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. Prerequisite ARCH-2120. 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. 4 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. 6 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 the processes of critical inquiry specifically as it relates to architecture investigations. These processes are seen as interrelated and always informed by the societal, technological, and historical contexts within which architects work. Parallel instruction in drawing, computing, and construction technology are integrated within the work of this studio. Technology 1: The technology aspects focus on discovering the basic systems used to create space, such as structural systems, enclosure types, and systems for movement. Emphasis is placed upon constructability and sustainability. These discoveries are through hands-on applications and field visits. Computing: Explorations with the computer focus on both the development of a fundamental knowledge of 3-D modeling and 2-D image manipulation software and a nontraditional application of this knowledge to design representations. The computer media (3-D modeling “space,” computer printouts, video projections) are conceived of as yet another “physical” material for experimentation, and are integrated in this way with the studio design projects. Drawing: The drawing segment consists of freehand drawing exercises that relate to studio projects and help students develop basic drawing skills and a familiarity with two-dimensional design concepts. 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. 2 credit hours

ARCH-2360 Environmental and Ecological Systems
An exploration of the fundamental principles of human physiology, thermal and luminous comfort, and indoor quality. Emphasis is on bioclimatic and psychrometric climate analysis and its relationship to architectural design, understanding the energy exchange between body in space, the natural meaning of enclosures, and nonstructural materials and systems. The focus is on passive heating, cooling, and daylighting systems and their design. Exercises include vital sign analysis of existing spaces (thermal, air, luminous), forming hypotheses of building performance, using scientific instrumentation, tenant survey techniques, and physical modeling and simulation techniques related to daylighting and shading techniques. Prerequisites: PHYS-1050, ARCH-2220 or permission of instructor. Spring term annually. 4 credit hours

ARCH-2410 Design Drawing
Drawing as the architect’s chief design tool and most potent medium of communication. Major ideas about communication, its cultural roots, and its implications for architecture. Demonstrations of and studio practice in graphical techniques used in all phases of the design process, from initial conceptual patterning to final...
presentation. Drawing exercises in abstracting, symbolizing, behavioral mapping, depicting processes and typologies, expressing spatial character. Prerequisite: at least one year of design studio courses recommended.  

4 credit hours

ARCH-2510 Materials and Design  
This course establishes an understanding of the most common materials, their properties and resulting uses, and the implications of their uses in the larger context of material life cycles. The structural makeup of metals, ceramics, polymers, and composite materials is discovered and their resulting properties, costs, and life cycle consequences are clarified. An understanding of basic mechanical properties is established hands on by conducting tension, compression, and 3 point bending tests (mse-lab). Physical performance of material constructs as synergy between form and material properties is further illustrated. Experiments are conducted that introduce such major concepts as structural loading, properties of sections, and resulting system performance. Sustainability: The concept of life cycles is introduced; material and energy flows are tracked throughout the entire material life cycle. This will be accomplished alongside introducing major material groupings (metals, polymers, ceramics, and composites). Students come to realize that environmental concerns are directly related to structural composition and material availability. Consequences of resource extraction, distribution, manipulation, use, and disposal, reuse or recycle are addressed at both local and global scales. Selected field trips to materials extraction, processing, manufacturing, disposal, and recycling facilities are aimed to give physical meaning to the concept of life cycle. 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

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
such, this is both a theory and a history course. Concepts of program, construction, and aesthetics. As the century as a radical requestioning of all traditional ideas of progress, technological enframing of the world, cultural phenomenon (extending back to Enlightenment scientific rationality, historical consciousness, etc.) and as an artistic/architectural discourse unfolding in the 20th century. An exploration of the idea of modernity as both a sociopolitical context, and historical circumstance of the period. Fall term alternate years.

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 maybe taken any time after ARCH-4250. Prerequisites: ARCH-4250, ARCH-4330, ARCH-4740 may be taken as a prerequisite or corequisite. It is recommended that ARCH-4740 be deferred one semester for students studying abroad only (ex: China) and take ARCH-2360 as a corequisite. 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 context 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 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. Spring term annually.

2 credit hours

ARCH-4650 American Building—20th Century
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. 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. 4 credit hours

ARCH-4840 Architectural Acoustics 1
This course provides an overview of the essentials for architectural acoustics design of performance and public spaces, including concert halls, theaters, museums, classrooms, sports arenas, courtrooms, and religious buildings. There are no prerequisites, but the course may be used as the starting point for a certificate in Architectural Acoustics, a concentration in an architecture student’s professional electives, or the beginning of a master’s degree in acoustics. The course covers basic principles of sound, room acoustics, sound absorption in rooms, sound isolation and privacy, acoustics of mechanical systems, and sound quality. After both Architectural Acoustics 1 and 2, the student should be prepared for a basic entry-level position in either acoustics in architecture or in acoustical consulting. 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. 4 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 3-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 advisor 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-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.

