theory and its practical application to the creation of graphic designs that communicate to an audience. Students hone their conceptual and creative skills through rigorous visual problems that they solve individually and then analyze in group critiques. Prerequisites: COMM-2610 and COMM-4570. Cross listed with COMM-4660. Students cannot obtain credit for both courses. Additional assignments at higher levels are required for those registered at the 6000 level. Fall term annually. 3 credit hours

COMM-6680 Rhetoric of Nature and the Environment
A seminar course focusing on how attitudes are formed and people mobilized to action on environmental issues. Topics will include traditions of nature writing and art, the symbolic/conceptual formation of “nature” and “the environment,” and methods for analysis and development of discursive formations and persuasive strategies. Prerequisites: junior or senior status, two environmentally focused H&SS courses, and two courses in biology and/or geology, or permission of the instructor. Spring term annually. 3 credit hours

COMM-6700 Rhetoric of the Photograph
This is a theoretical course exploring three aspects of photography that have a rhetorical component. These aspects are the formal “aesthetic” elements of the photographic image; the psychological, psychoanalytical relationship between viewer, model, camera, and photographer; and the social/political effects of photography in our culture. Prerequisite: graduate standing or permission of instructor. Offered on availability of instructor. 3 credit hours

COMM-6720 Web Designing for Community Networking
This course emphasizes participatory design and the development of functional communication products for real-world clients. Students create Web-based graphic, interactive, or multimedia information resources for arts and cultural organizations, city and county government, and social-service organizations in Troy, New York. These resources may be used by the Troy Coalition for Community Networking and TroyNet. Prerequisite: at least one course in database, multimedia, or Web design. Spring term annually. 4 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. Fall term alternate years. 3 credit hours

COMM-6740 Hypermedia Design and Development
This course introduces hypermedia interface design and has an opportunity to put theory into practice by designing and developing an interactive program. Prerequisite: COMM-4750, 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. Fall term annually. 3 credit hours
COMM-6760 Electronic Coaching Systems
This course is based on theoretical work in cognition and motor behavior and on applied research in computing, sports, and arts. This course analyzes how designers think about human performance systems. Support systems analyzed include online tutorials, wizards, agents, and Web-based systems. Prerequisite: COMM-4750 or another LL&C 4000-level graphics or document design course, or graduate standing. Spring 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. Cross-listed with COMM-4770; students taking COMM-6770 will be assigned an additional project. Students cannot obtain credit for both courses. Prerequisites: COMM-4420 or permission of instructor. Spring term annually. 3 credit hours

COMM-6780 Hypermedia Art and Fiction: Theory and Design
This course is a seminar for students with some experience designing interactive multimedia computer programs (or Web sites). The seminar will explore new directions in interactive electronic art, in particular, audiovisual artworks, and hypertext fiction. Students will evaluate how interactive electronic media can be used for creative expression and present their findings in oral presentations, written reports and electronic media. Cross listed with COMM-4780. Prerequisite: previous experience as per above. 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. Cross listed with COMM-4800. Students cannot obtain credit for both courses. Graduate students are required to complete additional assignments. Fall term annually. 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. Cross-listed with COMM-4180; students cannot obtain credit for both courses. Additional assignments required for students at the 6000 level. Prerequisites: COMM-6420, COMM-6750, COMM-6760 or COMM-6770. Spring term annually. 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. Cross-listed with COMM-4820. For COMM-6820, additional statistical analysis as part of each assignment and a literature-based paper on a usability topic are required. 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

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 us to concentrate on the fundamentals and not get 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.) Spring term annually.

4 credit hours

CSCI-1190 Beginning C Programming for Engineers
This course will teach elementary programming concepts using the C language for engineering students with little or no prior programming experience. Students cannot get credit for this course and any other Computer Science course. No prerequisites. Fall and spring terms annually. 1 credit hour

CSCI-1200 Computer Science II
Programming concepts: functions, parameter passing, pointers, arrays, strings, structs, classes, templates. Mathematical tools: sets, functions, and relations, O-notation, complexity of algorithms, proof by induction. Data structures and their representations: data abstraction and internal representation, sequences, trees, binary search trees, associative structures. Algorithms: searching and sorting, generic algorithms, iterative and recursive algorithms. Methods of testing correctness and measuring performance. Prerequisite: CSCI-1100 or permission of instructor. 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. Fall and spring terms annually. 2 credit hours

CSCI-2230 Programming in Perl
Introduction to programming in the Perl language. Perl is a programming language widely used for complex shell scripts, Common GateWay Interface programs for World Wide Web pages, and rapid prototyping in more general application areas. Topics include text manipulation facilities, associative arrays, Unix system-call facilities, and application to Web and systems programming. Prerequisite: CSCI-1200 or equivalent. Fall and spring terms annually. 2 credit hours

CSCI-2300 Data Structures and Algorithms
Data structures and algorithms, and the mathematical techniques necessary to design and analyze them. Basic data structures: lists, associative structures, trees. Mathematical techniques for designing algorithms and analyzing worst-case and expected-case algorithm efficiency. Advanced data structures: balanced trees, tries, heaps, priority queues, graphs. Searching, sorting. Algorithm design techniques: dynamic programming, greedy algorithms, divide-and-conquer, backtracking. Example graph, string, geometric, and numeric algorithms. Prerequisites: CSCI-1200, MATH-1010, and MATH-2800. Fall and spring terms annually. 4 credit hours

CSCI-2400 Models of Computation
This course introduces conceptual tools for reasoning about computational processes and the languages with which they are prescribed. It bears directly upon language translation, program verification, and computability. Topics to be covered include formal languages, finite automata, pushdown automata, nondeterminism, regular expressions, context-free grammars; parsing, compiler design basics; computability, Turing machines, Church's thesis, unsolvability and intractability. Prerequisites: CSCI-2300 and MATH-2800. Fall and spring terms annually. 4 credit hours

CSCI-2500 Computer Organization

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. 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-2400. 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, RBPs, Bayesian Learning, PAC Learning, Support Vector Machines, Gaussian processes, Hidden Markov Models. Prerequisites: familiarity with probability, linear algebra, and calculus. Offered on 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. Fall term annually.

4 credit hours

CSCI-4190 Introduction to Robotic Algorithms
An introduction to algorithms for robotic systems with a focus on motion planning, processing sensor information, world modeling, and handling uncertainty. Discusses application of techniques to mobile robotics and robotic manipulations. Emphasizes practical algorithms and implementing them in the laboratory. Prerequisites: CSCI-2300, MATH-1020, and MATH-2800. Spring term even-numbered years.

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. Fall and spring terms annually.

4 credit hours

CSCI-4220 Network Programming
An overview of the principles of computer networks, including a detailed look at the OSI reference model and an overview of various popular network protocol suites. Concentration on Unix interprocess communication, network programming using TCP/IP, and distributed objects using CORBA. Prerequisite: CSCI-4210. Spring term annually.

4 credit hours

CSCI-4250 Computer Architectures
Basic principles of computer design, including such topics as instruction sets, memory hierarchy, arithmetic, pipelining, vector processing, interconnection networks, and multiprocessors. The course emphasizes fundamental concepts and presents examples from existing computer systems. Prerequisites: CSCI-2500 and CSCI-2300. Fall term annually.

4 credit hours

CSCI-4260 Graph Theory
Fundamental concepts and methods of graph theory and its applications 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. (Cross listed as MATH-4150. Students cannot obtain credit for both this course and MATH-4150). Prerequisite: MATH-2800 and CSCI-1100. Spring term.

4 credit hours

CSCI-4290 Robot Motion Planning
This course is an introduction to algorithmic techniques for robot motion planning. Topics include configuration space representations, roadmap methods, cell decomposition and potential field techniques, randomized path planning, collision detection, multiple robot coordination, nonholonomic motion planning, and manipulation planning. These techniques will be motivated by applications to robot manipulators and mobile robots, assembly planning, computer-aided design, computer graphics, and molecular modeling. Prerequisites: CSCI-2300 and MATH-2010. Fall term, odd-years.

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-2400 and CSCI-2500. Spring term annually.

4 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. Prerequisites: CSCI-2300. 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 MATH-2800. Fall term annually. 4 credit hours

CSCI-4430 Programming Languages
This course is a study of the important concepts found in modern 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-2400. 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. Prerequisite: CSCI-2300. Fall and spring terms annually. 4 credit hours

CSCI-4520 Game Development
This class is a practical primer for anyone interested in a career in the rapidly evolving industry to 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 PSYC-4520. Prerequisites: PSYC-2520 or CSCI-2300. Spring term annually. 4 credit hours

CSCI-4600 The Human-Computer Interface
An exploration of the languages, techniques, and mechanisms used to define and enhance communication between people and computer applications, both for input and output, in the general case and for a variety of important special domains. Use of graphics in the interface; multimedia environments; alternative I/O devices; issues in interface design. Interactive in-class exercises and activities. Substantial programming projects are assigned in a number of languages and for a variety of platforms. Students also prepare oral presentations based on material from the current scientific literature. Offered on availability of instructor. 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. (Cross listed as MATH-4800. Students cannot obtain credit for both this course and MATH-4800). Prerequisites: CSCI-1100 and MATH-2010 or ENGR-1100. Corequisite: MATH-2400. Fall term annually. 4 credit hours

CSCI-4820 Introduction to Numerical Methods for Differential Equations
A survey of numerical methods for scientific and engineering problems. 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. (Cross listed as MATH-4820. Students cannot obtain credit for both this course and MATH-4820). Prerequisite: MATH-4800 or CSCI-4800. Spring term annually. 4 credit hours

CSCI-4940 Readings in Computer Science
1 to 4 credit hours

CSCI-4960 Topics in Computer Science
1 to 4 credit hours

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-2400 or equivalent. Fall term annually.  3 credit hours

CSCI-6090 Generic Software Design
Study of the generic programming approach to design and systematic classification of software components. Techniques for achieving correctness, efficiency, and generality of algorithms, data structures, and memory management. Methods of structuring a library of generic software components for maximum usability are practiced in a significant design and implementation project. Prerequisite: CSCI-2300 or equivalent. Fall term annually.  3 credit hours

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 on availability of instructor.  3 credit hours

CSCI-6130 Distributed Operating Systems
A detailed discussion of issues in distributed operating system design and in computer security. The topics discussed include distributed algorithms, distributed deadlock detection and recovery, distributed concurrency control and synchronization, cryptography, and computer security. If both CSCI-6130 and CSCI-6140 are to be taken, CSCI-6140 should be taken first. Prerequisite: CSCI-4210 or CSCI-6140. Offered on availability of instructor.  3 credit hours

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. Fall term annually.  3 credit hours

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. Fall term annually.  3 credit hours

CSCI-6220 Parallel Algorithm Design
Models of parallel computation; deterministic and probabilistic PRAM model; P-complete problems. Techniques for designing efficient parallel algorithms. Parallel sorting prefix and suffix computation, list ranking, DAG evaluation, solving linear systems, graph and combinatorial problems. Prerequisite: CSCI-4020 or equivalent. Offered on availability of instructor.  3 credit hours

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. Fall term annually.  3 credit hours

CSCI-6280 Mobile Robotics
An in-depth study of algorithms for mobile robots focusing on motion planning, localization, mapping, navigation, sensor fusion, and robot software architectures. The unifying themes of this course are navigation in known and unknown environments and structuring software to control mobile robots. Class activities include readings from the research literature and a series of programming projects. Prerequisites: CSCI-2300, and MATH-2010 or permission of instructor. Spring, odd-numbered years.  3 credit hours

CSCI-6290 Robot Motion Planning
This course is an introduction to algorithmic techniques for robot motion planning. Topics include configuration space representations, roadmap methods, cell decomposition and potential field techniques, randomized path planning, collision detection, multiple robot coordination, nonholonomic motion planning, and manipulation planning. These techniques will be motivated by applications to robot manipulators and mobile robots, assembly planning, computer-aided design, computer graphics, and molecular modeling. Prerequisites: CSCI-2300 and MATH-2010. Fall term, odd-numbered years.  3 credit hours

CSCI-6320 Graphical User Interfaces
Building graphical user interfaces, or GUIs, are the norm in modern computing. Once a user interface concept is designed and tested, it must be implemented by programming teams on specific hardware platforms. How the interface is specified is a real challenge. Likewise, a number of standards and tools exist that establish the “look
and feel” of the interface. Introduces the history of GUIs; shows how they can be specified; presents the concept of event-driven programming upon which they are based, and discusses their current status, and compares today’s standards such as Macintosh, Motif, and MS Windows. It also predicts the future based on current computer capabilities and interface trends. Prerequisite: user interface design experience.  

**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 on availability of instructor.  

**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 MATH-2800. Fall term annually.  

**CSCI-6460 Advanced Database Management**  
Topics  
This course is a continuation of CSCI-4380 and presents a more theoretical approach to logical and physical database design. It covers such topics as algorithms for logical database design, primary and secondary indexing techniques, query processing and query optimization, and database security. Problems of interfacing a database system with an operating system and some of the issues in implementing distributed database systems are also discussed. Much of the material comes from recent research papers. A term paper may be required. Prerequisite: CSCI-4380. Offered on availability of instructor.  

**CSCI-6470 Database Systems for Engineering Applications**  
A survey of traditional database systems is followed by an examination of differences between applications of those systems and engineering applications. Database systems for engineering applications are described including the concepts of long transactions, version control, object-oriented support, and concurrent engineering. Prerequisite: CSCI-4380 or equivalent or permission of instructor. Offered on availability of instructor.  

**CSCI-6480 Theory of Compiler Design**  
The use of language theory and automata theory in the design of compilers. Syntax-directed compilers. Lexical analysis and computer implementation of finite state machines. Syntax analysis, parsing versus restructuring. Top-down and bottom-up parsing algorithms. TD(k) and LR(k) grammars. The Younges algorithm. Syntax-directed transducers. Prerequisites: CSCI-6550 or equivalent and knowledge of PASCAL, C, or LISP. Offered on availability of instructor.  

**CSCI-6500 Distributed Computing Over The Internet**  
This course studies theoretical foundations –namely Petri nets, process calculi, actors, join calculus, and mobile agents–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. Spring term annually.  

**CSCI-6510 Distributed Algorithms and Systems**  
This course covers fundamentals of distributed computing. The algorithms are studied for particular commonly used distributed computing system models such as: shared memory, message passing, and peer-to-peer systems. Some of the distributed computing problems studied are: mutual exclusion; leader election; Byzantine agreement; spanning trees; vertex coloring. This course also studies distributed routing algorithms for store-and-forward, optical wireless and sensor networks. Prerequisite: CSCI-2300. Spring term annually.  

**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. (Cross listed as MATH-6800. Students cannot obtain credit for both this course and MATH-6800). Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Fall term even-numbered years.  

**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. (Cross listed as MATH-6820. Students cannot obtain credit for both this course and MATH-6820.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Spring term odd-numbered years.

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). (Cross listed as MATH-6840. Students cannot obtain credit for both this course and MATH-6840). Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Fall term odd-numbered years.

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. (Cross listed as MATH-6860. Students cannot obtain credit for both this course and MATH-6860.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Spring term even-numbered years.

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 Graduate School 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 IP are assigned until the thesis has been approved by the faculty adviser 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

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

DSES Decision Sciences and Engineering Systems (SOE)

DSES-2010 Statistics for Management
Descriptive statistics, probability and random variables, point and interval estimation, hypothesis testing, sample size determination, contingency table analysis, basic experimental design and analysis of variance, simple linear regression. Use of statistical software on business
DSES-2200 Production and Operations Management for Industrial Engineers
The analysis and design of production systems in manufacturing and service industries. Topics include forecasting, scheduling, inventory systems, total quality management, work load balancing, and capacity planning. Microcomputer software is used extensively. Students cannot obtain credit for both this course and ENGR-4700 or DSES-2210. Prerequisite: MATH-1020 or equivalent. Spring term annually. 3 credit hours

DSES-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 or DSES-2200. Prerequisites: MATH-1020 or equivalent. Spring term annually. 4 credit hours

DSES-2940 Readings in DSES 4 to 4 credit hours
DSES-2960 Topics in DSES 4 credit hours
DSES-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. Fall term annually. 4 credit hours

DSES-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. Prerequisite: ENGR-2600 or equivalent. Fall term annually. 4 credit hours

DSES-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: DSES-4140 or DSES-4760 (MATP-4620). Spring term annually. 3 credit hours

DSES-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. Fall term annually. 3 credit hours

DSES-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: DSES-2200 or equivalent, DSES-4140 or equivalent, and DSES-4640 or DSES-4770 (MATP-4700) or equivalent. Spring term annually. 3 credit hours

DSES-4260 Industrial Safety and Hygiene
Survey of procedures and practices in industrial safety and hygiene including government regulation (OSHA), life safety, electrical safety, air contamination, noise, radiation, ventilation, illumination, toxicology, and safety engineering organization. Contemporary topics (asbestos, PCBs, AIDS) are also covered. Fall term annually. 3 credit hours

DSES-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 writing-intensive course. Prerequisite: senior standing. Fall and spring terms annually. 3 credit hours

DSES-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
DSES-4470 Corporate Strategic Planning and Modeling

The integration of quantitative modeling concepts from management science, statistics, and industrial engineering as applied to strategic planning and corporate modeling. Emphasis on analytical application utilizing personal computers. Individual and group projects are utilized to provide experience in developing and managing complex planning and modeling projects. Prerequisites: DSES-4140 or equivalent and DSES-4650. Spring term annually.

3 credit hours

DSES-4510 Information Systems I

This course surveys information-systems technology for the management of corporate information as a resource. Topics include elements of system design life cycle, database concepts, and Internet processing. Managerial and technical dimensions of information systems are blended in a framework of MIS. Projects are required. Prerequisite: CSCI-1190 or equivalent. Spring term annually.

3 credit hours

DSES-4520 Information Systems II: System Analysis and Database Design

This course reviews information engineering methods and techniques in information system analysis and enterprise database design. Related topics such as telecommunications and enterprise integration and modeling are also discussed. The impact of advances in information technology is presented in the context of enterprise planning. Projects are required. Prerequisite: DSES-4510 or equivalent. Spring term annually.

3 credit hours

DSES-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. Students cannot obtain credit for both this course and DSES-4510 or DSES-4520. Prerequisite: CSCI-1190 or equivalent. Fall term annually.

4 credit hours

DSES-4610 Operations Research Methods I

Development of basic approaches of deterministic operations research to decision problems. Focus on optimization algorithms. Introduction to linear, integer, binary integer and nonlinear programming. Genetic algorithms. Consideration of model formulation and implementation. Prerequisite: MATH-1020 or equivalent. Fall term annually.

3 credit hours

DSES-4620 Operations Research Methods II

Development of basic approaches of probabilistic operations research to decision problems. Focus on the formulation, estimation, and analysis of Markov, queuing, and discrete-event simulation models. Extensive use of computers. Prerequisite: ENGR-2600 or equivalent. Spring term annually.

3 credit hours

DSES-4640 Operations Research I

Introduction to modeling and linear programming (LP) formulations of decision problems. Development of algorithms for deterministic LP models including general LP models and network models. Introduction to goal programming, dynamic programming, integer programming and nonlinear programming. Formulation and solution of LP models practiced using spreadsheet software or other LP software tools. Students cannot obtain credit for both this course and DSES-4610 or DSES-4770 or MATP-4700. Prerequisites: MATH-1020 or equivalent. Fall term annually.

4 credit hours

DSES-4650 Operations Research II

Development of basic approaches of probabilistic operations research to decision problems using Markov, queuing, and discrete-event simulation models. Focus on the formulation, estimation, and analysis of stochastic models. Extensive use of computer-based modeling. Students cannot obtain credit for both this course and DSES-4620. Prerequisite: ENGR-2600 or equivalent. Spring term annually.

4 credit hours

DSES-4740 Introduction to Financial Math 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. Students cannot get credit for both this course and MATH-4740. Fall term annually.

4 credit hours

DSES-4750 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. (Cross listed as MATP-4600. Students cannot obtain credit for both this course and MATP-4600.) Prerequisite: MATH-1020 or equivalent or permission of instructor. Fall term annually.  

**DSES-4760 Mathematical Statistics**  
A course in the theory of statistics which 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; confidence intervals; hypothesis testing including uniformly most powerful, likelihood ratio approaches, chi-square tests for goodness-of-fit and independence. The course will conclude with an introduction to linear statistical models. (Cross listed as MATP-4620. Students cannot obtain credit for both this course and MATP-4620.) Prerequisite: DSES-4750 or MATP-4600 or equivalent calculus-based course. Spring term annually.  

**DSES-4770 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. (Cross listed as MATP-4700. Students cannot obtain credit for both this course and MATP-4700.) Prerequisites: MATH-1020 and MATH-2010 or ENGR-1100 or equivalent or permission of instructor. Fall term annually.  

**DSES-4780 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 welcome in this course. A course project allows students to explore optimization methods and practical problems directly related to their interests. (Cross listed as MATP-4820. Students cannot obtain credit for both this course and MATP-4820.) Prerequisites: MATP-4700 or DSES-4770, and MATH-2010 or ENGR-1100, and CSCI-1100, or equivalent, or permission of instructor. Spring term annually.  

**DSES-4810 Computational Intelligence**  
With ever-increasing computer power readily available, new engineering methods based on "soft computing" are emerging at a rapid rate. This course provides students a working knowledge in computational intelligence covering the basics of fuzzy logic, neural networks, genetic algorithms, simulated annealing, wavelet analysis, fractal structures, and chaotic time series analysis. Applications in control, optimization, data mining, fractal image compression, and time series analysis are illustrated with engineering case studies. Spring term annually.  

**DSES-4940 Readings in DSES**  
1 to 4 credit hours  

**DSES-4960 Topics in DSES**  
1 to 6 credit hours  

**DSES-4980 Senior Design Project**  
3 credit hours  

**DSES-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. Prerequisite: DSES-4140, or DSES-4760 (MATP-4620), or DSES-6110, or permission of the instructor. Fall term annually.  

**DSES-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: DSES-4140, or DSES-4750 (MATP-4600) and DSES-4760 (MATP-4620), or DSES-6110, or permission of the instructor. Spring term annually.  

**DSES-6030 Sampling Methods**  
Sampling procedures including the following specific techniques: simple, stratified, systematic, cluster, double, and multiple sampling; estimates for totals, proportions, and variances; ratio and regression estimates; sources of error in surveys. Prerequisite: DSES-4140 or DSES-6110 or equivalent. Offered on sufficient demand.  

**DSES-6040 Nonparametric Methods**  
Distribution-free methodology, order statistics, quantiles, runs tests, rank tests, one-sample and two-sample location and scale problems, k-sample problems, goodness-of-fit tests, measures of association, asymptotic efficiencies. Nonparametric estimation. Prerequisite: DSES-4760 (MATP-4620) or DSES-6110, or equivalent. Offered on sufficient demand.
DSES-6050 Stochastic Processes
A foundational course to introduce the theory of stochastic processes and how it is used to mathematically model a wide variety of empirical phenomena such as queuing systems, inventory control, telecommunications and data networks, and reliability and maintainability. Topics include review of probability, random variables, and conditional expectation; definition of various classes of stochastic processes and their properties; the homogeneous, nonhomogeneous, and compound Poisson processes; renewal processes, discrete and continuous parameter Markov chains, birth and death processes. Prerequisites: calculus, DSES-4750 (MATP-4600). Corequisite: DSES-4760 (MATP-4620). Spring term even-numbered years.

3 credit hours

DSES-6060 Applied Multivariate Analysis
Multivariate distributions; correlations, multiple and partial; estimation and testing in multivariate analysis; multivariate regression analysis including regression with two or more variables subject to error; discriminating between multivariate populations; classification problems; determining the structure of multivariate observations by principle components and factor analysis. Prerequisite: DSES-4140 or DSES-6110. Spring term annually.

3 credit hours

DSES-6070 Statistical Methods for Reliability Engineering
Statistical methods for the analysis of life-test, failure, or other durational data. Engineering applications are emphasized, but the methods are applicable to biometric, actuarial, and social science durational data. Included are basic reliability concepts and definitions; statistical life and failure distributions such as the exponential, gamma, Weibull, normal, lognormal, and extreme value; probability and hazard plotting techniques; maximum likelihood and other estimation methods. Prerequisite: DSES-4140, or DSES-4760 (MATP-4620), or DSES-6110. Spring term odd-numbered years.

3 credit hours

DSES-6090 Decision Analysis
Normative and behavioral views are taken of decision making under uncertainty. This includes a discussion of utility theory and the general problem of ascertaining decision makers’ preferences. Problem structuring techniques such as influence diagrams and knowledge maps are presented. Risk analysis, including risk assessment and management, is discussed. Decision analysis software is used. A class project in risk analysis is conducted. Prerequisites: DSES-6110 or equivalent and DSES-6500 or equivalent. Spring term odd-numbered years.

3 credit hours

DSES-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: DSES-4760 (MATP-4620) or equivalent. Spring term odd-numbered years.

3 credit hours

DSES-6110 Introduction to Applied Statistics
A graduate course in basic statistics. Stresses application to common tasks such as summarizing large databases, making quick estimates, establishing relationships among variables, forecasting, and evaluating alternatives. Topics include probability, common discrete and continuous distributions, sampling, confidence intervals, hypothesis tests, contingency tables, statistical process control, multiple regression analysis. Extensive use of computers to analyze data sets. Students cannot obtain credit for both this course and DSES-4140. Spring term annually.

3 credit hours

DSES-6130 Statistical Computing
A course on modern computational and graphical statistics. It covers topics that are currently active in real world applications including biotechnology and information technology. The topics include stochastic simulation, importance sampling, Gibbs sampling, data visualization, dimensionality reduction, model selection, data smoothing techniques, and methods for pattern recognition. Prerequisites: DSES-4140 or DSES-4760 (MATP-4620), or DSES-6110. Fall term annually.

3 credit hours

DSES-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: DSES-4750 (MATP-4600) and DSES-4760 (MATP-4620) or equivalent; DSES-6100 recommended. Spring term even-numbered years.

3 credit hours

DSES-6150 Advanced Probability for Statistical Inference
Discusses advanced probability concepts and their application to statistical inference. Topics include discrete and continuous distributions, moment generating functions, random vectors and joint distributions, order statistics, bivariate normal distribution, modes of convergence, central limit theorem, goodness of fit, and simulation of random variables. Prerequisites: DSES-4750 (MATP-4600) and DSES-4760 (MATP-4620) or permission of instructor. Fall term annually.

3 credit hours
DSES-6170 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 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. Prerequisites: DSES-6110 and DSES-6230 or equivalent. (Cross listed as MGMT-6470. Students cannot obtain credit for both this course and MGMT-6470.) Fall term annually. 3 credit hours.

DSES-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. Spring term annually. 3 credit hours.

DSES-6200 Models in Facilities Planning and Materials Handling
Analytical and computational modeling of industrial engineering problems in the areas of industrial and manufacturing logistics. Specific applications include facilities planning/design, materials handling equipment/systems, material storage/distribution systems, flow line scheduling and modeling. Prerequisites: DSES-4770 (MATP-4700) or DSES-4640 or equivalent, and DSES-6110 or equivalent. Fall term even-numbered years. 3 credit hours.

DSES-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: DSES-4770 (MATP-4700), or equivalent. Fall term odd-numbered years. 3 credit hours.

DSES-6220 Concurrent Engineering
This course examines issues in concurrent engineering (CE), a product design process using extensive information and knowledge about the product's manufacture and life cycle performance, including design for manufacturing and assembly. Spring term annually. 3 credit hours.

DSES-6230 Quality Control and Reliability
This course has the same content and requirements as DSES-4230 with material added. Additional topics include basic concepts of system and component reliability; statistical distributions such as the exponential, gamma, Weibull, and lognormal, important in the description of life and failure phenomena; and the graphical and quantitative analysis of complete and censored life-testing and failure data. Prerequisite: DSES-4140 or DSES-4760 (MATP-4620), or DSES-6110. Spring term annually. 3 credit hours.

DSES-6470 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. (Cross listed as MGMT-6610. Students cannot obtain credit for both this course and MGMT-6610.) Prerequisite: permission of instructor. Fall term annually. 3 credit hours.

DSES-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. The final part concerns quantitative models with service operations. (Cross listed as MGMT-6480. Students cannot obtain credit for both this course and MGMT-6480.) Prerequisite: permission of instructor. Spring term annually. 3 credit hours.

DSES-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. Fall term annually. 3 credit hours.
DSES-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: DSES-6500 or permission of instructor. Spring term annually.
3 credit hours

DSES-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: DSES-4530 or DSES-6500 or permission of instructor. Spring term annually.
3 credit hours

DSES-6550 Information Systems Analysis and Design
Methods and procedures for understanding and modeling an organization's existing and planned information processing activities (both computerized and manual) are presented and analyzed. These models are then used to develop and design new information processing systems and management information systems. The design process includes procedures for implementing systems successfully. A CASE technology is utilized in conjunction with the design process. Prerequisite: DSES-6500 or permission of instructor. Offered on sufficient demand.
3 credit hours

DSES-6560 Information Technology and Systems for Enterprise Engineering
Role of information systems in engineering; conventional information handling models in manufacturing and services, the emerging concepts and techniques of information integration for enterprise engineering, such as e-engineering, industrial exchange (B&B) and extended enterprise control using Internet technologies. A systems development framework is employed, ranging from strategic use of information systems engineering methods for planning, analysis and design. Term projects required. Fall term annually.
3 credit hours

DSES-6570 Information Technology and Systems for E-Business
E-business uses of the Internet and other new information technologies to bring about extended enterprises on a global scale. The course examines the underlying models, methods, and the techniques of E-business systems from this enterprise perspective. Web technologies, information systems engineering, and contemporary topics such as agents and scalable enterprises are covered. Laboratory assignments and term projects are required. Prerequisite: Demonstration of literacy in information technology. Spring term annually.
3 credit hours

DSES-6600 Models for Production Control and Service Logistics
This course covers deterministic and stochastic models applied in manufacturing and service organizations with special emphasis on the study of inventory control models, logistics management models, and queuing models. Analysis of these models and their application to design and planning problems in manufacturing as well as service systems is emphasized. Prerequisites: DSES-4640 or DSES-4770 (MATP-4700), and DSES-6110 (or equivalent), or permission of instructor. Spring term annually.
3 credit hours

DSES-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. Prerequisite: DSES-6110 or permission of instructor. Fall term annually.
3 credit hours

DSES-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: DSES-6110 or equivalent. Fall term annually.
3 credit hours

DSES-6630 Financial Mathematics and Simulation
Introduction to financial derivatives pricing. Modeling using stochastic differential equations, solving and simulating SDEs, Monte Carlo simulation, Ito’s formula, Feynman-Kac theorem, Girsanov Theorem. Topics in option pricing, European, American and exotic options. Interest rate derivatives. Pricing in incomplete market. Real options. Other applications of modeling using SDEs in computer science, biological and hydrological sciences, and operations research are considered. Extensive computer-based simulation projects. Prerequisite: DSES-6620 or Math-4740 or permission of instructor. Students cannot get credit for both this course and MATH-6740. Spring term annually.
3 credit hours

DSES-6640 Quantitative Analysis of Health Systems
Analytical and computer-based approaches to problems
involving health care organizations are presented. Topics such as productivity, improvement, reengineering, total quality management, models to improve utilization of scarce resources, and spreadsheet models are included. The course puts analytical approaches into practice through a “live case study” in cooperation with a regional health organization. Prerequisite: DSES-6610 or equivalent. Offered on sufficient demand. 3 credit hours

DSES-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. (Cross listed as MATP-6620. Students cannot obtain credit for both this course and MATP-6620.) Prerequisite: DSES-4770 (MATP-4700). Spring term even-numbered years. 4 credit hours

DSES-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. (Cross listed as MATP-6640. Students cannot obtain credit for both this course and MATP-6640.) Prerequisite: DSES-4770 (MATP-4700). Spring term odd-numbered years. 4 credit hours

DSES-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. (Cross listed as MATP-6600. Students cannot obtain credit for both this course and MATP-6600.) Prerequisite: MATH-4200 or equivalent, or permission of instructor. Fall term annually. 4 credit hours

DSES-6800 Information Technology and Decision Systems 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. (This course is cross listed with ITEC-6800. Students cannot obtain credit for both this course and ITEC-6800.) Spring term annually. 3 credit hours

DSES-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. (Cross listed as ECSE-6820. Students cannot obtain credit for both this course and ECSE-6820.) Prerequisite: ECSE-4500 or DSES-4750 (MATP-4600), or equivalent. Spring term annually. 3 credit hours

DSES-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. (Cross listed as ECSE-6830. Students cannot obtain credit for both this course and ECSE-6830.) Prerequisite: ECSE-4500. Corequisite: DSES-4770 (MATP-4700) or equivalent or permission of instructor. Fall term odd-numbered years. 3 credit hours

DSES-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. (Cross listed as ECSE-6840. Students cannot obtain credit for both this course and ECSE-6840.) Prerequisites: DSES-4770 (MATP-4700) and ECSE-4500 or equivalent; DSES-6830 (ECSE-6830) desirable. Fall term even-numbered years. 3 credit hours

DSES-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 tests of 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. (Cross listed as ECSE-6860. Students cannot obtain credit for both this course and ECSE-6860.) Prerequisite: ECSE-4500 or DSES-4750 (MATP-4600) or equivalent. Fall term odd-numbered years. 3 credit hours

DSES-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 maps, genetic algorithms, neocognitron, adaline. Illustrated with computer programs and lectures. Fall term odd-numbered years. 3 credit hours

DSES-6890 Multiple Criteria Decision Making
Consideration of multiple objectives under certain and uncertain conditions, the concept of the ideal, anti-ideal, and value tradeoffs, the decision-making process, measurement of attribute importance, linear multi-objective programming, goal programming, compromise programming, dealing with uncertainty. Prerequisites: DSES-4770 (MATP-4700) or equivalent, and DSES-6110 or equivalent. Spring term odd-numbered years. 3 credit hours

DSES-6900 Seminar in DSES Research
A review of active DSES doctoral research projects and activities. Discussion of the process and stages of doctoral research in DSES. Communication of scientific research results. Prerequisite: DSES doctoral student or permission of instructor. Fall term annually. 0 credit hours

DSES-6910 Advanced Seminar in DSES
A writing intensive course. Students develop research papers 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. Prerequisite: DSES doctoral student or permission of instructor. Corequisite: Having previously passed the DSES DQE or applied to take it in the current semester. Fall term annually. 2 credit hours

DSES-6940 Readings in DSES 3 to 6 credit hours
DSES-6960 Topics in DSES 3 credit hours

DSES-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 Graduate School 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

DSES-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

DSES-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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

DSES-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 (HSSS)

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. Fall and spring terms annually. 4 credit hours
ECON-2010 Managerial Economics
Applications of 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. 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. Fall and spring terms annually. 4 credit hours

ECON-2940 Readings 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-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-2941 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. Prerequisite: ECON-1200 or permission of instructor. Offered on availability of instructor. 4 credit hours

ECON-2942 Quantitative Analysis
This course builds a foundation in the mechanics and application of linear programming and introduces simulation, systems modeling, decision analysis, and dynamic programming. Topics will be presented in lecture and then applied by a weekly computer lab, discussion section, or guest lecture. Applied examples are drawn from business management, operations research, and environmental management and policy. Labs, case studies, and a semester-long project will stress the application of various software packages and modeling techniques. Prerequisite: ECON-2010 or ECON-2020, or permission of instructor. 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. Spring term annually. 4 credit hours

ECON-4140 Structure of American Industry
Acquaints students with the structural characteristics and philosophical foundations of American enterprise. Several important industries are considered from the viewpoint of market structure, conduct, and performance. Such concepts as the corporation, technological competition, and private property, together with criteria for appropriate public policy toward business are examined to orient the student to contemporary American industrial activity. Prerequisite: ECON-1200 or permission of instructor. 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? We apply these questions 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 on 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 on availability of instructor. Spring term annually. 4 credit hours

ECON-4170 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 on availability of instructor. 4 credit hours
ECON-4190 International Economics
Principles of international specialization and exchange. Foreign trade and payment policies, as well as international institutions, are considered in relation to such issues as international investment, technology transfer, economic development, and world economic stability. Prerequisite: ECON-1200 or permission of instructor. Fall and spring term 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. 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. Students cannot receive credit for both ECON-4230 and ECON-6230. 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. Prerequisite: ECON-1200 or permission of instructor. Spring term annually. 4 credit hours

ECON-4250 Ecological Economics
Ecological economics is concerned with the relationship between economic systems and the biological and physical world. It recognizes that practical solutions to pressing social and environmental problems require new interdisciplinary approaches that focus on the links between economic, social, and ecological systems. This course draws on contemporary economic thought as well as evolutionary biology, ecology, and nonequilibrium systems theory. Current problems of economic growth and the prospects for continued development in a finite world are examined in the light of new findings in these fields. Prerequisites: ECON-1200, and either ECON-4230 or ECON-4240, or permission of instructor. Spring term annually. 4 credit hours

ECON-4570 Econometrics
A basic course in the theory and methods of quantitative economics; specification of mathematical models; single and simultaneous equations; least squares and other estimation methods; testing of hypotheses; identification, aggregation, time series analysis, lagged variables, etc. Application to economic problems in such areas as demand, costs, production function, technological change, innovations, etc. Prerequisites: MATH-2010 or equivalent, ECON-2010 or equivalent, or permission of instructor. 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. Open to seniors with permission of instructor. Spring term 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-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 and ECON-4140 or permission of instructor. Fall term annually. 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? We apply these questions 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. 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. Fall term 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. Spring term. 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, and sustainability, and the international dimensions of environmental issues. Prerequisite: ECON-2010 or permission of instructor. Students cannot receive credit for both ECON-4230 and ECON-6230. 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. Fall term annually. 3 credit hours

ECON-6250 Advanced Ecological Economics
A multidisciplinary course that explores linkages between economic, social, ecological, biological, and physical systems. Given its multidisciplinary approach to economic analysis, the course seeks to take a fresh look at economic theory and application. Contributing disciplines include psychology, philosophy of science, biology, and ecology. Prerequisite: ECON-6230 or ECON-6240. Spring 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 on 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. Fall term annually. 3 credit hours

ECON-6570 Econometrics
Application of statistical and mathematical techniques to selected economic problems. 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. The methods of multivariate analysis and time series analysis are examined and their use in economic research is evaluated. Prerequisites: ECON-2010, and ECON-2020 or permission of instructor. 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. Spring term alternate years. 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. 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 Masters 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. 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: EEEP Professional Masters students or permission of instructor. 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-2020 or ECON-6490 or 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. Prerequisites include: valuation, social construction, market failure, cultural studies, externalities, environmental policy and politics, Pareto optimality, and environmental ethics and philosophy. Fall term annually. 3 credit hours

ECON-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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

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. Fall, spring, and summer terms annually 4 credit hours, 6 contact hours

ECSE-2050 Analog Electronics
The physics and operation of semiconductor diodes, bipolar junction transistors, and field-effect transistors in elementary analog circuits. Amplifier biasing, small-signal analysis, frequency response, and noise. Feedback design, stability and oscillator circuits. Prerequisite: ECSE-2010. Fall, spring, and summer terms annually 4 credit hours, 6 contact hours

ECSE-2060 Digital Electronics
Analysis and design of switching-mode circuits: NMOS, CMOS, 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, interface circuitry, memories, A/D and D/A converters, GaAs digital circuits. Prerequisites: ECSE-2010 and ECSE-2610. Fall and spring terms annually 4 credit hours, 6 contact hours

ECSE-2100 Fields and Waves 1
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. Prerequisite: ECSE-2010. Fall, spring, and summer terms annually.

4 credit hours, 6 contact hours

**ECSE-2210 Microelectronics Technology**

An introductory survey of microelectronics technology emphasizing physical properties of semiconductors, device and circuit fabrication, semiconductor device operation, IC layout and design, and related CAD software. Topics include semiconductor crystals; energy bands; electronics and holes; dopant impurities; fabrication and operation of diodes, bipolar junction transistors, and field-effect transistors; CMOS chip design. Prerequisite: ECSE-2010. Corequisite: ECSE-2100 or PHYS-4210. Fall and spring terms annually.

4 credit hours, 6 contact hours

**ECSE-2410 Signals and Systems**


4 credit hours

**ECSE-2610 Computer Components and Operations**


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. Spring term annually.

4 credit hours, 6 contact hours

**ECSE-2900 ECSE Honors Seminar**

Introduction to research as a professional activity in electrical, computer, and systems engineering for participants in the ECSE Honors Program. Admission to the program is by application or invitation only, made during the fall term of the sophomore year. This seminar can be taken more than once. Spring term annually.

1 credit hour, 2 contact hours

**ECSE-4060 Communication Circuits**

Analysis and design of communications circuits, including coupling networks, oscillators, mixers, Class B and C r-f amplifiers; Class B and D broadband amplifiers; AM and FM modulators and demodulators; AGC and AFC and FSK circuits; pulse modulation techniques; phase-locked loops. Prerequisite: ECSE-2050; ECSE-4520 desirable. Spring term.

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. (Cross listed as EPOW-4080. Students cannot receive credit for both this course and EPOW-4080).

Prerequisite: ECSE-2050. Fall term annually.

3 credit hours

**ECSE-4120 Electronic Circuits Design**

A capstone design course.¹ This course integrates theory, computer simulation, and experimental laboratory work. Included are the principles of reliability and optimization. Projects include the design, simulation, practical implementation, and testing of electronic circuits. Prerequisite: ECSE-2050. Corequisites: ECSE-2610, ENGR-4010 and senior standing. Spring term annually.

3 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-4610. Offered on sufficient demand.

3 credit hours

¹ A capstone design course provides a curriculum-culminating major design experience. Students work in teams of three or more on open-ended projects with realistic constraints. The course is designated as writing intensive. Oral and written presentations are required. Course grade is based on team performance and individual contributions.
ECSE-4170 Introduction to Microwave Engineering
Techniques used in the analysis and design of microwave systems. Topics include wave propagation in free space and in guided structures; scattering parameters; signal flow graphs and applications to microwave networks; transmission lines and impedance matching; CAD of microwave circuits; system components; system design parameters and performance calculations. Prerequisites: ECSE-2050 and ECSE-2100. Offered on sufficient demand. 3 credit hours

ECSE-4180 Microwave Circuit Design
A project-oriented course on microwave amplifier design using CAD programs such as Touchstone, E-Syn, LineCal, and Microwave Spice. Each student will do four or five design projects involving narrow band and broad band small-signal amplifiers, multistage amplifiers, microwave filters, couplers, and power amplifiers. Oral presentation by each student. This is designated as a writing-intensive course. Prerequisite: ECSE-2100. Corequisite: ENGR-4010. Spring term annually. 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-2010 and ECSE-2610; ECSE-2210 recommended. Fall and Spring terms annually. 3 credit hours, 4 contact hours

ECSE-4250 Integrated Circuit Processes and Design
The 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. Corequisite: ENGR-4010. Fall and Spring terms annually. 3 credit hours, 4 contact hours

ECSE-4260 Electronic Packaging
Design and fabrication of interconnection structures in electronic systems; heat transfer and mechanical and environmental protection; applications, future trends, and limitations. (Cross listed as MTLE-4290 and MANE-4290. Students cannot receive credit for both this course and either MTLE-4290 or MANE-4290). Prerequisite: senior or graduate level at Rensselaer or an undergraduate degree in engineering or science. 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 on 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 of these plants. Simulation of complex control systems on digital computers. This is designated as a writing-intensive course. Prerequisite: ECSE-2410. Fall and spring terms annually. 3 credit hours

ECSE-4460 Control Systems Design
A capstone design course. Design principles include conceptual system design, components selection, modeling and simulation using computer-aided control design tools, and real-time programming. Each team will propose, design, evaluate, build, and test a working conceptual system design, components selection, modeling and simulation using computer-aided control design tools, and real-time programming. Each team will propose, design, evaluate, build, and test a working control system. Prerequisite: ECSE-4510 or ECSE-4440. Corequisites: ENGR-4010 and senior standing. Spring term annually. 3 credit hours

ECSE-4470 Applications of Linear Systems Analysis
A course in mathematical modeling and analysis of systems. Topics may vary and include applications of differential equations, Laplace transforms, state space techniques, classical control theory, numerical methods, Fourier transforms, and z-transforms. Weekly projects involving electrical and mechanical systems are required. Oral and written project presentations are also required. GE/RPI students only. Fall term annually. 3 credit hours

†A capstone design course provides a curriculum-culminating major design experience. Students work in teams of three or more on open-ended projects with realistic constraints. The course is designated as writing intensive. Oral and written presentations are required. Course grade is based on team performance and individual contributions.
ECSE-4490 Fundamentals of Robotics
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: ECSE-2410. Fall term annually. 3 credit hours

ECSE-4500 Probability for Engineering Applications
Axioms of probability, joint and conditional probability, random variables, probability density and distribution functions, functions of random variables, statistical averages, empirical distributions, parameter estimation, regression, tests of hypotheses, and Markov chains. Applications to engineering data such as device characteristics, failure rates, image processing and network traffic. Prerequisite: ECSE-2410. Fall, spring, and summer terms annually. 4 credit hours

ECSE-4510 Discrete Time Systems
Sampling, quantization, reconstruction of signals. Digital filters. Mathematical tools used in the modeling, analysis, and synthesis of discrete-time communication and control systems. These include discrete Fourier transform, z-transform, state-variable, and transfer-function techniques. Applications to sampled-data control and quantized-data communications systems. Prerequisite: ECSE-2410. Fall term annually. 3 credit hours

ECSE-4520 Communication Systems
An introduction to signals and noise in electrical communication systems. Spectral analysis and filtering, including random signals. Modulation theory and techniques. Transmitter and receiver structures. System performance in the presence of noise. Prerequisite: ECSE-2410. Corequisite: ECSE-4500. Fall term annually. 3 credit hours

ECSE-4540 Introduction to Voice and Image Processing
An introduction to the two fields of voice and image processing, covering analytical and implementation aspects. Optical, electronic analog and digital processing techniques are covered in the imagery field, including sampling and quantization, 2-D transforms, image transmission and compression, image enhancement, sensors, and diversified applications. The voice processing portion involves speech synthesis, analysis, identification, and transmission. Physiological properties of speech, word, and speaker identification systems, digital speech transmission and compression, Vocoders, and applications. The course usually includes one field trip. Prerequisite: ECSE-4510. Spring term annually. 3 credit hours

ECSE-4560 Signal Processing Design
A capstone design course. Supervised design projects in digital signal processing. Project areas include receivers, synchronizers, parameter estimators, digital filters, voice and image processors. Prerequisite: ECSE-4510. Corequisites: ECSE-4520, ENGR-4010 and senior standing. Spring term annually. 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. Three lecture hours and three laboratory hours per week. (Cross listed as PHYS-4630. Students cannot receive credit for both this course and PHYS-4630). Prerequisite: PHYS-2620 recommended. Fall term odd-numbered years. 4 credit hours

ECSE-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. Three lecture hours and three laboratory hours per week. (Cross listed as PHYS-4640. Students cannot receive credit for both this course and PHYS-4640.) Prerequisite: PHYS-2620. Fall term even-numbered years. 4 credit hours

ECSE-4670 Computer Communication Networks
Introduction to the basic concepts of computer and communication networks. In-depth presentation of the seven layers of the Open Systems Interconnection (OSI) reference model emphasizing network design. Network architectures and protocols such as the Internet, Ethernet, and Integrated Services Digital Networks are described in order to illustrate important networking concepts. Prerequisites: ECSE-2610 and combinatorial probability such as in MATH-2800, ENGR-2600 or ECSE-4500. Fall term annually. 3 credit hours

ECSE-4690 Experimental and Simulation Techniques for Computer Networking
This senior-level laboratory course teaches tools and techniques used in the design and analysis of computer networks and protocols such as simulation, animation, visualization, experiment design, trace collection/analysis, protocol development on Linux, and modular router development platforms (eg: Linux-based “Click” and Intel IIXA platform). Each tool is developed in a networking protocol context such as TCP reliable transport, TCP

†A capstone design course provides a curriculum-culminating major design experience. Students work in teams of three or more on open-ended projects with realistic constraints. The course is designated as writing intensive. Oral and written presentations are required. Course grade is based on team performance and individual contributions.
congestion control, routing protocols (RIP, OSPF, BGP), network management and 802.11 wireless networks. Prerequisite: C programming skills. Corequisite: ECSE-4670. Fall term annually. 3 credit hours

ECSE-4710 Interactive Computer-Aided Design
Development of computer-aided design techniques using computer graphics. Interactive design structures. Geometric modeling and computational geometry. Three-dimensional curve and surface geometry. Curve and surface design. Introduction to industrial interactive design systems. Extensive use of the Rensselaer Computer Graphics System. Prerequisite: CSCI-1100 or thorough knowledge of a scientific computer language, preferably C. 3 credit hours

ECSE-4720 Solid-State Physics
An introduction to theoretical and experimental solid-state physics. Wave mechanics in the perfect crystal. X-rays, electrons, and phonons. Electrical properties of metals and semiconductors. Qualitative treatment of lattice defects. (Cross listed as PHYS-4720. Students cannot receive credit for both this course and PHYS-4720.) Prerequisites: PHYS-2100 and PHYS-2510 or equivalent. Fall term annually. 4 credit hours

ECSE-4750 Computer Graphics

ECSE-4760 Computer Applications Laboratory
Experiments and lectures demonstrate the design of digital micro- and mini-computers as both decision tools and on-line system components. Topics include the basic operations of a minicomputer data I/O, process control, digital filter design, digital communication, and optimal control. Prerequisites: ECSE-2410 and either ECSE-4510 or ECSE-4520. 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 controllers for disks, cassettes, video systems, and stepping motors. Course includes a laboratory with access to FPGAs and microprocessors. Prerequisite: ECSE-2610; ENGR-2350 desirable. Fall term annually. 3 credit hours, 5 contact hours

ECSE-4780 Advanced Computer Hardware Design
A capstone design course. 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. Prerequisites: ECSE-4770. Corequisites: ECSE-2660, ENGR-4010 and senior standing. Spring term annually. 4 credit hours

ECSE-4790 Microprocessor Systems Design
A capstone design course. This course integrates hardware and software for real-time microprocessor based digital systems. Laboratory exercises are included to facilitate hardware and software development techniques practiced in industry. Prerequisites: ECSE-2610 and ENGR-2350. Corequisites: ENGR-4010 and senior standing. Fall 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. Corequisites: ECSE-4010 and senior standing. Fall and spring terms. 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-4980 Senior Design Project
Get information from the curriculum office. This is designated as a writing-intensive course. Corequisite: ENGR-4010. 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

†A capstone design course provides a curriculum-culminating major design experience. Students work in teams of three or more on open-ended projects with realistic constraints. The course is designated as writing intensive. Oral and written presentations are required. Course grade is based on team performance and individual contributions.
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. Fall term alternate years.  

3 credit hours

ECSE-6050 Advanced Electronic Circuits  
Design and analysis of wideband amplifiers, differential amplifiers, and operational amplifiers; the characteristics of op-amps and their use as linear and nonlinear elements, including compensation techniques; regulated power supplies. Prerequisite: ECSE-2050. Fall term alternate 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. Fall term annually.  

3 credit hours

ECSE-6230 Semiconductor Devices and Models I  
The physical operation of modern semiconductor devices and the determination of their internal parameters. Devices include diodes, unipolar and bipolar transistors, and metal-oxide-semiconductor devices. Emphasis is placed on the fundamental mechanisms that contribute to device performance. The interrelationship between device parameters and circuit performance is stressed. Prerequisite: ECSE-2210 or equivalent. 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. 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 on 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. Spring term odd-numbered years.  

3 credit hours

ECSE-6270 Optoelectronics  
Introduction to Optoelectronics; 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; Electro-optic, Acousto-optic and Non-linear optic based optical components such as Modulators, Switches, Couplers, Multiplexers, Amplifiers; Optical Waveguides and Fibers; Fiber Optic and Free Space Optical Communication Systems, Lightwave Networks. Prerequisites: ECSE-2210 and ECSE-4720 or equivalent. Offered on sufficient demand.  

3 credit hours

ECSE-6290 Semiconductor Devices and Models II  
A continuation of ECSE-6230. Physical operation of insulated-gate and heterojunction field-effect devices including short-channel and hot-carrier effects. Studies of other heterojunction devices emphasize the exploitation of particular quantum-mechanical phenomena to achieve unique device behavior. Prerequisite: ECSE-6230 or equivalent. Spring term.  

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. (Cross listed as MTLE-6300. Students cannot receive credit for both this course and MTLE-6300.) Prerequisite: ECSE-4250 or equivalent. Spring term annually.  

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. Fall term odd-numbered years.

ECSE-6320 Plasma Dynamics II
Plasma kinetic theory, suitability of magnetically confined plasmas, plasma radiation, plasma turbulence. Prerequisite: ECSE-6310. Spring term even-numbered years.

ECSE-6330 Plasma Devices
Analysis of magnetically confined high-temperature devices. Equilibrium and stability of a variety of magnetic confinement systems. Diagnostic techniques, current status of experimental results, and relationship to the development of controlled fusion. Prerequisite: ECSE-6320. Fall term on sufficient demand.

ECSE-6340 Plasma Diagnostics
Investigation of the major diagnostic techniques used for measuring parameters in magnetically confined plasmas. Several examples of mechanical, radiation, and particle techniques are developed. Emphasis is placed on the basic principles behind each technique, the hardware necessary to perform the measurements, the space and time limitations on the technique, and its role in studying fusion-oriented plasmas. Prerequisites: ECSE-6310 and ECSE-6320. Spring term on sufficient demand.

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. Fall and summer terms annually.

ECSE-6410 Robotics and Automation Systems
Kinematics and dynamics analysis and control design for general robotic systems, including serial manipulators, parallel manipulators, multi-fingered hands, and mobile robots. Topics include product of exponential formula, forward and inverse kinematics, robots under holonomic and nonholonomic constraints, motion and force control, path planning, and trajectory generation. Prerequisite: ECSE-6400; ECSE-4490 is desirable. Spring term odd-numbered years.

ECSE-6420 Nonlinear Control Systems

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. Fall term annually.

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. Spring term even-numbered years.

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 $H_2$, $H_{\infty}$, and structured singular value criteria. Prerequisite: ECSE-6400. Fall term even-numbered years.

ECSE-6480 Adaptive Systems
This course contains the fundamental theory required to design adaptive systems. Topics include parameter identification, ARMA modeling, model reference systems, model algorithmic control, self-tuning systems, and adaptive filtering. Applications to physical and physiological systems are introduced. (Cross listed as BMED-6480. Students cannot receive credit for both this course and BMED-6480.) Prerequisite: ECSE-6400 or equivalent. Spring term odd-numbered years.
ECSE-6490 Electromagnetic Compatibility
All electronic and electrical devices and equipment have to meet FCC, European, or other standards for electromagnetic emissions and/or susceptibility. The course will cover basic EMC standards, electromagnetic theory, antennas used for measuring electromagnetic emissions, signal spectra analysis of electromagnetic compatibility, radiated and conducted emissions and susceptibility, cross talk, shielding, electrostatic discharge, and system design including printed circuit board design of electromagnetic compatibility. The necessary electromagnetic theory will be taught in the course. Prerequisite: undergraduate degree in engineering, physics, or mathematics. Spring term. 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-4500 or equivalent. Fall term annually. 3 credit hours

ECSE-6520 Detection and Estimation Theory
Classical statistical decision theory, decision criteria, binary and composite hypothesis tests. Statistical models of signals and noise. Detection of known signals in Gaussian noise. Receiver operating characteristics and error probability. Applications to radar and communications. Detection of signals with unknown or random parameters, detection of stochastic signals, nonparametric detection techniques. Statistical estimation theory, performance measures. Cramer-Rao bounds, estimation of unknown signal parameters, optimum demodulation, signal design. Prerequisites: probability theory and ECSE-6510. 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. 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. Fall term on sufficient demand. 3 credit hours

ECSE-6560 Digital Communications Engineering
The functional characterization of digital signals and transmission facilities, band-limited and duration-limited signals, modulation and demodulation techniques for digital signals, error probability, intersymbol interference and its effects, equalization and optimization of baseband binary and M-ary signaling systems, error control coding techniques, digital filtering current practices in modern design. Introduction to communication networks and switched systems, store-and-forward communication systems, broadband communication techniques, channel protocol, current developments in digital communication systems design and operation. Prerequisites: ECSE-4520, linear systems theory and transform theory. Fall term annually. 3 credit hours

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. 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 trade-offs. Prerequisite: ECSE-6510. Spring term annually.

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. We will address the topics of system capacity and the effects of automatic power control, wireless networks, and DSP applications for wireless. Prerequisites: ECSE-4500 and ECSE-4670. Spring term annually.

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.

ECSE-6610 Pattern Recognition

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-4500, ECSE-4510. Fall term annually.

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. Prerequisites: ECSE-6510, ECSE-6620. Spring term annually.

ECSE-6640 Digital Picture Processing
Pictures and their computer representation. Image digitization, transform, and prediction methods. Image coding and image data compression. Digital enhancement techniques, histogram equalization, differencing, smoothing, and geometric corrections. Restoration and filtering. Edge detection and picture segmentation. Geometric analysis, connectedness, size, distance, directionality, and shape. Image processing languages and software. Applications from remote sensing, scene analysis, and medical-image analysis. Prerequisites: prior exposure to probability, stochastic processes, and assembler language programming is recommended but not required. Offered on sufficient demand.

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 on sufficient demand.

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 & router-design, traffic engineering, fiber optical communications, optical networking concepts, protection/restoration/survivability, optical link layers, quality of service, Gigabit Ethernet for MANs and broadband last-mile technologies. Prerequisite: ECSE-4500, ECSE-4670. Spring term odd-numbered years.
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-4500, ECSE-4670. Spring term even-numbered years. 3 credit hours

ECSE-6680 Advanced VLSI Design
The reliable development of VLSI designs. Topics include device modeling, comparative circuit performance, design for testability, multiprocessor architectures, and memory and microprocessor design. Laboratory experiments involve the use of an ensemble of CAD tools, including SPICE, placement and routing, and high-level design descriptions. A term project and report are required. Prerequisite: ECSE-4220. Offered on 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 on sufficient demand. 3 credit hours

ECSE-6700 Computer Architecture Prototyping with FPGAs
An advanced design and laboratory course. Design methodologies include register transfer modules 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. 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. 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 on 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 on sufficient demand. 3 credit hours

ECSE-6740 Introduction to Parallel Computation
Motivation for parallel processing, technological constraints, complexity, performance characterization, communications, interconnection networks, reconfiguration and fault tolerance, systolic arrays, memory systems, large-bandwidth input/output, disk arrays, online visualization, coarse and fine-grain processor design, parallel FORTRAN and C, finite-difference and finite-elements, parallel optimization and transformation algorithms, selected signal and image processing applications, selected architectures: DAP, NCUBE, CM-2, and MasPar. Prerequisites: ECSE-2610 and knowledge of probability theory. Offered on 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 on 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. 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. Spring term. 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, halved line elimination, polyhedron intersection, and algorithms for scenes with thousands of faces are discussed. Major research paper required. Prerequisites: ECSE-4710 or ECSE-4750, and CSCI-2300 or equivalent. Offered on 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++. Spring term. 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. (Cross listed as DSES-6820. Students cannot receive credit for both this course and DSES-6820.) Prerequisite: ECSE-4500 or DSES-4750 or MATP-4600. Spring term even-numbered years. 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 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. (Cross listed as DSES-6830. Students cannot receive credit for both this course and DSES-6830.) Prerequisite: ECSE-4500. Corequisite: MATP-4700 or DSES-4770 or equivalent, or permission of instructor. 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. (Cross listed as DSES-6840. Students cannot receive credit for both this course and DSES-6840.) Prerequisites: MATP-4700 and ECSE-4500 (or equivalent); ECSE-6830 desirable. Fall term annually. 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. (Cross listed as DSES-6860. Students cannot receive credit for both this course and DSES-6860.) Prerequisite: ECSE-4500 or DSES-4750 (MATP-4600) or equivalent. Fall term odd-numbered years. 3 credit hours

ECSE-6900 Seminar in Electrical, Computer, and Systems Engineering
Credit hours to be arranged
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. 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 Graduate School 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.

ECSE-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. 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 IP are assigned until the thesis has been approved by the faculty adviser 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. 6 to 9 credit hours

ECSE-9990 Dissertation

Electrical, Computer and Systems Engineering at Hartford

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 PAP and PIN diodes. Also includes applications of optical fibers in optical communications, in data processing, and in control systems. Offered biannually. 3 credit hours

ECSE-7020 Digital Control and Estimation
Computer control and estimation algorithms including deterministic and stochastic models. Markov sequence and Bayes decision rules, linear Kalman filtering, predicting and smoothing. Parameter identification, combined state and parameter estimation. Adaptive filters and on-line rapid estimation schemes, extended and nonlinear filters. Optimal digital control of deterministic and stochastic systems. Separation theorems. Prerequisite: ECSE-6400. Offered biannually. 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 on sufficient demand. Offered biannually. 3 credit hours

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. 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. 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
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. Fall, spring, and summer terms annually.  
1 credit hour, 3 contact hours

ENGR-1310 Introduction to Engineering Electronics
A hands-on experience with electronic circuits and modern laboratory instrumentation. Motivates further study of engineering. The laboratory provides opportunities to build and test simple electronic circuits that illustrate basic concepts. A design project is included. Fall and spring terms annually.  
1 credit hour, 3 contact hours

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. Prerequisite: CHEM-1300 or CHEM-1100, although the former is recommended. 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. 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. Corequisite: PHYS-1200. 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, and single degree of freedom vibrations. Prerequisites: ENGR-1100 and PHYS-1100. Corequisite: MATH-2400. 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. 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: a programming language, preferably C. 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. 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. 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. 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 visual, 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 hours

ENGR-4100/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. Fall term annually. 4 credits undergraduate, 5 credits graduate

ENGR-4300 Electronic Instrumentation
A survey, application-oriented course for engineering and science majors. Transducers and measurement devices. DC and AC analog circuits including impedance, power, frequency response, and resonance. Diodes, transistors, and operational amplifiers. Signal conditional, noise, and shielding. Digital electronics, A/D and D/A conversion. Power supplies, rectifiers, and electromagnetic devices. Credit not allowed for ECSE majors or for students taking ECSE-2010. Prerequisite: MATH-2400 and PHYS-1200. 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 this course and DSES-2210. Spring term annually. 3 credit hours

ENGR-4710 Advanced Manufacturing Laboratory I
Theory and laboratory experimentation in selected modern manufacturing technologies. Topics include robotics, injection molding, computer numerically controlled (CNC) machines, metal processing systems, nondestructive testing (NDT), and industrial safety. Prerequisite: ENGR-4700 recommended. Fall term annually. 3 credit hours, 6 contact hours

ENGR-4720 Advanced Manufacturing Laboratory II
Students are organized into “companies” to design, manufacture, and sell products based on the technologies of ENGR-4710. Individual projects for in-depth studies of one or more of these technologies. Additional topics include marketing and development of technical writing and oral presentation skills. Prerequisite: ENGR-4710. Spring term annually. 3 credit hours, 6 contact 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 DSES-4240. 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. Spring term annually. 3 credit hours

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 Graduate School 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. Corequisite: MATH-2400. 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. (Cross listed as CHEM-4690 and ERTH-4690). Students cannot obtain credit for both this course and either CHEM-4690 or ERTH-4690). Prerequisite: permission of the instructor. Fall term annually. 4 credit hours

ENVE-4150 Environmental Engineering Laboratory
A laboratory course on experimental analysis of natural and engineered environmental processes. Emphasis is placed on planning of experiments, data evaluation, and report writing. Prerequisite: ENVE-2110 or permission of instructor. Fall term annually. 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. This is a writing intensive course. Students will develop communication skills through proposal preparation, report writing, oral presentation. Prerequisite: ENVE-2110 and senior standing. 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. 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 on availability of faculty. 3 credit hours

ENVE-4220 Environmental Law
This course provides environmental engineers, researchers, managers, public officials, and corporate executives with a firm foundation in the environmental laws and regulations with which and under which they must work. Classroom lectures and discussions generate papers on selected environmental law topics. Offered on availability of faculty. 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, phyto remediation, composting of solid waste and soil columns, and microbial respirometry. Spring term annually.  

ENVE-4310 Applied Hydrology and Hydraulics

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. Prerequisites: ENVE-2110 or CHME-2010. Corequisite: CHME-4010. Spring term annually.  

ENVE-4330 Atmospheric Pollution
Fundamentals of atmospheric pollution with emphasis on emissions from major sources such as combustion. Principal pollutants discussed are: particles, trace metals, sulfur-, nitrogen-, and carbon oxides, oxidants, and hazardous organics; as well as the thermodynamic and kinetic aspects of their formation. Role of meteorology in pollutant emission, atmospheric transport, and atmospheric chemistry, source/receptor relationships, including modeling of these relationships using one or more computer models. Some aspects of engineering control of emissions. Prerequisites: CHEM-1300 and CHME-4010. Fall term annually.  

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. Prerequisite: CHME-4010. Spring term annually.  

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 reactors for pollution control. Topics covered include biogeochemical cycling, thermodynamics of biodegradative processes, activated sludge, trickling filters, stabilization ponds, sludge treatment and digestion, bioremediation, hazardous waste treatment, biological metal cycling and biological solid waste treatment processes. Prerequisite: ENVE-4320. Fall term annually.  

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 Seepage, Drainage, and Groundwater
Introduction to groundwater hydrology, well hydraulics, permeability, seepage, flow nets, filter criteria, dewatering, slope stabilization, practical applications. (Cross listed as CIVL-6530. Students cannot obtain credit for both this course and CIVL-6530). Prerequisite: CIVL-2630 or permission of instructor. Spring term annually.  

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 on availability of faculty.  

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. Spring term alternate years.  

ENVE-6150 Limnology
Classification and identification of microscopic and macroscopic aquatic plant and animal life. Chemical analysis sufficient to relate the organisms to their environment. Measurement of the physical characteristics of a lake. Field and laboratory studies on different aquatic systems. Classes conducted at Darrin Fresh Water Institute on Lake George. Prerequisite: permission of instructor.
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. Open to graduate students in science or engineering. Offered on availability of faculty. 3 credit hours

ENVE-6170 Atmospheric Chemistry
The course presents important thermodynamic and kinetic aspects of reactions in the atmospheric layer. Consideration is given to transport phenomena in determining atmospheric compositions and kinetics. Applications of principles to upper atmospheric and lower (air pollution) atmospheric cases are discussed. Prerequisites: CHEM-2250, CHEM-2260 or equivalent or permission of instructor. Offered on availability of faculty. 3 credit hours

ENVE-6180 Air Pollution Meteorology
Investigation of atmospheric processes of particular importance in dealing with the environmental problems of air pollution: atmospheric turbulence, temperature lapse rates, wind profiles, plume rise, plume dispersion relations, urban dispersion models, wet and dry atmospheric scavenging processes, and inadvertent climate and weather modification. Open to graduate students in science or engineering. Prerequisites: ENGR-2050, ENVE-4330 or permission of instructor. Offered on availability of faculty. 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 on availability of faculty. 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. Prerequisites: permission of instructor. 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. 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. Spring term alternate years. 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 on the availability of faculty. 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 on availability of faculty. 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. ENVE-4350 or equivalent is recommended as a prerequisite. Spring term. 3 credits
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. 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 Graduate School 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.

ENVE-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. 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.

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.

EPOW Electric Power Engineering (SOE)

EPOW-4010 Power Engineering Fundamentals
Study of the principal components of electric power systems as individual pieces of equipment and as parts of a system. Balanced 3-phase circuits, per unit quantities. Circle diagrams, control of voltage, and power flow. Unbalanced faults. Symmetrical components. The study includes physical modeling and the use of standard software simulation tools. Prerequisite: ECSE-2010 or permission of instructor. Fall term annually.

EPOW-4020 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. Prerequisites: ECSE-2010, ENGR-4300 or permission of instructor. Spring term annually.

EPOW-4030 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: EPOW-4020 or EPOW-4080 or permission of instructor. Spring term annually.

EPOW-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. (Cross listed as ECSE-4080. Students cannot obtain credit for both this course and ECSE-4080.) Prerequisite: ENGR-4300 or ECSE-2050. Fall term annually.
EPOW-4840 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: EPOW-4010 or equivalent or permission of instructor. Spring term annually.

3 credit hours

EPOW-4850 Electric Power Engineering Design
A capstone design course. Structure and integrated design experience in which a plurality of analytical tools is invoked to meet a design specification for a selected item of hardware. This will involve electrical, thermal, mechanical, environmental, and economic considerations, as appropriate, and may require laboratory and/or computer work in the design or evaluation. Prerequisites: EPOW-4010 and EPOW-4020 or permission of instructor. Corequisites: ENGR-4010 and senior standing. Spring term annually.

3 credit hours

EPOW-4940 Electric Power Engineering Project
1 to 6 credit hours

EPOW-4980 Senior Project
3 credit hours

EPOW-6090 Advanced Power Electronics Laboratory
A laboratory-based examination of rectifiers, DC/DC converters, resonant converters and inverters, focusing on the interactions among the semiconductor switches and the filter elements of the converter. Control circuits for the semiconductor switches are designed and implemented. Laboratory exercises consist of simulation and physical measurements. Transient performance of various inverters is also examined. A student-initiated project dealing with some aspect of power electronics is required. Prerequisite: EPOW-6090 or permission of instructor. Spring term, even-numbered years.

3 credit hours

EPOW-6810 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. Fall term annually.

3 credit hours

EPOW-6820 Power Quality Power
Quality examines the causes of and solutions to electric power quality problems. Power quality 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. It is recommended that students have taken either EPOW-6860 or EPOW-4080 prior to enrolling in this class. Spring term annually.

3 credit hours

EPOW-6830 Protective Relaying

3 credit hours

EPOW-6840 Power Generation Operation and Control

3 credit hours

EPOW-6850 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. Prerequisites: ECSE-2100, EPOW-4010, and EPOW-4020 or their equivalents. Fall term annually.

3 credit hours

EPOW-6860 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. Fall term annually.

3 credit hours

EPOW-6870 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, etc.

3 credit hours

†A capstone design course provides a curriculum-culminating major design experience. Students work in teams of three or more on open-ended projects with realistic constraints. The course is designated as writing intensive. Oral and written presentations are required. Course grade is based on team performance and individual contributions.
short circuit forces on windings and bus structures. Prerequisite: permission of instructor. Spring term annually.

3 credit hours

EPOW-6880 The Utility as a Business
The business aspects of electric utilities are highlighted, including source of funds, components of cost for generation, transmission, and distribution, the rate setting process, planning for future loads, least-cost system planning, and operation and economics of conservation. The course features the changing structure of electric utilities in the new regulatory environment and competition in this energy sector, especially for generation. Spring or summer term.

3 credit hours

EPOW-6890 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: EPOW-6810 or equivalent or permission of instructor. Spring term annually.

3 credit hours

EPOW-6900 Seminar in Electric Power Engineering
0 credit hours

EPOW-6940 Electric Power Engineering Project
1 to 6 credit hours

EPOW-6960 Topics in Electric Power Engineering
State of the art in selected important areas of electric power systems such as ultra-high-voltage transmission, generator excitation systems, circuit interruption technologies, HVDC converters, frequency and tie line control, and power system reliability. Spring or summer term.

3 credit hours

EPOW-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 Graduate School 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

EPOW-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

EPOW-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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

EPOW-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

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.) 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.) 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.) 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 primarily by outside investigators who are currently active in those fields. 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. 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.) 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 coasts. The course explores the processes by which these and other features develop and change, the opportunities or hazards they present, and the ways in which humans can modify their development. Lectures and lab. (Students cannot obtain credit for both ERTH-1020 and ERTH-1200.) 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. 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. 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. (Cross listed as CHEM-2540. Students cannot obtain credit for both this course and CHEM-2540.) Prerequisite: ERTH-1100 and/or ERTH-1200, or permission of instructor. Spring term annually. 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 course is writing intensive. Prerequisites: ERTH-1100 or ERTH-1200 or permission of instructor. Fall term annually. 2 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. 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. 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. Fall and spring terms annually.

**ERTH-4070 Sedimentology**
Sediments and sedimentary rocks as part of the geologic cycles; the present as a key to the past. Sedimentary processes, products, and environments. Sedimentary strata as documents of geologic chronology. Includes a weekly laboratory and field trip(s). Spring term odd-numbered years. 4 credit hours

**ERTH-4180 Environmental Geology**
An overview of near-surface geological systems and human interaction with them, followed by a topical discussion of key geo-societal issues including, but not limited to, earthquake hazards, landslides, water pollution, waste disposal, and health risks posed by radon and asbestos. Spring term annually. Includes laboratory and one Saturday field trip. 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. (Cross listed as CHEM-4190. Students cannot obtain credit for both this course and CHEM-4190.) Prerequisite: permission of the instructor required. Lectures and lab. Fall term odd-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. Spring term even-numbered years. 4 credit hours

**ERTH-4500 Global Environmental Change**
Environmental issues of global concern will be investigated from a scientific perspective. Analysis of historic and current data bases on population, resources, land use, and climate will provide an introduction to detailed consideration of more specific case studies in areas including global warming, El Nino Southern Oscillation, ozone depletion, regional drought and water management, long-range transport of pollutants, species extinction and biological diversity loss. (Cross listed as IENV-4500. Students cannot obtain credit for both this course and IENV-4500.) Prerequisites: junior, senior, or graduate student status. Fall term odd-numbered years. 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. (Cross listed as CHEM-4540. Students cannot obtain credit for both this course and CHEM-4540.) Prerequisites: CHEM-2210 and ERTH-1200 or permission of instructor. Spring term odd-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. On 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 mechanics, seismic risk analysis, exploration seismology, and tomographic imaging. Prerequisite: MATH-1020. 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. (Cross listed as CHEM-4690 and ENVE-4110. Students cannot obtain credit for both this course and either CHEM-4690 or ENVE-4110.) Prerequisite: permission of instructor. Fall term annually. 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. Fall term annually. 4 credit hours
ERTH-4740 Applied Groundwater Modeling
Study of numerical solutions to the ordinary and partial differential equations of groundwater flow and contaminant transport. Emphasis on modeling methodology and solving applied problems. Prerequisite: ERTH-4710 or ERTH-6710 or permission of instructor. Spring term odd-numbered years. 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. 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. (Cross listed as CHEM-4810. Students cannot obtain credit for both this course and CHEM-4810.) Prerequisites: CHEM-1200 and one prior or concurrent course in organic chemistry or permission of instructor. Spring term annually. 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 Senior Field Thesis
Independent field experience for undergraduates. Requires a written proposal and final report. 2 to 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. Fall term odd-numbered years. 4 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. 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. 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. Fall term annually. 3 credit hours

ERTH-6720 Advanced Groundwater Hydraulics
An in-depth, quantitative treatment of fluid flow in subsurface media. Derivation of the fluid flow equation followed by application to various hydrologic situations, including flow to wells. Emphasis on analytic solutions and their assumptions. Some field trips are possible. Prerequisites: knowledge of differential equations and vector calculus, ERTH-6710 or equivalent, or permission of instructor. Spring term annually. 3 credit hours

ERTH-6730 Groundwater Contaminant Transport
Theoretical and applied study of solute transport phenomena. Analytical and numerical solutions of the advection-dispersion equation and other techniques for solving groundwater contaminant transport problems. Issues of contamination sources, basic chemical concerns during transport, and monitoring and remediation are also covered. Transport modeling is also introduced. Some field trips are possible. Prerequisites: MATH-4600 or equivalent, ERTH-4710 or ERTH-6710 or equivalent, or permission of instructor. Spring 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, geoexploration, 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 Graduate School 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

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 IP are assigned until the thesis has been approved by the faculty adviser 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

ERTH-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

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 master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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

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
A weekly seminar required for students who are beginning their degree program in environmental science and open to other first-year students. Speakers include faculty, graduate students, and guest environmental professionals. Topical environmental issues are considered from numerous perspectives. Fall 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. (Cross listed as IHSS-2100. Students cannot obtain credit for both this course and IHSS-2100.) Spring term annually. 4 credit hours
IENV-4500 Global Environmental Change
Environmental issues of global concern will be investigated from a scientific perspective. Analysis of historic and current data bases on population, resources, land use, and climate will provide an introduction to detailed consideration of more specific case studies in areas including global warming, El Nino Southern Oscillation, ozone depletion, regional drought and water management, long-range transport of pollutants, species extinction and biological diversity loss. (Cross listed as ERTH-4500. Students cannot obtain credit for both this course and ERTH-4500.) Prerequisite: junior, senior, or graduate student status. Fall term odd numbered years. 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. 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 do we acquire, organize and share our understandings of the world? 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. Offered fall term. This course is cross listed as ITEC-1210. A student cannot take both courses for credit. 4 credit hours

IHSS-1220 Politics and Economics of Information Technology
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 the 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. (Cross listed as ITEC-1220. Students cannot obtain credit for both this course and ITEC-1220.) Spring term annually. 4 credit hours

IHSS-1500 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. 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. (Cross listed as IENV-2100. Students cannot obtain credit for both this course and IENV-2100.) Spring term annually. 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 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. Prerequisite: PDI I or PDI II or permission of instructor. 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 on demand.

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-4500 Topics in Origins of Life
Study or research in areas relevant to origins of life, to demonstrate interest in and ability for independent work. Prerequisite: junior standing or higher or permission of instructor. Fall and spring terms annually. 3 or 4 credit hours

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. ISCI-4510 will be graded satisfactory/unsatisfactory and it cannot be counted towards the Institute’s baccalaureate requirement of 24 credits in the sciences. Fall and spring terms annually. 1 credit hour

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 until the project 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. 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 IP are assigned until the thesis has been approved by the faculty adviser 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

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

ITEC Information Technology (IT)

ITEC-1210 Information in History and Society
What is the relationship between information, information technology, and culture? How do we acquire, organize and share our understanding of the world? 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 course is cross listed as IHSS-1210. A student cannot take both courses for credit. Fall term annually. 4 credit hours

ITEC-1220 Politics and Economics of Information Technology
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. (Cross listed as IHSS-1220. Students cannot obtain credit for both this course and IHSS-1220.) Spring term annually. 4 credit hours
ITEC-2110 Exploiting the Information World
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. Prerequisites: CSCI-1200 or equivalent. Fall term annually. 4 credit hours

ITEC-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. (Cross listed as PSYC-2210. Students cannot obtain credit for both this course and PSYC-2210.) Spring term annually. 4 credit hours

ITEC-4100 ITEC Capstone Experience
Students work on collaborative projects to design innovative IT 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 IT solution learning best practices for IT project management, communication, and user-center design. This course serves as the culminating experience for the undergraduate IT program. Restricted to ITEC majors. Prerequisites: ITEC-2210 and ITEC-4310. This is a writing-intensive class. Fall term annually. 4 credit hours

ITEC-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: ITEC-2110 or permission of instructor. Fall term annually. 4 credit hours

ITEC-4300/ITEC-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. (Cross listed as ENGR-4100/ENGR-6100. Students can only obtain credit for one of these courses.) Fall and spring term annually. 4 credits undergraduate; 3 credits graduate

ITEC-6800 IT 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. (Cross listed as DSES-6800. Students cannot get credit for both this course and DSES-6800.) Spring term annually. 3 credit hours

ITEC-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. 3 to 4 credit hours

ITEC-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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. 3 to 6 credit hours

LANG Foreign Languages and Literature (HSSH)
(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. This
course is enhanced by the use of audio-visual materials whose purpose is to expose the student to contemporary broadly based French culture which constitutes the foundation for an end of the semester paper (in English). Fall term annually. 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. Spring term annually. 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. Fall term annually. 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. Spring term annually. 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. Fall term annually. 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. Spring term annually. 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. Fall annually. 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 complement 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. Spring annually. 4 credit hours

**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. Fall term annually. 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. Spring term annually. 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. 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 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. 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. Spring term annually. 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. Spring term annually. 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. Fall term annually. 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 650 characters, 1000 words, and use more complicated grammatical structures, e.g., reduplication of adjectives and verbs, resultative and potential complements. In sum, students learn more in all four aspects—listening, speaking, reading and writing—presented in Chinese II. Prerequisite: LANG-1420. Fall annually. 4 credit hours

LANG-2940 Language Studies
Readings and projects adapted to the needs of individual students. 4 credit hours

LANG-2960 Topics in Language
Experimental courses tried out in one or two terms. 4 credit hours

LANG-2940 Language Studies
Readings and projects adapted to the needs of individual students. 4 credit hours

LANG-2960 Topics in Language
Experimental courses tried out in one or two terms. 4 credit hours

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. Spring term annually. 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 the instructor. Fall term annually. 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. Spring term annually. 4 credit hours

LANG-2430 Chinese IV
This is a continuation of Chinese III, a course for standard modern Chinese language (Mandarin). Students learn additional 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. Spring term annually. 4 credit hours

LANG-4940 Language Studies
Readings and projects adapted to the needs of individual students. 4 credit hours

LANG-4960 Topics in Language
Experimental courses tried out in one or two terms. 4 credit hours
LANG-6940 Language Studies
Readings and projects adapted to the needs of individual students. 3 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. 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. 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. Fall term annually. 4 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. 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. Spring terms 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. 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. 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, spectroradiometry, measurement techniques for advanced light sources, radiometry, and photometry. 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-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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
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. Spring term annually. 4 credit hours

LITR-2150 Contemporary Literature
A study of significant works of world literature of the 20th century. Each work provides the student with a concrete experience of some overriding problem of our time—for example, the difficulty of becoming one's self in the modern age. Fall and spring terms annually. 4 credit hours

LITR-2310 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 notions of the mental world. All seek to explain emotion, reason, dreams, and memory. Drawing on material from Homeric Greece to 20th-century cyber-culture, this course pairs one psychological explanation of mind with a corresponding literary work. Fall term alternate years. 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. 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. Fall term alternate years. 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. 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. Fall term alternate years. 4 credit hours

LITR-2460 Black Film
A survey of black films of the 20th century and an analysis of the plot, theme, cultural construction, characterization, moral-philosophical implications, black images, and historical context to black life and national conditions. Offered on availability of instructor. 4 credit hours

LITR-2470 Study of African-American Literature
This course provides an introduction to black authors and their literary contributions and an analysis of their relationship to black thought and culture. Various forms of literature, such as folk tales, poetry, short story, prose, and essay, will be presented with emphasis on literary style and content as influenced by the social environment of the periods of America's historical development from 1619 to the present. Students will write about these works in class, including a thirty-page (typed) critical research paper outside of class. Workshops, lectures, oral reports, and group discussions will be the methodology for each class session. Offered on availability of instructor. 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 on availability of instructor. 4 credit hours

LITR-2540 Modern Drama
A survey of the work of modern dramatists such as Shaw, Ibsen, and O'Neill, as well as more contemporary playwrights such as Miller, Williams, Brecht, Beckett, Orton, and Stoppard. Offered on availability of instructor. 4 credit hours

LITR-2570 Women Writers
A study of works of literature written by women, featuring such writers as Jane Austen, Charlotte Bronte, Emily Bronte, George Eliot, and Virginia Woolf, and including the work of selected contemporary writers. Fall term annually. 4 credit hours

LITR-2600 Literary Theory
A study of critical theory and its application to selected works of literature. Focuses on various theoretical movements and their impact on literary criticism. 4 credit hours

LITR-2650 Contemporary Literature
A study of significant works of world literature of the 20th century. Each work provides the student with a concrete experience of some overriding problem of our time—for example, the difficulty of becoming one's self in the modern age. Fall and spring terms 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 alternate years. 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. Spring term alternate years. 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.” We 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 annually. 4 credit hours

LITR-4450 Nonwestern Fiction and Film
This course explores the work of indigenous writers and film-makers from the Pacific Islands, Africa, India, and China and considers how local/native, national, and transnational identities are constructed through their voices. The books and films studied deal with immigrant experience, the condition of diaspora, the politically self-conscious invention of a national voice, and critique of the postcolonial nation-state. Prerequisite: any film course or permission of instructor. Spring term annually. 4 credit hours

LITR-4960 Topics in Literature
Experimental courses tried out in one or two terms. 4 credit hours

LITR-6330 Critical Theory
Focuses on the major philosophical, political, and psychological theories that have shaped literary studies since 1965. Students will be introduced to major theories [including Deconstruction, Psychoanalysis (Freud-Lacan), Marxism, Feminism] and to a series of topics that ask students to integrate two or more of these theories. Prerequisite: graduate standing or permission of instructor. Offered on availability of instructor. 3 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 the elements of fluid mechanics, thermodynamics, heat transfer, aerodynamics, aircraft and rocket propulsion, launch systems, spaceflight dynamics, and reentry mechanics. Application of this material to airplane performance calculations and to airplane and spacecraft design. Spring term annually. 4 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. 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 either CHEM-1100 or CHEM-1300. 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
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. 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. Corequisite: MANE-4010. 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. Mechanical components including shafts, couplings, bearings, gears, springs, clutches, brakes, screws and fasteners, and bonded joints. Prerequisites: MATH-2400, ENGR-2530. Fall and spring terms annually.  
4 credit hours

MANE-4040 Mechanical Systems Laboratory  
Laboratory experience to complement MANE-4030. Stress and strain measurement; load, fatigue, and failure testing; friction and wear behavior. Reverse engineering of a mechanical assembly. Corequisite: MANE-4030. Fall and spring terms annually.  
2 credit hours

MANE-4050 Modeling and Control of Dynamic Systems  
4 credit hours

MANE-4060 Aerospace Structural Analysis  
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. Prerequisite: ENGR-2530. Fall and spring terms annually.  
4 credit hours

MANE-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 MANE-2060. Fall term annually.  
3 credit hours

MANE-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: MANE-4070 or permission of instructor. Fall term annually.  
4 credit hours

MANE-4090 Flight Mechanics  
4 credit hours

MANE-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, MANE-2060, and MATH-2400, or equivalent. Fall term annually.  
4 credit hours

MANE-4110 Advanced Fluid Mechanics  
Comprehensive treatment of fluid mechanics for both incompressible and compressible as well as viscous and inviscid flows, with emphasis on fundamental concepts and analytical methods. Topics include review of kinematics of fluid flow, derivation of the Navier-Stokes equations including their boundary conditions, exact solutions of Navier-Stokes equations, similarity solutions including laminar boundary layers, transition to turbulence, and one- and two-dimensional ideal compressible flow. Prerequisite: MANE-4010 or equivalent. Offered on sufficient demand.  
3 credit hours

MANE-4130 Analysis and Design of Composite Structures  
3 credit hours
MANE-4150 Stresses in Machine Elements
Application of the principles of strength of materials to the analysis and design of machine parts. Curved bars, multisupport shafts, torsion, cylinders under pressure, thermal stresses, creep, and relaxation, rotating disks and other machine elements are considered. Fall and spring terms annually. 3 credit hours.

MANE-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. Spring term annually. 3 credit hours.

MANE-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. 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. Full term annually. 4 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 designated as a writing-intensive course. Prerequisite: ENGR-2050 or permission of instructor. Fall and spring terms annually. 3 credit hours.

MANE-4230 Fixed-Wing Aircraft Design
Conceptual and preliminary design of a fixed-wing aircraft to satisfy given commercial aircraft specifications. Includes elements of initial sizing and weights, geometry selection, aerodynamic design, propulsion integration, stability and control, loads, structural design, manufacturability, and cost analysis. Writing-intensive assignments help develop communication skills. Prerequisites: MANE-4060 and MANE-4070. 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. (Cross listed as CIVL-4240. Students cannot obtain credit for both this course and CIVL-4240.) Prerequisites: ENGR-2250 or ENGR-2530 or ECSE-4160 and senior standing. Fall and spring terms annually. 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. 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. Design techniques are presented in lecture. The design projects require students to draw upon their engineering background, experience, and other pertinent resources. Oral and written presentations are required. Writing-intensive assignments help develop communication skills. Prerequisite: MANE-4030. Fall and spring terms annually. 3 credit hours.

MANE-4270 Dynamics and Control of Multibody Systems

MANE-4280 Design Optimization: Theory and Practice
This course introduces the student to the theory and use
of numerical design optimization methods, with a major focus on the algorithms and problem formulations relevant to engineering design. The lectures concentrate on the algorithm development while the exercises emphasize correct problem formulation and evaluation of the results. Topics include methods for unconstrained nonlinear problems, constrained linear and nonlinear problems, sensitivity analysis, multiobjective optimization, and mechanism optimization. Prerequisite: MANE-4030 or equivalent. Fall term annually. 3 credit hours

MANE-4290 Electronic Packaging
Design and fabrication of interconnection structures in electronic systems; heat transfer and mechanical and environmental protection; applications, future trends, and limitations. (Cross listed as ECSE-4290 and MTLE-4290. Students cannot obtain credit for both this course and either ECSE-4290 or MTLE-4290.) Prerequisites: senior or graduate level at Rensselaer or an undergraduate degree in engineering or science. Fall term annually. 3 credit hours

MANE-4330 Analytical Methods in Solid Mechanics I
Vectors, tensors, indicial and invariant notation, orthogonal curvilinear coordinates, integral theorems. Infinitesimal strain tensor. Conservation equations, stress tensor, equations of motion, boundary conditions. Variational procedures. Anisotropic and isotropic linear elastic constitutive equations. Elementary waves and vibrations in linear elastic solids. Prerequisites: ENGR-2530, MATH-2400 or equivalent. 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, 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. Fall term annually. 3 credit hours

MANE-4360 Introduction to Fusion Devices and Systems
Examination of the requirements and approaches for the commercial 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, engineering, and technology issues associated with fusion development. Consideration of economics, environmental, and resource implications of fusion energy systems. Prerequisite: permission of instructor. Fall term annually. 3 credit hours

MANE-4370 Nuclear Engineering and Engineering Physics Laboratory
A laboratory course covering topics in instrumentation, computer-controlled instrument interfacing and data acquisition, electronics (simple circuits, signal analysis and Fourier Transforms), applied physics, optical interferometry, laser-doppler interferometry, multiphase flow, fluid dynamics, and alpha spectroscopy. 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. Fall term annually. 3 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 experience. The product of each design project is a comprehensive report or design proposal having both global and detail completeness. Under 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 writing-intensive course. Prerequisite: permission of instructor. Fall term annually. 3 credit hours

MANE-4390 NEEP Senior Design Project II
This is a required continuation of MANE-4380. Spring term annually. 2 credit hours
MANE-4400 Nuclear Power Systems Engineering
Application of thermodynamics, heat transfer, and fluid flow principles to nuclear energy generation systems, including nuclear reactors, 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. 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. Fall term annually. 4 credit hours

MANE-4420 Radiation Technology
An introductory course on the generation, distribution, and interaction of ionizing radiation. Radiation sources such as radioisotopes, accelerators, focused ion beams, and cosmic rays are studied. Applications to semiconductor electronic devices, chemical polymerization, food preservation, sterilization, material modification, industrial and medical radiography, and radiation damage are presented. Prerequisite: MANE-2830. 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. 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. Spring term annually. 3 credit hours

MANE-4450 Nuclear Fuel Management

MANE-4460 Nuclear Power Plant Operations
Reactor instrumentation and control. License, technical specification, plans, and procedures. Limits, margins, and set points. System modeling and safety analyses. Refueling and 5059 changes. Startup and at-power tests. Surveillance. Expert systems. Power plant simulator laboratory. Operation of RPI reactor. Prerequisite: MANE-2400 or equivalent. Fall term. 3 credit hours

MANE-4470 Radiological Engineering
An introductory lecture and laboratory course on health physics principles and laboratory skills. Lecture topics include radioactive decay, dosimetry for internal and external exposures, shielding design and regulations on radiation safety. Experiments include calibration and operation of survey meters, measurements of various radioactive samples using NaI and HPGe gamma spectrometers, gas proportional counter, liquid scintillation counter, and MOSFET dosimeters, and a project on shielding design using MCNP code. Prerequisite: MANE-2830 or equivalent. Spring term annually. 4 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. 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. 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. Spring term annually. 3 credit hours

MANE-4610 Vibrations

MANE-4650 Fracture Mechanics

MANE-4670 Mechanical Behavior of Materials I
Mechanical behavior of materials and its influence on design applications. Topics include simple mechanical behavior (tension, compression, etc.), combined stress effects on deformation and fracture, ductile fracture, fracture toughness, creep behavior, fatigue, damping, and internal friction. Prerequisite: ENGR-2530. 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. Open to juniors and above. Spring term annually. 3 credit hours

MANE-4710 Advanced 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. Fall term annually. 3 credit hours

MANE-4720 Design and Analysis of Energy Systems
This course applies basic concepts of fluid mechanics and heat transfer to a wide variety of energy system components such as heat exchangers, pumps, fans, and bearings. Design and analysis techniques including modeling and simulation methods are developed for energy systems such as piping networks and refrigeration units. Prerequisite: MANE-4010. 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. 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. 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. Fall term annually. 3 credit hours

MANE-4830 Acoustics Engineering
Solutions of acoustic wave and diffusion equations; stationary and moving monopole, dipole, quadrapole 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. Spring term annually. 3 credit hours

MANE-4850 Transatmospheric Vehicle Design
Introduces all elements of the Transatmospheric Vehicle (TAV) design process from proposal preparation through detailed specification and prototyping. Students are organized into design teams to develop a solution to a TAV systems 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, engineering prototyping, and presentation skills. Writing-intensive assignments help develop communication skills. Writing-intensive assignments help develop communication skills. Prerequisites: ENGR-2250 and MATH-2400. Spring 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. Writing-intensive assignments help develop communication skills. Prerequisites: ENGR-2250 and MATH-2400. Spring term annually. 3 credit hours

MANE-4880 Analysis of Engineering Problems
An advanced course in mechanical engineering principles applied to practical engineering problems and systems. Topics vary and may include heat transfer, thermodynamics, rigid-body dynamics, fluid mechanics, and design synthesis. Complex variables and probability and statistics are also covered and applied to practical problems. A weekly project is required, with an oral or written presentation. GE/RPI students only. Prerequisite: ECSE-4470. Spring term annually. 3 credit hours

MANE-4900 Aeroelasticity and Structural Vibrations
Basic concepts in static and dynamic aeroelasticity. Divergence and control surface effectiveness, using section models. Structural vibrations, free and forced motion of discrete and continuous structures, introduction to modal analysis. Aeroelastic behavior of complex structures, dynamic aeroelasticity. The role of numerical methods will be emphasized. Prerequisites: MATH-2400, MANE-2060 and MANE-4060 or equivalent. Spring term annually. 3 credit hours

MANE-4910 Fluid Dynamics Laboratory
Laboratory experiments with primary emphasis on flow studies using subsonic and supersonic wind tunnels and shock tubes. Hot-wire anemometry and laser-Doppler velocimetry. Corequisite: MANE-4080. Fall 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, etc. Prerequisite: MANE-4060. Spring term annually. 2 credit hours

MANE-4940 Individual Projects in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
Prerequisite: permission of instructor. Fall and spring terms annually. 3 to 6 credit hours

MANE-4960 Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
Fall and spring terms annually. 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. Fall term annually. 3 credit hours

MANE-6070 Aerodynamics of Rotors
Momentum, blade element, vortex, and cascade theories. Nonuniform inflow; rigid and nonrigid wakes; rotating and fixed system interactions; steady and nonsteady flow. Static thrust (hover), axial flow (rotor ascent and descent, propeller forward flight), cross flow (rotor forward flight, propeller yaw) flight conditions. Prerequisite: MANE-4070 or equivalent. Offered on sufficient demand. 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. 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 on 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 rotodynamic phenomena. Seniors and graduate
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 on availability of faculty. 3 credit hours

MANE-6160 Advanced Design with Composites
Advanced topics in structural design with continuous-fiber advanced composites. Development of plate equations including interlaminar stresses. Introduction to and use of constrained numerical optimization program. Statistical effects on failure. Saint Venant’s principle for anisotropic materials. Failure criteria, including stress concentration effects. Plate and shell buckling. A detailed student design project is assigned. Prerequisite: MANE-4130 or permission of instructor. Spring term annually. 3 credit hours

MANE-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. (Cross listed as CIVL-6170. Students cannot obtain credit for both this course and CIVL-6170.) Spring term annually. 3 credit hours

MANE-6180 Mechanics of Composite Materials
Mechanics of elastic heterogeneous solids. Plasticity of composite materials. Thermoelastic and thermoplastic behavior. Mechanics of distributed damage. Mechanical behavior. (Cross listed as CIVL-6180. Students cannot obtain credit for both this course and CIVL-6180.) Prerequisite: one graduate course in mechanics of solids. Full term annually. 3 credit hours

MANE-6200 Plates and Shells
Preliminaries on linear, three-dimensional elasticity theory. Reduction of the elasticity theory to theories of plates and shells. Anisotropy. Nonlinear theories. Applications. (Cross listed as CIVL-6200. Students cannot obtain credit for both this course and CIVL-6200.) Annually. 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. (Cross listed as CIVL-6210. Students cannot obtain credit for both this course and CIVL-6110.) Annually. 3 credit hours

MANE-6220 Thermal Stresses
The coupled linear thermoelastic and generalized heat equations, as derived from irreversible thermodynamics. Solutions in terms of Boussinesq-Papkovitch potentials. Reduction of thermoelastic problems to isothermal elastic problems. Steady state and transient elastic, anelastic, and viscoelastic thermal-stress analysis. Offered on sufficient demand. 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. (Cross-listed as DSES-6870. Students cannot obtain credit for both this course and DSES-6870). Fall term alternate years. 3 credit hours

MANE-6250 Continuum Mechanics

MANE-6260 Applications in Linear Elasticity
Problems in isotropic linear elasticity. Torsion and flexure of bars. Plane stress and plane strain. The Boussinesq-Papkovitch potentials and their application to certain three-dimensional problems. Stress concentration and contact of elastic bodies. Dynamic potentials and wave equations. Propagation, reflection, and refraction of elastic waves. Vibrations of elastic bodies. Prerequisite: MANE-4330 or equivalent. Offered on sufficient demand. 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 on availability of faculty. 4 credit hours

MANE-6280 Nuclear Reactor Analysis II
Reactor kinetics, stability, and control. Perturbation methods, reactivity coefficients; feedback mechanisms, long-term reactivity changes. Fission product effects on reactor startup and spatial stability. Fuel depletion. Theory of control and burnable poisons. Prerequisite: MANE-4480. Fall term annually. 3 credit hours

MANE-6290 Radiation Transport Methods

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. Fall term alternate 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). Spring term alternate years. 3 credit hours

MANE-6320 Radioactive Waste Management
Characterization and description of low-level and high-level wastes. Calculational methods, radiological considerations, regulatory requirements. Radwaste treatment system in nuclear power plants, enrichment and reprocessing plants. Volume reduction and solidification of waste. Transportation and burial site practices. Environmental surveillance. Decontamination and decommissioning of nuclear facilities. Prerequisite: MANE-2400. Spring term alternate years. 3 credit hours

MANE-6350 Radiation Shielding

MANE-6360 Reactor Reliability and Safety

MANE-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 accident conditions. Prerequisite: MANE-6840 or equivalent. Offered on availability of faculty. 3 credit hours

MANE-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 zircaloy are covered. Prerequisites: MANE-4480. Offered on availability of faculty. 3 credit hours

MANE-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. Spring term alternate years. 3 credit hours

MANE-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. Fall term annually. 3 credit hours

MANE-6410 Celestial Mechanics
Introduction to celestial mechanics, orbits, and perturbations, exterior ballistics, powered flight trajectories, space flight trajectories. Offered on sufficient demand. 3 credit hours

MANE-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, Lagrange, 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. Spring term alternate 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. Spring term annually. 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 on sufficient demand. 3 credit hours

MANE-6460 Mechanical Behavior of Materials II
Failure of structural materials under cyclic stress. Topics include historical review, low cycle fatigue, role of cyclic plastic strain, mean stress, notch behavior, fatigue crack initiation and propagation, fracture mechanics approaches, J-Integral and short crack problems, environment, elevated temperature, testing methods. Spring term annually. 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. Fall term annually. 3 credit hours

MANE-6490 Plasticity
Stress invariants. Polynaxial stress-strain relation for strain-hardening materials. Ideal plasticity, various yield conditions and associated flow rules. Variational principles. Limit analysis. Applications in elastic-plastic stress analysis, metal forming, plastic collapse, and plastic instability. 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 on sufficient demand. 3 credit hours

MANE-6520 Advanced Topics in Two-Phase Flow
Treatment of advanced topics encountered in two-phase flow, including averaging of conservation equations, interfacial transport and constitutive equations, virtual mass effects, matrix formulation of two fluid modeling, well posedness, drift flux modeling and transient analysis, dynamic and continuity waves and flooding phenomena, stability analysis of two-phase systems, numerical techniques, and two-phase flow instrumentation. Prerequisite: MANE-6850. Spring term alternate years. 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 MANE-4110 or equivalent. Spring term annually. 3 credit hours

MANE-6540 Advanced Thermodynamics
General principles and applications of equilibrium thermodynamics. Second law analysis of energy systems. Thermodynamic relations, equations of state, properties of single and multiphase systems. Elementary statistical thermodynamics. Fundamentals of nonequilibrium thermodynamics. Annually. 3 credit hours
MANE-6550 Theory of Compressible Flow
General equations of compressible flow. Specialization to inviscid flows in two space dimensions. Linearized solutions in subsonic and supersonic flow. Characteristic equations for supersonic flow with applications in external and internal flow. One-dimensional nonsteady compressible flow. Introduction to transonic flow. Prerequisite: MANE-4070 or equivalent. Fall term annually. 3 credit hours

MANE-6580 Gas Dynamics
Properties of gases at high temperatures; thermodynamics and chemical kinetics. Macroscopic description of high-speed flows of chemically reacting and ionized gases. Shock tube theory and applications. Reentry aerodynamics. The interaction of high-speed plasma flows with electromagnetic fields. Prerequisite: permission of instructor. Offered on availability of faculty. 3 credit hours

MANE-6610 Transonic Aerodynamics
Introduction to the equations of inviscid compressible flow; expansion procedure for airfoils in transonic flow and the Karman-Guderley equation; transonic-shock jump relations; the hodograph equations for transonic flow, with elementary applications; lift and drag integrals; transonic far fields; axially symmetric flow. Prerequisite: MANE-6550 or equivalent. Spring term alternate years. 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. 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. Annually. 3 credit hours

MANE-6650 Convective Heat Transfer
Fundamental study of convection 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. 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. (Cross listed as CIVL-6660. Students cannot obtain credit for both this course and CIVL-6660.) Prerequisite: MATH-2400 or equivalent. Fall term annually. 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. (Cross listed as CIVL-6670. Students cannot obtain credit for both this course and CIVL-6670.) Prerequisite: CIVL-6660 or MANE-6660. Fall term odd-numbered years. 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. (Cross listed as CIVL-6680. Students cannot obtain credit for both this course and CIVL-6680.) Prerequisite: CIVL-6660, MANE-6660, CSCI-6860 or MATH-6860. Spring term odd-numbered years. 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. (Cross listed as CIVL-6690. Students cannot obtain credit for both this
course and CIVL-6690.) Prerequisite: CIVL-6660 or MANE-6660. Spring term even-numbered years.

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. (Cross listed as CIVL-6700. Students cannot obtain credit for both this course and CIVL-6700.) Prerequisite: CIVL-6660 or MANE-6660. Fall term odd-numbered years.

3 credit hours

MANE-6710 Design and Simulation of Experiments in Heat and Mass Transfer
This graduate course provides interactive, hands-on learning of experimental techniques, finite element modeling and fundamentals of fluid mechanics and heat transfer. Topics include analogy between heat, mass, and momentum transfer. Dimensional analysis. Steady state and transient techniques for property measurements. Errors. Heat transfer coefficients in forced and free convection. Shear stress and friction coefficients on the flat plate. Enclosures. Prerequisites: MANE-6630 and MANE-6650, or equivalent. Fall term annually.

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 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. 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. 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. 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. 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. Spring term odd-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. (Cross listed as CIVL-6780. Students cannot obtain credit for both this course and CIVL-6780.) Prerequisite: CIVL-6660 or MANE-6660. Spring term even-numbered years.

3 credit hours

MANE-6790 Mathematical Applications in Nuclear Engineering and Engineering Physics
Advanced methods of mathematics with applications to...
problems relating to a broad range of mathematical physics such as required for analysis of fluid mechanics, heat transfer, nuclear reactions, bending and vibrations, wave motions. Ordinary and partial differential equations, Laplace transforms, series solutions, boundary value problems, vector analysis, higher-dimensional calculus, complex variables. Prerequisite: MATH-2400. Spring term annually. 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. Fall term annually. 3 credit hours

MANE-6810 Advanced Manufacturing Methods
Some of the basic principles and recent developments in advanced manufacturing processes and methods will be covered. Basics of mechanics of materials and plasticity theory will be covered initially. Areas of manufacturing to be examined are Part Description, Primary Forming, Secondary Forming, and Finish Machining. Examples of these areas are to be given and follow a selected and logical sequence of design and manufacturing. Spring 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. 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. (Cross listed as CHME-6830. Students cannot obtain credit for both this course and CHME-6830.) Prerequisite: permission of instructor. Spring term odd-numbered years. 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. Students satisfactorily completing this course are expected to thoroughly understand the current thermal-hydraulics literature on multiphase heat and mass transfer and be able to conduct independent research in this field. (Cross listed as CHME-6840. Students cannot obtain credit for both this course and CHME-6840.) Prerequisite: a working knowledge of fluid mechanics and heat transfer. Fall term annually. 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. (Cross listed as CHME-6850. Students cannot obtain credit for both this course and CHME-6850.) Prerequisite: CHME-6840 or MANE-6840. Spring term annually. 3 credit hours

MANE-6860 Rotary Wing Structural Dynamics I: Vibrations
Dynamics of flexible rotating beams, gyroscopic motion, drive system dynamics. Analysis of fuselage vibrations, with emphasis on rotor-fuselage coupling and design for minimum vibration; vibration test procedures. Prerequisite: MANE-4610. Annually. 3 credit hours

MANE-6870 Rotary Wing Structural Dynamics II: Aeroelastic Stability
Continuation of MANE-6860 with emphasis on aeromechanical and aeroelastic stability of rotors and rotor-pylon systems; stability of linear multi-degree-of-freedom systems, Floquet theory, ground and air resonance, unsteady aerodynamics, stall flutter, test procedures. Prerequisites: MANE-6860, MANE-4900 and MANE-4070 or equivalent. Annually. 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 (Cross listed as MGMT-6890. Students cannot obtain credit for both this course and MGMT-6890). Prerequisites: Engineering B.S. or MGMT-6040 and MGMT-6050 or MGMT-6620 or permission of the instructor. Spring term annually.
MANE-6890 Mechanical Diagnostics
A comprehensive introduction to mechanical fault detection, isolation, and severity assessment. Topics include mechanical fault signature generating mechanism; advanced mechanical signal processing including time domain processing, frequency domain processing and time-frequency distribution; system identification and model-based diagnostics; pattern classification techniques and diagnostic algorithms for mechanical components including rolling bearings, gears, and cutting tools. Prerequisite: MANE-4050 or equivalent. Fall term annually. 3 credit hours

MANE-6900 Seminar
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. Fall and spring terms annually. 3 to 6 credit hours

MANE-6960 Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
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 Graduate School 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 IP are assigned until the thesis has been approved by the faculty adviser 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

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

MANE Mechanical, Aerospace, and Nuclear Engineering at Hartford (SOE)

MANE-5060 Introduction to Compressible Flow
One-dimensional isentropic compressible flow. Normal stationary and moving shock waves. Design on inlet and ducted diffusers, steady flow wind tunnels and shock tubes. Flow in ducts with friction and heat transfer. Offered biannually. 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. Offered biannually. 3 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. 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. Fall and spring terms annually. 4 credit hours
MATH-1500 Calculus for Architecture, Management, and H&SS  
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 H&SS. Fall term annually. 4 credit hours

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. 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 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 and Humanities and Social Sciences and MATH-1010 or MATH-1500 or permission of instructor. 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. These courses cannot be used to help satisfy the eight credit hours of mathematics bachelor’s degree requirement. Prerequisite: first-year math majors. 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. These courses cannot be used to help satisfy the eight credit hours of mathematics bachelor’s degree requirement. Prerequisite: first-year math majors. Fall 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. 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. Fall and spring terms annually. 4 credit hours

MATH-2700 Fundamentals of Mathematics  
This course is designed to assist students who will be taking 4000-level advanced mathematics courses. The main emphasis is on the development of sound mathematical reasoning and construction of solid mathematical proofs. Mathematical ideas and concepts from the foundations of the number system, set theory, logic, algebra, and elementary topology are selected as illustrations. Students are challenged to develop their own conceptual understanding of the mathematical proof, and to defend their mathematical positions. Prerequisite: math major or permission of instructor, and MATH-1020. Spring term 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 well-ordering; principles of counting; relations and graphs; recurrences; discrete probability. Prerequisite: MATH-1010 or MATH-1500 or equivalent. 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 including algebraic aspects of set theory, of relations and functions, and of number theory. Prerequisite: a readiness to reason abstractly; MATH-4100 is desirable but not required. 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 cryptology, 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. Spring term odd-numbered years. 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 Mobius strips, Klein bottles, identification spaces, homotopy, the fundamental group of a surface, sequences in topological spaces, pseudo-metric spaces, completeness, Baire category, space-filling curves, weak topologies, quotient spaces, strong topologies, hyperspaces, the Hausdorff metric, and topological dimension. Corequisite: MATH-4200. Fall term even-numbered years. 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, eigenvalues, minimal polynomials, canonical forms of linear transformations; inner products, adjoints, orthogonal projections and complements. Prerequisite: MATH-2010. 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. 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. (Cross listed as CSCI-4260. Students cannot obtain credit for both this course and CSCI-4260.) Prerequisite: CSCI-2300. Spring term even-numbered years. 4 credit hours

MATH-4200, MATH-4210 Mathematical Analysis I, II
Fundamental concepts of mathematical analysis. A two-term sequence covering such topics as the real number system, limits, sequences, series, continuity, uniform convergence, functions of one variable, differential and integral calculus. Fall-spring sequence annually. 4 credit hours each

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. 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. Topic 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. 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. 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. Prerequisite: MATH-2010. 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. 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. Fall term odd-numbered years.  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. 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. (Cross listed as CSCI-4800. Students cannot obtain credit for both this course and CSCI-4800.) Prerequisites: CSCI-1100 and MATH-2010 or ENGR-1100. Corequisite: MATH-2400. Fall and spring terms annually.  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. (Cross listed as CSCI-4820. Students cannot obtain credit for both this course and CSCI-4820.) Prerequisite: MATH-4800 or CSCI-4800 Spring term annually.  4 credit hours

MATH-4940 Readings in Mathematics
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. Open to mathematics seniors only. To be graded S/U.Fall term annually.  4 credit hours

MATH-4960 Topics in Mathematics
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. Open to mathematics seniors only. To be graded S/U.Fall term annually.  4 credit hours

MATH-4980 Undergraduate Project in 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. Spring term even-numbered years.  4 credit hours

MATH-4990 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. 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. 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. 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. Prerequisite: MATH-6220 or equivalent or permission of instructor. 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. 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-Bendixon 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. 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. 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. 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. 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. 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. 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. Spring term odd-numbered years.  4 credit hours

MATH-6740 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, shock capturing and tracking schemes), methods for elliptic problems (finite difference and finite volume methods). (Cross listed as CSCI-6840. Students cannot obtain credit for both this course and CSCI-6840.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Fall term odd-numbered years.  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, biometrics, and finance. Prerequisites: vary with topic. 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. (Cross listed as CSCI-6800. Students cannot obtain credit for both this course and CSCI-6800.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Fall term annually.  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. (Cross listed as CSCI-6820. Students cannot obtain credit for both this course and CSCI-6820.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Spring term odd-numbered years.  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 dispersion, shock capturing and tracking schemes), methods for elliptic problems (finite difference and finite volume methods). (Cross listed as CSCI-6840. Students cannot obtain credit for both this course and CSCI-6840.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Fall term odd-numbered years.  4 credit hours

MATH-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. (Cross listed as CSCI-6860. Students cannot obtain credit for both this course and CSCI-6860.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Spring term even-numbered years.  4 credit hours

MATH-6880 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. (Cross listed as CSCI-6800. Students cannot obtain credit for both this course and CSCI-6800.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Fall term annually.  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. 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. Fall term annually.  1 credit hour

MATH-6951 Introduction to Research in Mathematics
This seminar introduces first-year graduate students in mathematics 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. Spring term annually.

MATH-6960 Topics in Mathematics
1 credit hour

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 required by the adviser, but is not submitted to the Graduate School 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 supervision of a faculty adviser, leading to a master’s project report. 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 the library. Grades will then be listed as S.

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 Education to be archived in a standard format in the library. Grades will then be listed as S.

MATP Mathematical Programming, Probability, and Mathematical 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. (Cross listed as DSES-4750. Students cannot obtain credit for both this course and DSES-4750.) Prerequisite: MATH-1020 or equivalent or permission of instructor. Fall term annually.

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. (Cross listed as DSES-4760. Students cannot obtain credit for both this course and DSES-4760.) Prerequisite: DSES-4750 or MATP-4600 or equivalent calculus-based course. Spring term annually.

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. (Cross listed as DSES-4770. Students cannot obtain credit for both this course and DSES-4770.) Prerequisites: MATH-1020, and MATH-2010 or ENGR-1100, or equivalent, or permission of instructor. Fall term annually.

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. (Cross listed as DSES-4780. Students cannot obtain credit for both this course and either MATP-6610 or DSES-4780.) Prerequisites: MATH-2010 or ENGR-1100, and CSCI-1100 or permission of instructor. Spring term annually.

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-4970 Master’s Practicum 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. (Cross listed as DSES-6780. Students cannot obtain credit for both this course and DSES-6780.) Prerequisite: MATH-4200 or equivalent or permission of instructor. Fall term annually. 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 either DSES-4780 or MATP-6610. 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. (Cross listed as DSES-6760. Students cannot obtain credit for both this course and DSES-6760.) Prerequisite: MATP-4700 or DSES-4770. Spring term odd-numbered years. 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. (Cross listed as DSES-6770. Students cannot obtain credit for both this course and DSES-6770.) Prerequisite: MATP-4700 or DSES-4770. Spring term even-numbered years. 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. 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 and Technology (MGMT)

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. It is offered in the fall and spring terms annually. 4 credit hours

MGMT-1240 and MGMT-1250 Management Leadership 1 and 2
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. Fall and spring sequences annually. 2 credit hours each

MGMT-1260 External Environment of Business
Introduction to the legal, ethical, social, technological, environmental, political, and economic considerations underlying, defining, and creating modern management responsibilities. 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. 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. 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. 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. 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. Fall and spring terms annually. 1 to 4 credit hours per course, not to exceed 12 for this course number

MGMT-2960 Topics in Management 4 credit hours

MGMT-4020 Junior Achievement
Junior Achievement Inc. is a nonprofit organization financed by over 100,000 businesses, foundations, and individuals. Junior Achievement’s stated purpose is to educate and inspire young people to value free enterprise, to understand business and economics, and to become workplace ready. It is the purpose of the class to carry out Junior Achievement’s mission in the 6th, 7th, and 8th grade classes that students will teach at Doyle Middle School in Troy, NY. All materials are provided, and students will have a unique opportunity to develop presentation and leadership skills while contributing to the youth of our community. Fall and spring terms annually. 4 credit hours

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. Fall and spring terms. 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. 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. 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. Fall and spring terms. 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. Fall and spring terms. 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. Fall and spring terms 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 on availability of instructor. 4 credit hours

MGMT-4230 Manufacturing Accounting and Control Systems
This course provides the students with an understanding of basic cost accounting and of current topics in manufacturing accounting. In particular, the course covers activity-based costing and management systems, standard costing, and transfer pricing. Although the course is primarily oriented toward manufacturing environments, the principles covered are directly applicable to service industries. Prerequisites: MGMT-2300 and MGMT-2100. Offered on availability of instructor. 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. Fall and spring terms. 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. 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. Prerequisite: MGMT-2320. 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. Principles of option and futures pricing and strategies. Prerequisites: MGMT-2320 and MGMT-4320. 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. Fall and spring terms annually. 4 credit hours

MGMT-4370 Risk Management
Analysis and management of some non speculative risks in business, and management devices available for dealing
with them. Insurance, the most important of these, is dealt with extensively. Intelligent employment of insurance makes possible the transfer of significant risks, at minimum and known cost. Self-insurance considered. Case studies are employed to demonstrate the principles and objectives of static risk management. Prerequisite MGMT-2320. Spring 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. Spring term biannually. 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. Fall and spring terms 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. 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. Prerequisites: DSES-2010 or equivalent and MGMT-4430. 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. 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. Students benefit greatly from the active participation of Professor Ivar Giaevar, Nobel-prize winning scientist. 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. 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. Fall and spring terms annually. 4 credit hours

MGMT-4550 Business Models for Digital Enterprises
This course is designed as a survey introduction of the range of topics in an e-business. It will consider both entrepreneurial and ongoing organizations. It considers examples of both entrepreneurial approaches and innovation within established companies in areas such as business-to-business (B2B) or business-to-consumer (B2C). Topics include: supply chain management,
customer resource planning, organizational design and virtual firms, security and privacy, finance and valuation, and implementation of e-business technologies and strategies in existing firms. The course will evolve due to the varied interests of participants and changes in the e-business marketplace. Prerequisites: MGMT-1100, MGMT-2300, MGMT-2320, MGMT-4140 or equivalent information technology course, or permission of the instructor. Fall term annually. 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 analysis are used in class to help provide students with insights into these processes. Fall and spring term. 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 and is presented in the fall and spring terms. 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. Fall and spring terms. 4 credit hours each

**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. 1 to 8 credit hours

**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 persons. Using a combination of case studies and simulations, the course offers a weeklong immersion experience into the mindset, actions and concerns of true business innovators. 0 credit hours

**MGMT-6020 Economic & Financial Analysis I**
This course provides MBA students with a broad array of fundamental business tools and skills in the areas of accounting, finance, economics and statistics. With these tools in hand, students will be better able to analyze, evaluate and assess business performance, productivity, and outcomes as well as develop effective management decision-making capabilities. Among the specific skills taught will be understanding accounting records, financial report analysis, financial forecasting and investment analysis, evaluating economic and stakeholder interests, and developing the analytical tools to understand and react to changes in broad economic policies and regulations in the macro-economy from both a domestic and international perspective. 9 credit hours

**MGMT-6030 Economic & Financial Analysis 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 Creating and Managing an Enterprise I**
This course is designed to help students understand the critical challenges and tasks associated with developing, growing, and managing a successful business. Students learn how to lead and manage an enterprise as well as gain a fundamental understanding of each functional department required to operate a business and how each fits into the greater scope of the business organization. 3 credit hours
MGMT-6050 Creating and Managing an Enterprise II
This course builds upon the principles learned in Creating and Managing the Enterprise I within the context of start-ups, internal new ventures, strategic alliances, joint ventures, and other organizational forms. Success in creating and managing any business is contingent upon careful analysis and management of five key segments–people, product, market, finances, and competition. Students have an opportunity to put into practice the latest management theory while balancing the resources and constraints of these five segments. 3 credit hours

MGMT-6060 Business Implications of Emerging Technologies I
This course investigates the business dimensions of major technological advances, highlighting how industry structures and 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-6070 Business Implications of Emerging Technologies II
The second of our Business Implications of Emerging Technology courses further investigates the business dimensions of major technological advances, highlighting how industry structures and 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 I
This course considers the evolving 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). Summer term. 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 integration of analysis techniques to address the management issues at hand, with 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). Summer term. 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.
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. Fall term.

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 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. Spring term.

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. (Cross listed as DSES-6550. Students cannot receive credit for both courses.) Prerequisite: MGMT-6140 or equivalent. Spring term.

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. Spring term.

MGMT-6190 Financial and Managerial Accounting
The nature and role of finance; the financial system; accounting for financial activities; valuation concepts and the balance sheet; revenue recognition, cost determinants, and the income statement; financial planning and budgeting; the cash budget, statement of sources and uses of funds, and pro forma statements; capital budgeting under certainty, project evaluation, and selection; profit planning and break-even analysis; fund accounting for governmental and nonprofit organizations. 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. Fall term.

MGMT-6210 Advanced Accounting
This course teaches MBA/M.S. Management students advanced theory and practice of contemporary accounting issues. The first part, advanced financial accounting, examines accounting for business combinations, consolidation of financial statements, foreign currency translation, leases, pensions, and employee stock options. The second part, advanced managerial accounting, covers applications of advanced costing models and advanced managerial accounting systems, including activity-based costing, balanced scorecard, and EVA. Prerequisite for MBA cohorts: MGMT-6020. Spring term.

MGMT-6230 Advanced Environmental Economics
This course examines neoclassical and other approaches to environmental economics. This key is determining when and which additional approaches are required to take into account environmental considerations for economic issues and questions. The course stresses both applied microeconomics concepts of market solutions and broader policy notions such as sustainability. Spring term.

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, MGMT-6310, or permission of instructor. Spring term. 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. Spring term. 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. Fall term. 3 credit hours

MGMT-6300 Business Economics
This course is an introduction to the economic environment in which a manager operates. Elements of this environment include the concepts of marginality and the trade-offs among conflicting goals. Microeconomic dimensions include cost and production theory, demand theory, and market theory. The macroeconomic elements of importance include the relations among gross output, income, and employment, and the effect of governmental economic policy on the operations of the firm. 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. Prerequisites: MGMT-6190 and MGMT-6300. Spring term. 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-6310. This course available to Hartford students only. Fall term. 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 available to Hartford students only. Spring term. 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-6310 or MGMT-6020 and MGMT-6300. Fall term. 3 credit hours

MGMT-6350 International Business
An integrated course on the international aspects of the modern corporation emphasizing the basic principles of international trade, investment decisions, and the operational management of an established multinational enterprise. The strategies necessary for competing in global markets. The course will provide students with an understanding of business decision making in a global environment. Prerequisites: MGMT-6310, or MGMT-6020 and MGMT-6300, or permission of instructor. Spring term. 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-6310, or MGMT-6020 and MGMT-6300. Spring term. 3 credit hours

MGMT-6370 Derivatives Markets
Institutional structure of the markets for derivatives, hedging and basis risk, interest rate, and stock-index derivatives with financial management applications. Introduction to options, rational option pricing restrictions, binomial option pricing model, put and call option strategies. 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. Prerequisite: MGMT-6310, Corequisite: MGMT-6320. Spring term. 3 credit hours

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-6310 or MGMT-6020 and MGMT-6030. Fall term. 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. Spring term. 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 must have doctoral standing and should have taken at least two finance courses and MGMT-6100. 3 credit hours

MGMT-6410 Investments
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. Spring term. 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. Prerequisites: DSES-6110 and DSES-6230 or equivalent. (Cross listed as DSES-6170. Students cannot obtain credit for both this course and DSES-6170.) Fall term. 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. (Cross listed as DSES-6480. Students cannot obtain credit for both this course and DSES-6480.) Spring term. 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. Fall term. 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. Fall term annually.

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. Prerequisites: permission of instructor. Fall term.

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. Prerequisites: MGMT-6100 or permission of instructor. Spring term.

MGMT-6560 Managing New Product Development
This course focuses on the basics of new product development. Using multimedia and interactive learning materials and simulations, students get an understanding of the importance of the integration of design, manufacturing, and marketing. Prerequisites: access to a computer with CD ROM and Internet access. 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. Fall term.

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. Prerequisites: permission of instructor. Spring term.

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. Spring term.

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. (Cross listed as DSES-6470; students cannot obtain credit for both this course and DSES-6470). Fall term.

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. Fall term.

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. Spring term.
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. Spring term. 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. Fall term. 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. Spring term. 3 credit hours

MGMT-6670 Practicum in Technological Entrepreneurship
Provides students with opportunities to learn, by practical fieldwork, how successful new technological ventures are created, developed, and financed. Students work in small teams with guidance from experienced entrepreneurs. Business plans are developed, and a formal report to a sponsoring company is required. Prerequisite: MGMT-6620. Spring term. 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 5-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. Spring term. 3 credit hours

MGMT-6690 Supply Chain Management
This course examines how the Internet and emerging e-business models are transforming the flow of products, information, and revenues across supply chains. It focuses on how inter-enterprise integration and value chain constellations can be deployed to effectively detect and fulfill custom needs in a cost-effective manner by eliminating traditional constraints in supply chain design, dislodging obsolete intermediaries, and creating new forms of value added intermediation. The role of exchanges and hubs in the procurement of industrial goods and services will also be examined in depth. Concepts will be discussed for different types of products such as physical goods, informational goods, and services. Students will develop the ability to conceptualize design and implement supply chains for e-business organizations. Prerequisites: Background in marketing or operations management and a background in information technology are required to enroll in this course. The background could have been obtained either through appropriate course work or through work experience. Fall term. 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. Spring term. 3 credit hours

MGMT-6710 Designing, Developing, and Staffing High-Performance Organizations I
This course is concerned with different ways organizations change and learn. Taking a systems approach, implications on the organizations and on people are considered with topics such as team building motivation, communication, decision making, organizational design, leadership, and socialization. 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. Summer term. 3 credit hours

MGMT-6720 Designing, Developing, and Staffing High Performance Organizations II
This course focuses on the human resources function and activities within a firm such as recruiting, selection,
compensation, reward systems, evaluation, careers, labor relations, and job design. It also explores how the strategic implications of human resources function within an organization and how HR contributes to organizational success. The course is intended for students enrolled in the M.S. program, the part-time MBA, or those seeking degrees in other schools at Rensselaer. Spring and summer terms.

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. Fall term.

MGMT-6740 Technology and Organization
This course explores our current understanding of the relationship between technological and organizational change. It draws on current research in management, engineering, science, and the humanities and social sciences to examine the diverse ways in which technology affects the character of organizational life and structure.

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. Fall term.

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. Doctoral course or permission of instructor.

MGMT-6800 Ethical, Political, and Legal Context of Business
Issues and forces of the environment of business including social and cultural, public policy and legal, technological, economic, physical, and international. Changing environment and pressures upon business. Managerial ideology and practices. Values and ethics. Technology: history of innovation, productivity, assessment, societal effects. Business and government relationships; legal framework of business. Corporate governance and management. Relations with the various constituencies of the business firm. 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. Fall, spring, and summer terms.

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. Fall term.

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.

MGMT-6830 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.

MGMT-6850 Environmental Management and Policy
Documents, assesses, and explains recent changes in executive positions, programs, and tactics concerning
environmental management. Topic areas include environmental audits and quality assurance programs, regulatory compliance and corporate strategy, community right-to-know initiatives, relation of energy planning to environmental externalities. This course satisfies an EMP core requirement and is open to all MBA students and graduate engineers. Fall term.

**MGMT-6890 Product Realization**
Understand how ideas become real products. Concepts and tools that enable business and engineering leaders to jointly make sound technology/business decisions will be taught and exercised in the context of a project that will enhance the chances of success of a New Venture business. Topics: Off-line Invention vs. Disciplined Product Realization Processes, Project Funding Decisions for New Venture and Established Firms, Customer Contract, Technical Risk Management, Quality and Management of Variability, World-class design, Value Engineering, Sourcing Components and Technology, Product Reliability, Testing and Product Launch Decisions. Prerequisites: undergraduate degree in any engineering field or MGMT-6050 or equivalent. Undergraduates who have completed the engineering capstone course or an equivalent experience for business students may also be admitted with the instructor’s permission. Spring term.

**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. We review the underpinnings of scientific theory and 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. 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. 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 economic, 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. Full term.

**3 credit hours**

**MGMT-6940 Independent Study**
1 to 6 credit hours

**MGMT-6960 Topics in Management**
3 credit hours

**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-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 Graduate School 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.

**MGMT-7010 Decision Models**
This course examines how decision models are used in industries by companies to make specific choices in key functional areas, including research and development, operations, finance, accounting, and marketing. With the advent of powerful computers and easy access to information, decision models are playing a critical role in supporting managerial decision-making. Students learn how to apply these tools to real business issues, such as new product analysis, cash/budget management, project management, sales force allocation, and facility location.

**1 credit hour**

**MGMT-7020 Global Business**
This course examines the recent changes occurring in the international business environment, providing students a managerial framework to review and assess the impact of these changes on business thinking, organization and operation. By examining different corporate responses to globalization, students develop in-depth insights into how management practices, business architectures, and operational platforms have been affected by global and
region forces as well as local cultures and socio-political factors.

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.

MGMT-7040 Strategy, Technology & Competition II
This second course in the strategy sequence integrates multiple elements of the MBA program into a major project that provides students a platform to explore their overall understanding of the critical role of strategy in an existing or new business situation. With the cooperation of an actual new venture or not-for profit organizations, student teams write and present operational, business, and strategic plans with near-term and long-range projections. This project is accompanied by a capstone simulation project, “CapSim,” that develops the practical understanding of business and makes the subject relevant, rigorous, and complex.

MGMT-7050 Developing Innovative New Products and Services 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.

MGMT-7060 Developing Innovative New Products and Services 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.
MTLE Materials Science and Engineering (SOE)

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. Spring term. 4 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. 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. Fall term. 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. Fall term. 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-1300, ENGR-1600 or equivalent. 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-1300, ENGR-1600. Spring term annually. 4 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. Spring semester 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. Fall semester of the second year of the MBA cohort for five days prior to semester start. Offered fall semester. 0 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-4160 Semiconducting Materials
Review of electronic properties of materials. Growth and
classification of semiconductors. Diffusion, ion implantation,
formation, 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. Spring term.
3 credit hours

MTLE-4200 Properties of Engineering Materials I
Introduction to wave mechanics of particles. Applications
to harmonic oscillator, free electrons, Kronig-Penney and
Ziman models. Electron energy bands in solids. Charge
carrier transport. Electrical conductivity of metals and
semiconductors. Junctions and devices based on them.
Microelectronics, dielectric and optical properties of
materials. Optoelectronic devices. Includes laboratory.
Prerequisites: ENGR-1600, MTLE-2100, PHYS-1200. Fall
term annually.
3 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.
Spring term annually.
4 credit hours

MTLE-4290 Electronic Packaging
Design and fabrication of interconnection structures in
electronic systems; heat transfer and mechanical and
environmental protection; applications, future trends, and
limitations. (Cross listed as ECSE-4290 and MANE-4290.
Students cannot receive credit for both this course and
either ECSE-4290 or MANE-4290.) Prerequisite: senior
or graduate level at Rensselaer or an undergraduate degree
in engineering or science. Fall term.
3 credit hours

MTLE-4310 Corrosion
Mechanisms, characteristics, and types of corrosion.
Methods for testing, combating, and evaluating corrosion
resistance. Suitability of metals, ceramics, and organic
materials in corrosive environments. Oxidation and other
high-temperature gas-metal reactions. Spring term.
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. Fall term annually. Includes laborato-
ry experience.
4 credit hours

MTLE-4410 Welding Processes and Metallurgy
Fundamental principles, primary variables, and
metallurgical changes 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
transformations, 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. Practical
examples highlight theory. Hands-on laboratory exercises
complement lectures. Prerequisite: ENGR-1600. Fall
term.
3 credit hours

MTLE-4420 Joining of Advanced Materials
Individual joining processes including mechanical
fastening, adhesive bonding, welding, brazing, soldering,
thermal spraying, and variants or hybrids of these.
Advantages and disadvantages, mechanisms 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. Prerequisites: ENGR-1600 and ENGR-2010. Fall
term.
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 removal processes, and
annealing/heat treatment processes. Includes laboratory
component. Prerequisite: MTLE-4400. Spring term
annually.
4 credit hours

MTLE-4630 Composites Laboratory
Fabrication and characterization of composite materials
and structures. Characterization techniques include
strength, stiffness, adhesive shear strength, coefficient
of thermal expansion, and differential thermal analysis. A
short design project involving a composite structure is
carried out. Laboratory sessions are complemented by a
weekly lecture. Prerequisite: ENGR-1600. Spring term.
3 credit hours, 5 contact hours

MTLE-4910 Design in Materials Engineering
Basic design concepts and the underlying structure-
property-process-performance interaction. Engineering
materials, structures and properties, principles and process
of materials selection, generation of materials
MTLE-4100 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. Spring term.

MTLE-4110 Phases and Phase Transformations

MTLE-4910 Advanced Electron Microscopy
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. Prerequisite: MTLE-2100 or MTLE-6040. Fall term.

MTLE-4920 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. The course revolves totally around a design project, focusing on the structural properties-process-performance interaction underlying all design, with no homework or exams; just memos on progress, individual and group meetings with the instructor, conceptual design report, project notebook or journal, and final report. Prerequisite: satisfactory completion of MTLE-4910. Spring term.

MTLE-4960 Topics in Materials Engineering
Spring term annually.

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. Fall term.

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. Fall term.

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. Spring term.

MTLE-6060 Kinetics of Materials Reactions I

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. Prerequisite: MTLE-2100 or MTLE-6040. Fall term.

MTLE-6100 Advanced Electron Microscopy
The theory and practice of image interpretation in transmission electron microscopy, including kinematical and dynamical theory of electron diffraction, contrast analysis of defects, lattice and structure imaging, convergent beam diffraction. Prerequisite: MTLE-6040 or equivalent. Spring term.

MTLE-6110 Diffusion in Solids

MTLE-6150 Fracture of Solids

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.

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. (Cross listed as ECSE-6300. Students cannot obtain credit for both this course and ECSE-6300.) Prerequisite: ECSE-4250 or equivalent. Spring term annually. 3 credit hours

MTLE-6350 Composite Materials
Introduction to fiber-reinforced composites: atomistic basis for ultimate properties of solids; flaws and flaw distributions; shear-lag model for fiber/matrix stress transfer; predictions of composite strength and toughness as related to real material behavior. Preparation, advantages, and limitations of fiber reinforcements, and of polymer, metal, and ceramic matrix composites are discussed. Anisotropic continuum representations as well as test and characterization methods are introduced. Prerequisites: graduate standing in material science or consent of instructor. Fall term. 3 credit hours

MTLE-6400 Vacuum Techniques
Principles and practice of producing, measuring, and using pressures from atmospheric down to $10^{-15}$ atmospheres. Gas kinetics and flow of gases at low pressures. Basic vacuum system calculations. System design and leak detection. Physical and chemisorption of gases. Generation of clean surfaces and study of reactions on them. Spring term. 3 credit hours

MTLE-6420 Surface Phenomena

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. Fall term odd-numbered years. 3 credit hours

MTLE-6450 Melting and Solidification

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. Spring term even 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. Spring term. 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. Spring term. 3 credit hours

MTLE-6830 Deformation of Materials and Rheology
A course intended to acquaint the student with the phenomenological description of constitutive equations for solids and melts. The necessary background material on stress tensors, strain tensors, rate-of-deformation tensors, invariants, principal axes, and isotropic and deviatoric tensors is fully developed. Specific applications include the linear elastic solid, the anisotropic elastic solid, the nonlinear elastic solid, the viscoelastic solid, creep, relaxation, yielding, viscoelastic fluids, and viscometric flows. The required mathematics background is a course in linear algebra (matrices) or equivalent. Fall term. 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. Spring term. 3 credit hours

MTLE-6900 Graduate Seminar
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

MTLE-6940 Materials Engineering Project
3 credit hours

MTLE-6960 Topics in Materials Engineering
3 credit hours

MTLE-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 Graduate School 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.

MTLE-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

MTLE-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser 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

MTLE-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

NSST Natural Science for School Teachers

NSST-4110 Introduction to Instructional Technologies
This course is designed to improve high school mathematics and science education by enabling teachers to develop classroom materials using modern instructional technologies. Among specific topics are spreadsheets, data acquisition and visualization in computer based labs, simulation, hyper-and multi-media, mathematical software, modern calculators. This course may not be used for credit in any program except the M.S. in Natural Sciences. Summer term.

4 credit hours

NSST-4120 Teaching with Technology
This course will continue the work of the preceding course, Introduction to Instructional Technologies, into the use of computer networks such as the World Wide Web, and a further exploration of the computer in laboratory science. Discussions will center on the best ways to apply instructional technologies to enhance the educational environment. Students will develop a philosophy of technology integration to guide them in the appropriate application of technology in the classroom. This course may not be used in any program except the M.S. in Natural Sciences. Summer term.

4 credit hours

NSST-4310 Nature of the Mathematical Sciences
Participants in this course will explore the nature of mathematics by working on a variety of mathematical problems including some questions which are considered open questions by most mathematicians. In addition, participants will consider the important role of mathematics as a tool in other areas of study, especially science. There will be an emphasis on important mathematical concepts, history, and applications that are suitable for use in secondary school classrooms. Emphasis will also be placed on methods of communicating mathematics and science as well as developing the mathematical and scientific abilities of young people. This course may not be used in any program except the M.S. in Natural Sciences. Summer term.

3 credit hours

NSST-4350 Engineering Math Methods and Physical Principles I
Mathematical skills are built through modeling of physical systems with a review of physical principles and the modeling and solution of basic engineering problems. This first course treats familiar physical phenomena, geometric relationships, force balances, conservation laws for fluid and electrical systems. Engineering software such as MarLab will be used. Studio course. Prerequisite: admission to the M.S. in Engineering Principles program. Summer term.

3 credit hours
NSST-4400 Foundations of Instruction and Learning in Secondary School Education I
Drawing from on-site secondary school classroom experiences in local schools, students are led to topics in educational and cognitive psychology, pedagogy in teaching mathematics and science, and history, philosophy, and sociology of education. Each week there will be at least 5 hours of field work required and 4 1/2 hours of a problem-solving seminar at Rensselaer. No prerequisites, but a course in general, cognitive, or adolescent psychology desirable. Restricted to students admitted to the Rensselaer Teacher Education Program. Fall term. 6 credit hours

NSST-4410 Foundations of Instruction and Learning in Secondary School Education II
A continuation of NSST-4400. Students spend at least four hours per week working with teachers in the Troy School District and four hours each week in a problem-solving experience at Rensselaer. (Cross listed as PSYC-4430. Students cannot obtain credit for both this course and PSYC-4430.) Spring term annually. 6 credit hours

NSST-4420 Student Teaching in the Secondary School
As part of their academic requirements, students work full time as student teachers in a local secondary school classroom gradually taking on full-time teaching responsibilities in the content areas where teaching certification will be granted. Students are supervised by a local Mentor Teacher and by a Rensselaer faculty member or adjunct. Fall term annually. This course is offered on a satisfactory/unsatisfactory basis. 0 to 9 credit hours

NSST-4440 Student Teaching Seminar
Student teachers meet in a seminar once a week at Rensselaer to discuss their classroom teaching experiences and to reflect upon the relationship between their present student teaching experience and the previous year’s work. Corequisite: NSST-4420. Fall term annually. 3 credit hours

NSST-4450 Secondary School Instructional Materials Design
A reading or research course. Students work on state-of-the-art instructional technologies to produce innovative curriculum materials reflecting the subject content of the area where teacher certification will be granted. Spring term annually. 4 credit hours

NSST-4610 Nature and Processes of Natural Sciences
The content of this course will be drawn from the areas of motion, energy, electricity and magnetism, and the periodic table of the elements. Work will center around the great ideas in the physical sciences, with emphasis on conceptual development, historical background, and applications of interest at the secondary level. This course may not be used for credit in any program except the M.S. in Natural Sciences. Summer term. 3 credit hours

NSST-6120 Curriculum of the Future
This course represents the capstone of the instructional technologies strand of the program. Teachers will learn the design, production, and implementation of fully interactive learning technologies. Various multimedia authoring tools will be discussed and their capabilities assessed for differing educational purposes and technological feasibility in the teacher’s current school situation. Principles of instructional design, use of multi-sensory communication, techniques of story boarding and the use of interactive simulations in science and math education modules will be covered. Participants will gain hands-on experience with an advanced multimedia authoring tool as well as the preparation of a variety of media-graphics, animation, sound, and video. The final project will be the creation of a multimedia learning module which the teacher brings back for use in the classroom and/or on the World Wide Web. This course may not be used in any program except the M.S. in Natural Sciences. Summer term. 4 credit hours

NSST-6130 Studying Teaching and Learning
Participants will study teaching and learning beginning with reflection on their own pedagogical practices and leading to an examination of perspectives on learning offered by developmental psychology, cognitive science, and interactional sociology. Students will refine their skills in analyzing social situations and diagnosing their student’s understanding and misunderstanding. A course project will involve students in comparing teaching and learning across a range of interactions, teaching contexts including their own classes, and interactive multimedia learning environments. This course may not be used in any program except the M.S. in Natural Sciences. Summer term. 3 credit hours

NSST-6210 Human Biology
The course will emphasize the application of basic cellular and physiological principles to human and higher mammalian organisms. An introduction to the neural, sensory, circulatory, renal, respiratory, and hormonal systems will be included with an emphasis on the control and integration of these systems. The course format will include lecture and workshop activities with emphasis on the use of technology to enhance classroom experiences. This course may not be used in any program except the M.S. in Natural Sciences. Summer term. 3 credit hours

NSST-6220 Science of the Environment
An introduction to a variety of ways to study the environment, especially through the cooperation of the humanities and the sciences, including both the social and the natural sciences. The course addresses the issue of
sustainability by assessing the scale of human activities in relation to natural processes. Topics such as carrying capacity, social structure, biodiversity, energy, climate change, emergent diseases and social justice will be considered. This course may not be used in any program except the M.S. in Natural Sciences. Summer term.

3 credit hours

NSST-6230 Biochemical Science
Fundamentals of biochemistry including the structure of proteins and protein complexes; mechanisms, kinetics, energetic, and regulation of enzymatic reactions; structure of lipids and cellular membranes; and introduction to metabolic pathways emphasizing carbohydrate metabolism. Taught in studio format which includes a mix of lectures, student use of computer-based interactive tutorials, and informal student-faculty interactions. This course may not be used in any program except the M.S. in Natural Sciences. Summer.

3 credit hours

NSST-6240 Biomolecular Science
Course will describe the interactions at the molecular, cellular, and organ level of one or more biological processes, i.e., the immune response, antibody production, and cellular immunity. This course may not be used in any program except the M.S. in Natural Sciences. Summer term.

3 credit hours

NSST-6260 Environmental Chemistry
A discussion of some important chemical processes in the environment, both those that occur naturally and those that result from human activities. Chemistry of the atmosphere, of aqueous systems, and of soils and rock will be included. Examples of topics include the chemistry of important elements (examples are biogeochemical cycles of carbon, nitrogen, and sulfur; toxic heavy metals such as mercury and lead), nuclear chemistry of natural and anthropomorphic origins, chemistry of petroleum, plastics, and other organic materials. This course may not be used in any program except the M.S. in Natural Sciences.

3 credit hours

NSST-6270 Principles of Modern Chemical Analysis
Much of modern chemical analysis is based on instrumental techniques. This course will consider the basic principles underlying some widely used methods and will include hands-on laboratory experience carrying out some analytical procedures. Examples of methods to be included are atomic absorption spectroscopy, flame emission spectroscopy, visible-ultraviolet absorption spectroscopy, visible and X-ray fluorescence, gas and liquid chromatography. This course may not be used in any program except the M.S. in Natural Sciences.

3 credit hours

NSST-6280 Molecular Structure and Spectra
Atomic and molecular structure will be discussed from the point of view of bonding and energy and how these relate to spectroscopic properties. Use of spectra for establishing the structure of molecules will be stressed. Some laboratory exercises will be included. This course may not be used in any program except the M.S. in Natural Sciences.

3 credit hours

NSST-6310 Mathematics of Discrete Processes
Depending on the instructor, this course will introduce the student to, among other things, some fundamental concepts from graph theory and combinatorics and will address additional topics from a standard discrete mathematics course within the context of these content areas. There will be an emphasis on modeling real situations and testing intuition. The course seeks to stress pedagogically the process of doing mathematics as an ongoing process and to emphasize the importance of communication of questions, conjectures, and results in mathematics, both verbally and in writing and to model an environment in which inquiry-based learning plays an important role.

3 credit hours

NSST-6320 Dynamical Mathematics
Students will be introduced to some fundamental concepts from discrete dynamics, including, among others, chaos theory, and will be urged to suggest and discuss applications of mathematics to several fields, such as epidemiology. This course may not be used in any program except the M.S. in Natural Sciences. Summer term.

3 credit hours

NSST-6330 Geometry: Constructions, Theory and Applications
Students will use one or more software packages to investigate the problems and explore the nature of the various geometries. Topics will be chosen from, among others, ruler and compass constructions and constructible number; history and famous problems in geometry; advanced Euclidean geometry; axiomatic approaches to geometry; transformations of the Euclidean Plane; convexity and applications. This course may not be used in any program except the M.S. in Natural Sciences.

3 credit hours

NSST-6960 Studying Teaching and Learning
Participants will study teaching and learning beginning with reflection on their own pedagogical practices and leading to an examination of perspectives on learning offered by developmental psychology, cognitive science and interactional sociology. Students will refine their skills in analyzing social situations and diagnosing their students’ understanding and misunderstanding. A course project will involve students in comparing teaching and learning across a range of instructional teaching contexts including their own classes and interactive multimedia learning environments.
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. Fall and spring terms annually. 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. (Cross-listed as STSH-2130. Students cannot obtain credit for both this course and STSH-2130.) Spring term annually. 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. Fall term annually. 4 credit hours

PHIL-2150 Inspired Lives: Moral Exemplars and Visionaries
We focus on the character and conscience, teaching and deeds of reputed ethical exemplars. Everyday “local heroes” working in obscurity in our communities are highlighted alongside ethical superstars like Mother Teresa, Gandhi, or King. How do exemplars embody and function as models of character development and aspiration? What lessons can we draw from these exemplary lives for our workaday lives and personal reflections. Term: offered upon availability of instructor. 4 credit hours

PHIL-2220 Philosophy of Technology
How is life within our technosystem different from or similar to other forms of life that humans have lived or are possible? This is the guiding question for the course, with emphasis on environmental ethics and ecology. Readings come from both analytic and existentialist traditions in philosophy as well as current scholarship in psychology, sociology, and anthropology. Alternate years. 4 credit hours

PHIL-2300 Asian Philosophies
An introduction to the major Asian philosophical traditions. Comparisons between different Asian traditions and between Asian and non-Asian traditions as appropriate. Fall term 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. (Cross-listed as STSH-2500. Students cannot obtain credit for both this course and STSH-2500.) Spring term annually. 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). (Cross-listed as PSYC-2600. Students cannot obtain credit for both this course and PSYC-2600.) Annually. 4 credit hours

PHIL-2710 Sanity, Madness, and Society
An examination of the models of a human being associated with various theories of madness (e.g., the psychoanalytic theory), and of the structure of interpersonal relationships in such settings as the family and mental institutions. The social and ethical implications of saying that someone is mentally ill, together with the claim that there is no such fact as mental illness, are also examined. Readings are drawn from the work of such authors as Laing, Szasz, Goffman, Sartre, Bateson, and Freud. Offered on availability of instructor. 4 credit hours

PHIL-2830 Comparative Religion
What is religion? What are its origins? What are its essential practices? To answer these questions, different religious traditions—Judaism, Christianity, Islam, Hinduism, Buddhism, Confucianism, Taoism, and Shinto are studied in terms of their concepts of radical defectiveness, the sacred, ways of ultimate transformation, and human perfection. 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-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. 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. Fall or spring term annually.

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. Fall term annually.

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. (Cross listed as STSH-4300. Students cannot obtain credit for both this course and STSH-4300.) Prerequisite: junior or senior standing or permission of instructor. Term: offered upon availability of instructor.

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. (Cross listed as STSH-4310. Students cannot obtain credit for both this course and STSH-4310.) Prerequisite: PHIL-1110 or PHIL-2130/STSH-2130. Term: offered upon availability of instructor.

PHIL-4360 Philosophical Problems of Space and Time
Relevant aspects of the work of Kant, Leibniz, and Newton; Gauss, Riemann, and Poincare; 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. Prerequisite: PHIL-2130 or permission of instructor. Spring term annually.

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. Prerequisite: PHIL-1110 or PHIL-2130. Offered on availability of instructor.

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, Godel’s incompleteness results, and so forth. A hands-on laboratory component is included. Prerequisite: PHIL-2140. Spring term annually.

PHIL-4440 Knowledge, Belief, and Cognition or Theory of Knowledge
An exploration of what it means to know something, of the difference between knowing and believing, and of the relation between a knowledge claim and the evidence on which the claim is based. Students attempt to find philosophical counters to skepticism in respect to memory, knowledge, truth, knowledge of the physical world, of the self, and of other minds. Prerequisite: one course in philosophy. Spring term, alternate years.

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 ... We take all of these to involve 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? Prerequisite: one course in philosophy. Spring term, alternate years.

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. Prerequisite: one course in philosophy or permission of instructor. Term: offered upon availability of instructor.
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. Spring term annually. 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. (Cross listed as STSH-4740. Students cannot obtain credit for both this course and STSH-4740.) Prerequisite: one philosophy or STS course or permission of instructor. Offered on availability of instructor. 4 credit hours

PHIL-4750 Cognition and Education
We think of ourselves pre-scientifically, as “floating observers” in a theater of experience, mentally directing deliberations and willing actions. Educators approach our “aptitudes” in this way. But suppose we are primarily brains, operating as decentralized, parallel processing computational systems? How should we think of ourselves then? If we have multiple (unconscious) intelligences—not a single understanding—how should education be tailored to serve? We address such questions through cognitive science and philosophy of mind. Prerequisite: one previous course in philosophy or psychology. Offered alternate years. 4 credit hours

PHIL-4800 Comparative Cognition
What are the fundamental assumptions of cognitive science? Using a comparative approach, this course examines assumptions about the nature of mind, knowledge, self, and reality that underlie contemporary cognitive science from the perspective of traditional Buddhist mind science. Prerequisite: one course in philosophy. Alternate years. 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. 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. Term: 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 on 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. Fall term annually. 1 credit hour

PHYS-1050 Physical Principles of Design
Physics fundamentals for Architecture students. Mechanics with emphasis on equilibrium and statics, fluids, oscillations, and waves. Basics of thermodynamics and electromagnetic radiation. Reflection, refraction, and optics. 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, elementary electrostatics, and motion of charged particles in a magnetic field. Corequisite: MATH-1010 or equivalent or permission of instructor. Fall and spring terms annually. 4 credit hours

PHYS-1200 Physics II
The second semester of the two-semester sequence of interactive courses. Topics include Gauss’s Law, current electricity, 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. Fall and spring terms 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. Fall term annually. 4 credit hours

PHYS-1960 Topics in Physics
1 credit hour

PHYS-2050 Science of Information Technology
Addresses scientific concepts behind modern methods of information processing, storage, and transfer, and considers future technologies. Drawing on the expertise of Rensselaer researchers, this studio course teaches information not found in traditional textbooks. Class time includes hands-on activities so students can explore the processes providing the foundation of information technology. High-school physics is assumed. Some calculus is used in lectures, but students are not required to perform calculus on assignments. Spring term annually. 4 credit hours

PHYS-2100 Introduction to Methods of Theoretical Physics
Linear differential equations for classical systems; complex analysis; Fourier Transforms for waves; wave equations and solutions; vector analysis for classical fields; Lorentz transformation and four vectors. Prerequisites: PHYS-1100/1200 and MATH-1010/1020. Fall term annually. 4 credit hours

PHYS-2240 Medical Physics
An exploration of the interfaces between physics, medicine, and biology. Topics include: membrane transport, nerve membranes, the electrocardiogram, biomagnetism, image reconstruction, X-rays, nuclear medicine, and magnetic resonance imaging. Prerequisite: PHYS-1200. Consult department about when offered. 3 credit hours

PHYS-2330 Intermediate 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. Coupled systems and normal coordinates. Deformable media. Introduction to Hamilton-Jacobi theory. Prerequisite: MATH-2400. Fall term annually. 4 credit hours

PHYS-2350 Experimental Physics
Experiments in mechanics, optics, electricity and electromagnetics, oscillations and waves, atomic, nuclear, and solid-state physics. Experimental methods, quantitative observations, and interpretation of data. This course is writing intensive. Spring term annually. 4 credit hours, 9 contact hours

PHYS-2510 Quantum Physics
Matter waves and Schrodinger wave mechanics. Problems in one, two, and three dimensions including central force problems and one-electron atoms. Introduction to perturbation theory. Angular momentum and spin. Prerequisite: MATH-2400. Fall term annually. 4 credit hours

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. 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. 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. Prerequisite: MATH-2400 and PHYS-1200. Spring term annually. 4 credit hours

PHYS-4370 Research Participation
An introduction to research. Research participation in projects on campus, not necessarily in physics. The student is aided in finding a research group and presents a report at the end of the term. Prerequisite: PHYS-2350. Fall term annually. 3-4 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. Prerequisites: PHYS-1200 (or PHYS-2510) and MATH-2400. Spring term annually. 4 credit hours
PHYS-4510 Quantum Mechanics I
Review of Schrödinger wave mechanics. Operator algebra and theory of representation. Approximation methods for stationary problems. The theory of scattering and application to atomic and nuclear scattering problems. Students cannot obtain credit for both this course and PHYS-6510. Prerequisite: PHYS-4100 or equivalent. Fall term annually. 3 credit hours

PHYS-4620 Particles and Nuclei
This course develops current theories of the elementary structure of particles and fields and their fundamental interactions. The role of symmetries in nature is stressed, and the possible unification of the basic interactions is considered. The properties of atomic nuclei are discussed in terms of the elementary nuclear force and in terms of nuclear models such as the shell model. Prerequisite: PHYS-4100 or equivalent. Spring term annually. 4 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. Three lecture hours and three laboratory hours per week. (Cross listed with ECSE-4630. Students cannot obtain credit for both this course and ECSE-4630.) Prerequisite: PHYS-2620 recommended. Fall term odd-numbered years. 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. Three lecture hours and three laboratory hours per week. (Cross listed with ECSE-4640. Students cannot receive credit for both this course and ECSE-4640.) Prerequisite: PHYS-2620. Fall term even-numbered years. 4 credit hours

PHYS-4670 Solid-State Physics
An introduction to theoretical and experimental solid-state physics. Wave mechanics in the perfect crystal. X-rays, electrons, and phonons. Electrical properties of metals and semiconductors. Qualitative treatment of lattice defects. (Cross listed with ECSE-4720. Students cannot receive credit for both this course and ECSE-4720.) Prerequisites: PHYS-2100 and PHYS-2510 or equivalent. Fall term annually. 4 credit hours

PHYS-4750 Introduction to Surface Physics
A survey of the phenomena occurring at surfaces. Surface structure and surface electronic properties. Surface processes including adsorption, surface diffusion, crystal growth. Interaction of charged particles with surfaces. Prerequisite: PHYS-2510 or permission of instructor. Consult department about when offered. 4 credit hours

PHYS-4810 Computer Modeling in Physics
A survey course in the basic techniques of computational physics, emphasizing studies of physical systems by numerical experimentation. The systems to be studied include examples from plasma physics, nuclear physics, condensed matter physics, high energy physics, and astrophysics. Prerequisites: CSCI-1100, PHYS-1100, and PHYS-1200 or permission of instructor. Consult department about when offered. 4 credit hours

PHYS-4960 Topics in Physics
4 credit hours

PHYS-6110 Methods in Theoretical Physics
Vector calculus and partial differential equations, especially with applications to electrodynamics. Separation of variables and second-order differential equations. Sturm-Liouville theory with applications to special functions. Complex analysis and conformal mapping. Green functions and boundary value problems. Fall term annually. 3 credit hours

PHYS-6310 Advanced Mechanics
Variation principle formulation; applications to two-body central force problems and to rigid body motion; small oscillations and normal modes; Hamilton's equations of motion; Hamilton-Jacobi theory. Prerequisite: PHYS-2330 or equivalent. Fall term annually. 3 credit hours

PHYS-6410 Electrodynamics
Boundary value and radiation problems. Propagation of electromagnetic waves in inhomogeneous media and scattering phenomena. Dispersion theory. Waveguides. Relativistic electrodynamics and fields associated with accelerated charged particles. Prerequisite: PHYS-6110. Spring term annually. 3 credit hours

PHYS-6510 Quantum Mechanics I
Review of Schrödinger wave mechanics. Operator algebra and theory of representation. Approximation methods for stationary problems. The theory of scattering and application to atomic and nuclear scattering problems. Students cannot obtain credit for both this course and PHYS-4510. Prerequisite: PHYS-4100 or equivalent. Fall term annually. 3 credit hours

PHYS-6520 Quantum Mechanics II
Continuation of PHYS-6510. Time-dependent perturbations. Radiation absorption and emission. Relativistic quantum mechanics. Introduction to quantum electrodynamics. Prerequisite: PHYS-6510. Spring term annually. 3 credit hours

PHYS-6530 Quantum Mechanics III
Relativistic wave equations. Commutation relations and the quantization of free fields. Spin and statistics of Bose

3 credit hours

PHYS-6590 Statistical Mechanics

3 credit hours

PHYS-6620 Nuclear and Particle Physics I
An introduction to the physical concepts and methods of modern nuclear and elementary particle physics, for specialists and nonspecialists. Nonrelativistic scattering theory, resonance production, group symmetries and conservation laws, quark-model of hadron structure, and simple Feynman diagrams. Prerequisite: PHYS-6520. On availability of instructor.

3 credit hours

PHYS-6710 Theory of Solids I

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. On availability of instructor.

3 credit hours

PHYS-6810 Nonlinear and Quantum Optics

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 Graduate School 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 IP are assigned until the thesis has been approved by the faculty adviser 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

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.

Variable credit hours

PSYC Psychology (HSSS)

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 stimulations, class demonstrations, group projects. Fall, spring, and summer terms annually. 

4 credit hours

**PSYC-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 technologies. (Cross listed as ITEC-2210. Students cannot obtain credit for both this course and ITEC-2210.) Fall term annually. 

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. Annually. 

4 credit hours

**PSYC-2310 Experimental Methods and Statistics**

This course provides an introduction to basic methods of psychological research and the use of statistics to interpret psychological data. Students participate in several experiments and prepare written reports. Topics include experimental design, data collection and analysis, and communication of results. Prerequisite: PSYC-1200 or permission of instructor. Annually. 

4 credit hours

**PSYC-2410 Introduction to 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. Fall term annually. 

4 credit hours

**PSYC-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. Fall term annually. 

4 credit hours

**PSYC-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). (Cross listed as PHIL-2600. Students cannot obtain credit for both this course and PHIL-2600.) Annually. 

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. Prerequisite: PSYC-1200. 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. 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. 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 on 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 an
effective manager or leader 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 only. Fall and spring terms annually.

**PSYC-4180 Selected Topics in Engineering Psychology**

An interactive seminar in human factors involving discussion of recent research on visual displays, multiple resources, mental work load, skill training, and reaction time. Corequisite: PSYC-2220 or graduate status. Spring term annually.

4 credit hours.

**PSYC-4190 Program Evaluation**

Methods and procedures of evaluating program effectiveness in public and private organizations are critically evaluated. The integration of organizational principles and quantitative techniques is stressed. Prerequisite: PSYC-1200 and one statistics course. Annually.

4 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. 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. Annually.

4 credit hours.

**PSYC-4280 Human-Computer Interaction**

Covers current topics in the field of human-computer interact design including research in interactional hardware and software, matching models, tasks, design, and organizational impact. Class discussion focuses mainly on theory and practice from the perspectives of cognitive science and cognitive engineering. Prerequisites: PSYC-1200 and PSYC-2220 or permission of instructor. Annually.

4 credit hours.

**PSYC-4320 Psychobiology**

The neural and hormonal systems are studied in an evolutionary perspective with particular emphasis on the relation between physiological systems and human performance. Group projects, computer-simulated experiments, and film-clip-based discussions provide a multifaceted interactive component. Prerequisite: PSYC-1200. Spring term annually.

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. 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. 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. Prerequisite: PSYC-1200. Offered on 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. Annually.

4 credit hours.

**PSYC 4420 Perception in Action**

This course will focus on the role of perception in the performance of both routine and skilled goal-directed activities, such as walking along a crowded sidewalk, playing sports, and driving automobiles. Content will be drawn from current empirical, theoretical, and computational research on such topics as perceiving direction of self-motion, intercepting moving objects, catching and hitting balls, and avoiding collisions with obstacles. Prerequisite: PSYC-4410 Spring term annually.

4 credit hours.

**PSYC-4430 Foundations of Instruction and Learning in Secondary School Education II**

A continuation of ISCI-4400. Students spend at least four.
hours per week working with teachers in the Troy School District and four hours each week in a problem-solving experience at Rensselaer. (Cross listed as NSST-4410. Students cannot obtain credit for both this course and NSST-4410.) Prerequisite: NSST-4400. Spring term annually.

**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. Annually.

**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. Annually.

**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 and CSCI-2300. Recommended: CSCI-4150 and/or PSYC-4370 or permission of instructor. Spring term annually.

**PSYC-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 we 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: PSYC-2520 or CSCI-2300. Spring term annually.

**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. Fall term annually.

**PSYC-4630 AIDS: Paradise Lost**
AIDS, with its combination of sex, death, and celebrities, holds a strong fascination for our society. The AIDS story is a complex one, shaped by a number of forces. While the primary focus is on the biology of the HIV virus and its interface with the immune system, we do not neglect how social, technical, administrative, political, legal, and economic factors mold the AIDS story. (Cross listed as BIOL-4430. Students cannot obtain credit for both this course and BIOL-4430.) Prerequisite: BIOL-2120. Spring term annually.

**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. Annually.

**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. Fall term annually.

**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. Spring term annually.

**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. Annually.

**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. Prerequisite: permission of a supervising faculty member. Fall, spring, and summer terms annually. 3 to 6 credit hours

PSYC-6200 Cognition
Current issues and methodologies in cognitive psychology are discussed. Topics include sensory processes, signal detection theory, semantic memory, selective attention, automatic processes, reading behavior, and text comprehension. These topics are covered in an in-depth manner that includes critical evaluation and synthesis of major issues. Graduate students only. Fall term annually. 4 credit hours

PSYC-6320 Seminar in Psychopharmacology
This course deals with the recent literature on selected topics in psychopharmacology and neuroscience. Prerequisite: PSYC-4770. Annually. 4 credit hours

STSH Science and Technology Studies—Humanities Credit (HSSH)
(For Science and Technology Studies-Social Sciences Credit, see STSS.)

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. (Cross listed as PHIL-2130. Students cannot obtain credit for both this course and PHIL-2130.) Fall term annually. 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. Fall and spring annually. 4 credit hours

STSH-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. (Cross-listed as PHIL-2500. Students cannot obtain credit for both this course and PHIL-2500.) Spring term annually. 4 credit hours

STSH-2670 History of 19th Century Europe
A treatment of the major events and issues in European history from the French Revolution to the eve of the First World War. The main focus is on the interplay among politics, economics, technology, and society as Europe changed from a largely agrarian to a predominantly industrial society. Annually. 4 credit hours

STSH-2720 Masculine/Feminine
What are our conceptions of being a woman or a man, a daughter or a son, a wife or a husband, a mother or a father? This course attempts to answer this question from a variety of perspectives, including history, biology, social psychology, anthropology, and especially philosophy. Emphasis is placed on the potential for sexual liberation in being friends or
lovers, in a marriage or a family, as well as in a career. Offered on availability of instructor. 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-4170 Ethical Issues in Computing
This course examines the ethical issues that arise as a result of increasing use of (and dependence on) computers and the responsibilities of computer professionals with regard to these issues. The course stresses the ways computers challenge traditional ethical and philosophical concepts and raise old issues in a new way. Topics include codes of conduct for computer professionals, property rights in computer software, privacy, cracking, liability, and responsibility in computing. Prerequisites: STSH-1110/STSS-1110, STSS-2400, or permission of instructor. Alternate years. 4 credit hours

STSH-4230 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, and the local populations. (Cross listed as STSS-4580. Spring term alternate years.) 4 credit hours

STSH-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 human-nature matrix. Some specific environmental problems are examined to illustrate the system of values implied by various solutions. (Cross listed as PHIL-4300. Students cannot obtain credit for both this course and PHIL-4300.) Prerequisite: junior or senior standing or permission of instructor. Offered on availability of instructor. 4 credit hours

STSH-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. (Cross listed as PHIL-4310. Students cannot obtain credit for both this course and PHIL-4310.) Prerequisite: PHIL-1110 or PHIL-2130/STSH-2130. Fall term alternate years. 4 credit hours

STSH-4420-Biofutures
This course examines the frontiers 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. Spring term annually. 4 credit hours

STSH-4570 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. Fall term alternate years. 4 credit hours

STSH-4580 Modern Latin America
A general introduction to Latin American culture: history from the colonial era to the present; Afro-American, Native American, and Euro-Latin cultures as portrayed in literature and ethnography; and current issues, such as race and racism and development and the local populations. (Cross listed as STSS-4580. Students cannot obtain credit for both this course and STSS-4580.) Prerequisite: one H&SS course or permission of instructor. Offered on availability of instructor. 4 credit hours

STSH-4710 Psychology, Culture and Design
Design research is used by firms to identify opportunities for strategic innovation that originate in people’s unspoken needs and desires. This course introduces these methods and uses them to explore the tacit experience of users and designers. A central focus is on the role of design in shaping cognition and action. Students hone
observational and interpretation skills on topics such as intelligent spaces, the nature of fun, emotion and everyday artifacts. Prerequisite: STSS-1510 or permission of the instructor. Fall term annually.  

**STSH-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. (Cross listed as PHIL-4740. Students cannot obtain credit for both this course and PHIL-4740.) Prerequisite: one philosophy or STS course or permission of instructor. Offered on availability of instructor.  

**STSH-4750 Troy, A 19th-Century Industrial City**  
A study, taking advantage of the university's locale, about industrialization as one important component in the development of American culture. Topics such as water for transportation and energy sources, architectural and engineering developments in conjunction with industrial growth, and social and political problems arising out of 19th-century industrialization are considered. Each student must keep a journal and is required to undertake a project and report findings in class. Classes are complemented by frequent, usually short, field trips to appropriate sites that are agreed upon by instructor and students. Prerequisite: one college-level course in American history or permission of instructor. Fall term annually.  

**STSH-4760 American Material Culture Down to the 20th Century (American Architecture and Artifacts, 1700-1850)**  
An attempt to understand the elements that have entered into the formation of the American culture. Topics such as water for transportation and energy sources, architectural and engineering developments in conjunction with industrial growth, and social and political problems arising out of 19th-century industrialization are considered. Each student must keep a journal and is required to undertake a research project and report the findings to the class. Classes are complemented by frequent, usually short, field trips at times agreed upon by instructor and students to appropriate sites. Prerequisite: a college-level course in American history or permission of instructor. Spring term alternate years.  

**STSH-4780 Medieval Architecture and Art**  
An attempt to grasp the meaning of the Middle Ages as a time of spiritual insight and experience sandwiched between the Classical and Renaissance ages of reason. This is accomplished by a visual study of the architecture, sculpture, and painting of the period. The medieval culture offers insights into the contemporary experience. Each student must keep a journal and is required to undertake a research project and report the findings to the class. Classes are complemented by frequent, usually short, field trips at times agreed upon by instructor and students to appropriate sites. Prerequisite: a college-level course in American history or permission of instructor. Spring term alternate years.  

**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. (Cross listed as STSS-4800. Students cannot obtain credit for both this course and STSS-4800.) Prerequisites: STSH-1110/STSS-1110; IHSS-1960; or permission of instructor. Fall and spring terms annually.  

**STSH-4840 Product Design and Innovation Studio V**  
PDI studio 5 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. Fall term annually.  

**STSH-4900 Science, Technology, and Society Seminar: Selected Topics**  
In seminar style, all participants have the opportunity to choose materials/topics and lead discussions. General topic varies each time the seminar is offered. We emphasize our own relationships in the community of science and technology studies. Restricted to S&S majors. Spring term annually.  

**STSH-4920 Topics in Science, Technology, and Society**  
Selected topics in science and society to meet the needs of science and society majors. Previous courses offered include Technology, Minorities, and Women; Birth and
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. Restricted to S&S majors with senior standing. Fall, spring, and summer terms annually. 4 credit hours per term (maximum of 6 total)

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. Spring term annually. 3 credit hours

STSH-6030 Nature of Inquiry
This course focuses on the role of the inquirer in inquiry, the relationship between language and inquiry, and the organizational and institutional contexts of inquiry. The emphasis in this course is on the methods of inquiry used in the humanities in relationship to STS problems. Required of STS doctoral students, other students by permission. Alternate years. 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. Annually. 3 credit hours

STSH-6300 Advanced Environmental Philosophy
Conducted in conjunction with STSH-4300, with additional graduate-level readings and assignments. Offered on the 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 submitted to the Graduate School 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.

STSS Science and Technology Studies—Social Sciences Credit (HSSS)
(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. (Cross listed as STSH-1110. Students cannot obtain credit for both this course and STSH-1110.) This course can be used to satisfy either humanities or social sciences distribution requirements. Fall and spring terms annually. 4 credit hours

STSS-1210 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
What is engineering? How should engineering fit into society? What is engineering design? What role should engineering designers play in 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. Annually.  

**STSS-2300 Environment and Society**
The course's main theme is ecological sustainability: what it is, how it might be achieved, how it can be maintained. The theory and practice of sustainability is explored in three parts: through an examination of the concepts, actors, and processes of society-environment interactions; through an analysis of environmental philosophies and models for action; and by addressing the problems and prospects for building sustainable societies. This course prepares students for advanced environmental humanities and social sciences courses. Prerequisite: STSH-1110/STSS-1110 or permission of instructor. Annually.  

**STSS-2400 Law, Values, 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. Annually.  

**STSS-2500 Historical and Cultural Perspectives on Science and Technology**
An introduction to historical and comparative aspects of science and technology, with special attention paid to issues of culture and power. The course covers differences among Western cultures and between Western and non-Western cultures. Offered on availability of instructor.  

**STSS-2550 Information, Society and Culture**
This course examines the social and cultural effects of information technology. One section explores how cultural, economic, and ethical factors influence the design of information systems. A second section explores how access to information and communication can impact health, education, family structure, labor force participation and income distribution. The final section of the course explores shifts in the way societies are governed and in the way citizens participate in movements for social change. Annually.  

**STSS-2560 Human Evolution**
The systematic study of human origins has excited scientific and popular imaginations since Darwin. We consider 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. We also develop critical perspectives on the exchange of ideas between science and society in determining the nature of human nature. Offered on availability of instructor.  

4 credit hours

STSS-2630 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. Annually.  

4 credit hours

STSS-2640 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. Annually.  

4 credit hours

STSS-2680 History of Contemporary Europe
A topical study of European history from 1914 to the present. This course deals with World War I, Bolshevism in the Soviet Union, the Red scare and the rise of fascism, economics during the Depression and the work of Keynes, World War II, the rise of the technological society, the Cold War, and demographic and cultural patterns. Annually.  

4 credit hours

STSS-2740 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. Annually.  

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.  

4 credit hours

STSS-2960 Topics in Science and Technology Studies, Anthropology/Archaeology, History, Political Science, or Sociology  

4 credit hours

STSS-4110 Social Effects of Science and Technology
Effects of science and technology on social life are examined in specific contexts, such as agriculture, mining, factory and office work, and the home. Other topics may include the impact of electronic technologies, the changing role of science and scientists, and issues of social control. Goals are to present information about the effects of science and technology and to introduce social science concepts and methods useful in thinking about those effects. Prerequisite: STSH-1110/STSS-1110 or permission of instructor. Offered on availability of instructor.  

4 credit hours

STSS-4130 Decision Making
Recent research suggests that how people do make decisions deviates from how people rationally should make decisions. Both topics are the focal concern of the course, which surveys the influence of mental heuristics and biases, social context, and affect on judgment and choice. The material for examining individual and group decisions is drawn from laboratory research as well as a number of real-world situations including military operations, legal settings, and risk assessment. Prerequisite: any social science course, preferably PSYC-1200, or permission of instructor. Fall or spring term annually.  

4 credit hours

STSS-4140 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? We examine such issues using social statistics, ethnographic accounts of people's lives, international comparative data, and theoretical writings on social class. Prerequisite: STSS-1210 or STSS-1110. Offered on availability of instructor.  

4 credit hours

STSS-4200 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 on availability of instructor.  

4 credit hours

STSS-4250 Human Dimensions of Biomedical Technologies
How do the products of biomedical technology affect us as taxpayers, patients, caregivers, technicians, inventors, and developers? The course considers the nature and scope of
biomedical technology. Intensively studied are genetic intervention, in vitro fertilization, the artificial heart and kidney, computer diagnosis, medical imaging systems, adult and neonatal intensive care units, and transplantation. The unintended consequences of these biomedical fixes are explored. Prerequisite: STSH-1110/STSS-1110 or STSS-2100 or STSS-1210 or PSYC-1200 or PHIL-2500 or STSS-4260 or permission of instructor. Fall term annually. 4 credit hours

STSS-4260 Sociology of Medicine
This course explores the contributions of social science to the field of medicine. Following an historical and methodological introduction, the student follows the patient through the five stages of illness and medical care. Topics at each stage are discussed from the viewpoint of the patient, the medical care giver, and the health system. Students are encouraged, by means of a term paper, to explore areas that particularly interest them. Prerequisite: STSS-1210 or STSS-2100 or permission of instructor. Spring term annually. 4 credit hours

STSS-4270 The Social Relations of Science
All forms of knowledge and belief are products and reflections of social life. This course introduces and develops this idea for the case of science. The study of science as social relations serves as a vehicle for exploring the social nature of thinking and believing in general. Topics include laboratory culture, science and religion, gender and science, and science and democracy. Prerequisites: STSH-1110/STSS-1110 or STSS-1210 or STSS-1510. Spring term annually. 4 credit hours

STSS-4310 Politics of Science and Technology
An introduction to the processes by which society guides (and fails to guide) science and technology. Aspects of politics to be studied include Congress and the Presidency, courts, regulatory agencies, interest groups, business, media, and public opinion. Substantive topics include government support of scientific research, environmental regulations, NASA, advanced weaponry, robotics, and biotechnology. Prerequisite: any 2000-level STS course or permission of instructor. Annually. 4 credit hours

STSS-4320 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. Annually. 4 credit hours

STSS-4330 World Politics
Analysis of major political forces and policies of the principal nation-state groupings and leading powers that, on the one hand, reflect long-and short-range goals of these entities and, on the other hand, tend to promote stability or conflict in the international community. Prerequisite: STSS-1330 or permission of instructor. Fall term annually. 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? We study a variety of objects: buildings, machines, artifacts in everyday use, computer programs, political constitutions, etc. Prerequisites: any 2000-level course in STS or permission of instructor. 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. Fall term alternate years. 4 credit hours

STSS-4390 Environment and International Policy
This course explores environmental issues that engage international attention and require new forms of policy and diplomacy. This course also explores the historical, cultural, and political-economic factors that contribute to contemporary concern about the environment. Particular attention is given to changing perceptions about the relationship between technological development, human welfare, and collective responsibility. Prerequisite: junior or senior status or permission of instructor. Annually. 4 credit hours

STSS-4400 Risky Technologies
Analyzes the political, social, and technical dimensions of civilian technologies perceived as potentially threatening to human health or the environment. Topics include chemical manufacturing, acid rain, pesticides, chemical and radioactive wastes, greenhouse effect, automobile safety, indoor air pollution, space flight, ozone, nuclear power, and other topics of interest to class members. Aspects of the political process studied include media, public opinion, risk perception, lobbying, scientific advice, Congress, President, courts, EPA and other regulatory agencies. Prerequisite: STSS-4310 or permission of instructor. Offered on availability of instructor. 4 credit hours

STSS-4500 Environment 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 and development 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. Spring term alternate years. 4 credit hours

**STSS-4530 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 on availability of instructor. 4 credit hours

**STSS-4540 Environment, Law, and Culture**
This course explores how culture influences the perception of environmental problems and the legal strategies relied on to solve them. The course also explores how environmental crisis challenges conventional ways of assessing and resolving social problems, requiring the innovation of new standards for establishing evidence, responsibility, and compensation. Case studies analyze historical change in the way the law operates, particularly with regard to threats to human health. Prerequisite: junior/senior status or permission of instructor. Spring term alternate years. 4 credit hours

**STSS-4550 The Middle East through Native and Western Eyes**
Using movies, newsreels, Middle Eastern fiction, and the writings of both Middle Eastern and Western anthropologists, we compare the ways Westerners and Middle Easterners see themselves. Topics include how the French and British viewed the countries of the Middle East they colonized, how the Arabs saw themselves and interpreted their struggles against colonialism, and how Americans perceive Middle Eastern events today. Prerequisite: a course in anthropology or permission of instructor. Offered on 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. We use gender 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. Prerequisite: STSH-1110/STSS-1110 or STSH-2720 or permission of instructor. Offered on availability of instructor. 4 credit hours

**STSS-4570 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. Fall term alternate years. 4 credit hours

**STSS-4580 Modern Latin America**
A general introduction to Latin American culture: history from the colonial era to the present; Afro-American, Native American, and Euro-Latin cultures as portrayed in literature and ethnography; and current issues, such as race and racism and development and the local populations. (Cross listed as STSH-4580. Students cannot obtain credit for both this course and STSH-4580.) Prerequisite: one H&SS course or permission of instructor. Offered on availability of instructor. 4 credit hours

**STSS-4610 Twentieth-Century Germany**
An introduction to the major events and issues in German history since 1914. The main focus is the interplay among politics, economics, and society in 20th-century Germany. Additional themes include the impact of war on society; the rich cultural legacy of the Weimar Republic; National Socialism’s effects on political, economic, and cultural life; and continuity and change in German history. Prerequisite: a European history course or permission of instructor. Alternate years. 4 credit hours

**STSS-4620 History of Medicine**
Medical theory and practice are shaped both by culture and by prevailing disease patterns. The first half of this course surveys the history of Western medicine from Hippocrates until 1800. The second half of the course concentrates on 19th century and 20th century medicine, focusing in particular on developments in the United States. Prerequisite: a course in STS or permission of instructor. Spring term annually. 4 credit hours

**STSS-4650 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. Annually. 4 credit hours
STSS-4660 History of American Science
Examines scientific thought and institutions in the United States from the 18th to 20th centuries. Emphases on the interrelations between science and society from Benjamin Franklin and Thomas Jefferson to explorations of the West, the American reception of Darwinism, the Scopes Monkey trial, growth of the scientific-military-industrial complex, and the bomb. Prerequisite: STSH-1110/STSS-1110 or one course in American history or permission of instructor. Annually. 4 credit hours

STSS-4670 History of Information Technology
This course will examine the social history of the information revolution, focusing on the post-World War II era. It explores the identity and cultural context of inventors and inventions, briefly surveying early mass communications, and then focusing on the first mainframes, the birth of cybernetics, the personal computer, and the Internet. Prerequisite: STSH-1110/STSS-1110 or one course in American history or permission of instructor. Annually. 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. (Cross listed as STSH-4800. Students cannot obtain credit for both this course and STSH-4800.) Prerequisites: STSH-1110/STSS-1110; IHSS-1960; first year studies course or permission of instructor. Fall and spring terms annually. 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. Fall and spring terms annually. 2 credit hours

STSS-4900 Science, Technology, and Society Seminar: Selected Topics
In seminar style, all participants have the opportunity to choose materials/topics and lead discussions. General topics vary each time the seminar is offered. We emphasize our own relationships in the community of science and technology studies. Restricted to S&S majors. Spring term annually. 4 credit hours

STSS-4920 Topics in Science, Technology, and Society
Selected topics in science and society to meet the needs of science and society majors. Previous courses offered include Government, Business, Military, and Science; Ecology and Society; Cultural Dimensions of Clinical Medicine; Technological Innovation; Arms Control and Disarmament; Public Policy and Energy Development; World Energy Politics; Cultural History of Water in the USA; and Science, Technology, and Culture in China. Prerequisite: any 2000-level STS course or consent of instructor. 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. 4 credit hours

STSS-4960 Topics in Science and Technology Studies, Anthropology/Archaeology, History, Political Science, or Sociology
4 credit hours

STSS-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. Restricted to S&S majors with senior standing. Fall, spring, and summer terms annually. 4 credit hours per term (maximum of 6 total)

STSS-6010, 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. Fall and spring terms annually. 3 credit hours each
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. 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. 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. 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. Alternate 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. 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? Fall term alternate years. 3 credit hours

STSS-6320 Advanced Environmental Politics and Policy
Conducted in conjunction with STSS-4320, with additional graduate-level readings and assignments. Spring term annually. 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 on 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. Fall term alternate years. 3 credit hours

STSS-6540 Advanced Environment, Law and Culture
Conducted in conjunction with STSS-4320, with additional graduate-level readings and assignments. Spring term alternate years. 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 on the 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 Masters 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. Fall term.

3 credit hours

STSS-6610 Western Science and Technology Since the Industrial Revolution
A graduate, seminar-style review of the extant interpretations of the history of science and technology in Western Civilization since the mid-1700s. Emphasis on historiographic mastery. Preparation of a bibliographic essay tailored to the student’s concentration. Prerequisites: graduate standing in STS or permission of instructor. Alternate years.

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 Masters students or permission of instructor. Fall term.

3 credit hours

STSS-6690 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

3 credit hours

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 IP are assigned until the thesis has been approved by the faculty adviser 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

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 30 credit hours

USAF Air and Space Studies (ROTC)

USAF-0010, USAF-0080 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. An eight-semester (fall and spring) sequence, beginning each fall.

0 credit hours, 2 contact hours

USAF-1010, USAF-1020 Air and Space Studies 100 A and B (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. 100 A (fall term) 100 B (spring term).

1 credit hour

USAF-2030, USAF-2040 Air and Space Studies 200 A and B (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
USAF-2050, USAF-2060 Air and Space Studies 300 A and B (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. 300 A (fall term) 300 B (spring term). 3 credit hours

USAF-2070, USAF-2080 Air and Space Studies 400 A and B (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. 400 A (fall term) 400 B (spring term). 3 credit hours

US Military Science (ROTC)

USAR-1010 Fundamentals of Military Science I

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 officering. 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. 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-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. 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-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 exercise 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 fundamental principals 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 officering, 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 Officering. 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 officering 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 officering, and demonstrate the ability to apply this
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). Leadership Laboratories are held every other week for two hours, and attendance is voluntary. Actual schedule will be posted in syllabus.  

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. Leadership Laboratories are held every other week for two hours, and attendance is voluntary. Actual schedule will be posted in syllabus.  

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. Leadership Laboratories are held every other week for two hours, and attendance is voluntary. Actual schedule will be posted in syllabus.  

USAR-4020 Advanced Military Management and Leadership II
The course focuses on completing the transition from cadet to lieutenant. As a follow-on to the ethics instruction in USAR-400, 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. Leadership Laboratories are held every other week for two hours, and attendance is voluntary. Actual schedule will be posted in syllabus.  

USNA Naval Science (ROTC)
*Note—students must have met certain academic and military training criteria; contact Military Science Department for determination.

USNA-0010–USNA-0080 Drill/Laboratory
Consists of one period each week lasting approximately 2 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. An eight-semester (fall and spring) sequence, beginning each fall.  

USNA-1010 The Military and Its Place in Society
The organization of the Department of Defense and the special role of ROTC. Concepts and strategy of national defense and the role of the military as an instrument of national power. The military in war and peace with emphasis on the traditional relationship between civil and military authority in the United States. Fall term annually.
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. 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. 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. Study compartmentation, propulsion systems, auxiliary power systems, ship control systems, and elements of damage control are included. 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. 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. 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. 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. Spring term alternate years.  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. Spring term alternate 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. 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 written, 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. 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. Fall and spring terms annually. 4 credit hours

WRIT-2310 Creative Writing
A workshop course in the practice of writing in one or more literary forms: poetry, drama, essay, fiction. Students work at their own pace and have opportunities to present their work for criticism by other students. The literary form featured during a given semester depends on the instructor. Spring term annually. 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. Fall term annually. 4 credit hours

WRIT-2360 Communication and Design
This course explores the communication processes of successful design teams, with a focus on how to create effective proposals, progress reports, final reports, and presentations. The course demonstrates the role of communication in design and provides guided practice in using various genres to communicate ideas verbally and visually. Helpful for students taking or planning to take capstone design or currently in design projects. Enrollment limit 25. Offered at least annually as staffing permits. 7 weeks.

WRIT-2410 Presentation Strategies
This course provides instruction and practice in making oral presentations. It focuses on creating and integrating visual aids (including the use of PowerPoint) analyzing and persuading an audience, and projecting an effective presence. Helpful for both beginning and experienced speakers. Enrollment limit 20. Offered fall and spring as staffing permits. 7 weeks.

WRIT-2500 Writing for the World of Work
This course concerns the modes, techniques, and formats of writing that are most often used in professional environments. Students explore the assumptions that govern writing in their fields and practice the writing skills and styles applicable to communicating effectively. Includes some work in oral presentation strategies. Enrollment limit 25. Offered at least annually as staffing permits. 7 weeks.

WRIT-2510 Writing to the World Wide Web
This course provides an introduction to Web site design with emphasis on the design of text and hypertext for personal and organizational purposes. The course offers an introduction to basic principles of writing, visual design, and usability analysis in addition to Web technologies such as HTML, coding and image production and editing. Junior or senior standing recommended. Fall and spring terms annually.

WRIT-2520 Writing: Print and Digital
This course emphasizes the repurposing of print text for use in interactive Web sites or CD-ROMs. The course links traditional writing skills (organization, style, audience, etc.) with new media skills such as information architecture. Annually. 4 credit hours

WRIT-2960 Topics in Writing
4 credit hours

WRIT-4120 Technical and Professional Communication
Principles and practice of technical communication as applied to reports, technical papers, oral presentations, business communications, press releases, and popular articles. Limited to juniors, seniors, and graduate students. Fall and spring terms annually. 4 credit hours

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 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. Fall term alternate years. 4 credit hours

WRIT-4610-Advanced Content Development for the World Wide Web
This course is intended for those seeking a career in web design and analysis who wish to explore concepts of content development and management in depth. This studio-oriented course gives students a chance to analyze and create effective content for the web. Topics include how to create and maintain information structures for dynamic content, and how to deliver customized content for specific user groups. Cross-listed with WRIT-6610. Students cannot obtain credit for both courses. Prerequisite: WRIT-2510 or equivalent. Fall term annually. 4 credit hours

WRIT-4960 Topics in Writing
4 credit hours

WRIT-6110 Writing and Editing
An advanced writing course designed to introduce students to writing and editing. Students complete four major writing projects covering a range of document types. Practices introduced include repurposing an existing document, analyzing communicative needs, doing a genre analysis, and producing a document for a client. Students...
also learn to review the work of others and use these reviews for revision. Prerequisite: undergraduate technical writing or advanced composition course. Fall term alternate years. 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 you how to write proposals that persuade. You 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. Fall term alternate years. 3 credit hours

WRIT-6610-Advanced Content Development for the World Wide Web
This course is intended for those seeking a career in web design and analysis who wish to explore concepts of content development and management in depth. This studio-oriented course gives students a chance to analyze and create effective content for the web. Topics include how to create and maintain information structures for dynamic content and how to deliver customized content for specific user groups. Cross-listed with WRIT-4610. Students cannot obtain credit for both courses. Additional assignments at higher levels are required for those registered at the 6000 level. Fall term annually. 3 credit hours
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Clay P. Bedford, Sr. ’24 Endowed Chair Professorship (2003) ..............................................(vacant)
Howard N. Blitman ’50 PE. Career Development Professor in Engineering (2004) ...............(vacant)
Irene and Robert Bozzone ’55 Assistant Professor of Management and Technology (1995) ......(vacant)
Ann and John H. Broadbent, Jr. ’59 Senior Constellation Professor,
Warren H. Bruggeman ’46 and Pauline Urban Bruggeman
- Distinguished Associate Professor (1995) ........................................................................Phillip Phan
- Henry Burlage Chaired Professor in Engineering (2005) .........................................................Pulickel Ajayen
- Constellation Professor, Future Chips (2004) .......................................................................Shawn-Yu Lin
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Ford Foundation Professor of Mathematics (1967) .................................................................Joyce R. McLaughlin
Frank and Lillian Gilbreth Professor in the Technologies
- of Management (1969) ..................................................................................................Albert S. Paulson
Alma and H. Erwin Hale ’30 Teaching Professorship of Humanities and Social Sciences (1991) Linda L. Layne
Edward P. Hamilton Distinguished Educator (1975) ............................................................Joseph G. Ecker
William Howard Hart Professor of Rational and Technical Mechanics (1883) .................George J. Dvorak
Wayne R. Hellman Chair (1996) .........................................................................................Mark S. Rea
John Tod Horton ’52 Professor of Materials Engineering (1971) ..............................................Martin E. Glicksman ’57
Robert W. Hunt Professor of Materials Science and Engineering (1938) ...............................Richard W. Siegel
Institute Professor of Nuclear Engineering (1981) .................................................................Don Steiner
Institute Professor of Science (1995) ........................................................................................E. Bruce Watson
Institute Professor of Science (1988) ........................................................................................Ivar Giaever ’64
Institute Professor of Science and Technology (1983) .............................................................Daniel Berg
Howard P. Iserramm ’42 Professor of Chemical and Biological Engineering (1989) ............Jonathan Dordick
Samuel A. Johnson ’37 and Elisabeth C. Johnson Professor in Engineering (1990) ...............Mark S. Shephard
J. Erik Jonsson ’22 Distinguished Professor (1997) ...............................................................Xi-Cheng Zhang
Kodak Associate Professor in Environmental Engineering (1991) ........................................James E. Kilduff
Louis Ellsworth Laflin Professor of English (1917) .................................................................Merrill D. Whitburn
Thomas Phelan Chair in Humanities and Social Sciences (1995) ..............................................Langdon Winner
Rosalind and John J. Redfern Jr. ’33 Professor of Engineering (1981) ....................................(vacant)
Eliza Ricketts Foundation Professor of Mathematics (1937) ................................................Donald A. Drew
Virginia and Lloyd W. Rittenhouse ’35 Teaching Professor of Humanities and
- Social Sciences (2004) ..................................................................................................(vacant)
Russell Sage Professor of Chemical and Biological Engineering (1938) .........................Georges Belfort
Alan Paul Schulz Career Development Professor of Chemistry (2004) ...............................(vacant)
Senior Constellation Professor, Bio computation and Bioinformatics (2005) .......................Angel E. Garcia
Philip Sporn Professor of Electric Power Engineering (1962) ..............................................J. Keith Nelson
William Weightman Walker Professor of Chemistry (1905) .........................................................(vacant)
William Weightman Walker Professor of Polymer Engineering (1905) ...............................Sanford S. Sternstein ’61
Wellfleet Senior Constellation Professor, Future Chips (2003) ........................................E. Fred Schubert
Cary L. Wellington Professor of Management of Technology (1988) ......................................Iftekhar Hasan
Dean R. Wellington ’83 Teaching Professorship in Management (1990) ...............................Robert A. Baron
Yamada Corporation Professor (2001) ..................................................................................James M. Tien ’66
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 Early Career Award.

Abbate-Gardner, Cinzia Clinical Assistant Professor of Architecture; M.Arch. (University of Rome).
Abdoun, Tarek Assistant Professor of Civil and Environmental Engineering; Ph.D. (Rensselaer Polytechnic Institute).
Abetti, Pier A. Clinical Professor, Lally School of Management and Technology; Ph.D. (Illinois Institute of Technology).
Aboul-Seoud, Mohamed Clinical Assistant Professor of Decision Sciences and Engineering Systems; Ph.D. (University of Washington, Seattle).
Abouzeid, Alhussein Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Washington, Seattle).
Abrajano, Teofilo A. Professor of Earth and Environmental Sciences; Ph.D. (Washington University, St. Louis).
Adali, Sibel Associate Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (University of Maryland).
Adams, Gary S. Professor of Physics; Ph.D. (Indiana University).
Adams, James Professor of Economics; Ph.D. (University of Chicago).
Adler, Michael Research Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Massachusetts Institute of Technology).
Ajayan, Pulickel Henry Burlage, Chaired Professor in Engineering; Professor of Materials Science and Engineering; Ph.D. (Northwestern University).
Akella, Sriravas Assistant Professor of Computer Science; Ph.D. (Carnegie Mellon University).
Aker, Atsushi Assistant Professor of Science and Technology Studies; Member, Faculty of Information Technology; Ph.D. (University of Pennsylvania).
Akpalu, Yvonne A. Assistant Professor of Chemistry and Chemical Biology; Ph.D. (University of Massachusetts, Amherst).
Alben, Richard Clinical Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Harvard University).
Amitay, Michael Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Technion, Israel Institute of Technology).
Anderson, Kurt Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Stanford University).
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Antal, Steven P. Research Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).
Arcak, Murat Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of California, Santa Barbara).
Azimi-Sadjadi, Babak Research Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Maryland).
Bahn, Curtis Associate Professor, Department of the Arts; Ph.D. (Princeton University).

Bailey, Ronald A. Associate Chair and Professor of Chemistry and Chemical Biology; Member, Faculty of Information Technology; Ph.D. (McGill University).

Balfour, Alan Dean, School of Architecture; Professor of Architecture; M.F.A. (Princeton University).

Baron, Robert A. Dean R. Wellington ’83 Teaching Professorship in Management; Professor, Lally School of Management and Technology; Professor of Psychology; Ph.D. (University of Iowa).

Barquera, Blanca Assistant Professor of Biology; Ph.D. (Institute de Fisiologre, Mexico).

Bedard, Donna Research Professor of Biology; Ph.D. (University of Chicago).

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Bell, Thomas D. Chair and Professor, Air and Space Studies; M.S. (University of Idaho).

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Berg, Daniel Institute Professor of Science and Technology; Professor of Decision Sciences and Engineering Systems; Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (Yale University).

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