1 credit hour

**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.

4 credit hours

**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.

1 credit hour

**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.

1 credit hour

**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.

1 credit hour

**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-6610. 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-6670 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. 1 credit hour

**ARCH-6680 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. Full term annually. 2 credit hours

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. Full term annually. 1 credit hour

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. 2 credit hours

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-4610, and 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. 4 credit hours

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. 4 credit hours

ARCH-6810 Research Design Seminar
The principal objective of this seminar is to provide students with the opportunity to learn the fundamentals of research design. Research design includes: 1) identifying and selecting focused research problems/opportunities/ideas; 2) documenting the state of the art in the selected research area; 3) identifying the critical resources and settings to carry out the research; 4) designing the research program including strategies and tactics for carrying out the research. It is hoped that the knowledge gained in the RD Seminar will assist students in the development of their own individual thesis proposals. Fall term annually. 4 credit hours

ARCH-6820 Research Methods in Acoustics
The goals of this course are the following: (1) to use lab projects to develop a deeper, hands-on understanding of measurement techniques, computer-modeling methods, signal processing and signal analysis, and (2) to prepare for specific research work with individualized projects in acoustics. Students perform some of the common design/measurement tasks that are found in an acoustical consultancy: determination of sound pressure level, measurement of sound level in dBA, octave band and third octave band filtering, reverberation time and room impulse response measurement, sound absorption by the standing wave (Kundt) tube method, sound absorption by the room method, sound power, sound radiation, sound insulation, vibration isolation, room-acoustics modeling (computer simulation), binaural auralization. Co-prerequisite for: ARCH-4840 Architectural Acoustics 1. Prerequisites: ARCH-4850 Architectural Acoustics 2, ARCH-6980 Master's Project, and ARCH-6990 Master Thesis. Fall term annually. 3 credit hours

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. 2 credit hours

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. 4 credit hours
ARCH-6880 Sonics Research Laboratory 2
The second semester of the Sonics Research Lab focuses on predictability models and virtual acoustics “auralization.” State-of-the-art software will be used for simulation of room acoustics in order to show the student how such programs assist in refining the design of performance and public spaces. Prerequisite: ARCH-6870 or instructor approval. Spring term annually.

2 credit hours

ARCH-6900 Graduate Thesis Seminar
Readings and discussion of topical materials that are selected to place graduate projects and theses in a comprehensive context. Fall and spring terms.

2 credit hours

ARCH-6910 Doctoral Seminar
This seminar cultivates a multi-disciplinary approach to the development of problem definition and research method. The topics being considered will be drawn from and situated between the various fields of study that support doctoral study in architectural sciences, as well as activities in related fields in engineering, science, and the humanities. Case studies of prototypical architectural science research will evaluate current practice, identifying state of knowledge with the field and the resources and settings necessary to support the research activity. Prerequisite: student must have passed the qualifying exam or permission of instructor. Fall term annually.

4 credit hours

ARCH-6940 Advanced Individual Projects in Architecture and Environmental Design
Individual projects and readings adapted to the needs of individual students at the advanced level.

1 to 6 credit hours

ARCH-6960 Special Topics in Architecture and Environmental Design
Experimental courses tried out in one or two terms as the general program requires.

1 to 4 credit hours

ARCH-6970 Professional Project
Active participation in a semester-long project, under the 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.

1 to 9 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.

4 credit hours

ARTS-1020 Media Studio: Imaging
This course introduces students to digital photography, web design, and interactive multimedia in making art. Students broaden their understanding of such topics as composition, effective use of images, color theory, typography, and narrative flow. Inquiry and experimentation are encouraged, leading towards the development of the skill and techniques needed to create visual art with electronic media.

4 credit hours

ARTS-1200 Basic Drawing
An introductory course in drawing designed to develop seeing ability and means of expressing visual ideas through graphic skills. The course consists of exercises in drawing
from observation and studies from the history of art. Fall and spring terms annually. 4 credit hours

**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. 4 credit hours

**ARTS-2010 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. 4 credit hours

**ARTS-2020 Computer Music**
Music composition taught in the context of modern computerized production methods. Technical topics include basic principles of computer sound generation, digital sound sampling, and the use of small computers for musical control of electronic instruments. Musical topics include a study of important musical works and compositional techniques of the 20th century. Student projects involve hands-on work on a variety of computer instruments and software. This course is a prerequisite for further creative work with Rensselaer’s computer music facilities. Prerequisite: ARTS-1010 or permission of instructor. Fall and spring terms annually. 4 credit hours

**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-2060 Fundamentals of Animation**
Fundamentals of Animation is an introduction to animation as an art form. Most of this course will be traditional based assignments designed to encourage spontaneous cre-ativity, explore animation concepts, and learn animation terminology. Assignments will build a solid foundation for entrance into Animation 1. This course will also be a historical and theoretical investigation with screenings and readings followed with discussion. Prerequisites: ARTS-1200 and ARTS-1010 or ARTS-1020. 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
This course will incorporate criticism with production. Taking a broad look at what defines "documentary" media, this course traces the development of jazz over its century of existence. Fall term annually. 4 credit hours

ARTS-2520 World Music
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-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-2550 History of Western Art
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 contributions 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-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 contributions 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. 1 to 4 credit hours

ARTS-2960 Topics in the Arts
Experimental courses offered for one or two terms as the general program requires. 2 to 4 credit hours

ARTS-4010-Interactive Arts Programming
IAP will examine theoretical concepts of interactive media as well as develop the practical skills needed to implement these concepts using the facilities of the iEAR studios. Topics include high and low level computer programming and electronics. Students will build installations and projects, which control live performance interactions with graphics, video, and sound. Prerequisites: 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
This studio/seminar consists of longer projects with attention to concept, process, and finish. The student will either work individually or as a member on a team and be expected to have a vision or concept they are driven to create. Some possible topics covered may include virtual environments, advanced shader networks, MEL, compositing, non photorealistic rendering, 3-D graphics programming, game engines, or motion capture. Prerequisites: ARTS-4070 or permission of instructor. 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: ARTS-2060 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, advanced lighting, advanced rendering, dynamics, particle animation, scene description, and story building. Prerequisite ARTS-4060 or permission of instructor. Fall term annually.  4 credit hours

ARTS-4090 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 students' 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-1020 or permission of instructor. Fall and spring terms annually.  4 credit hours

ARTS-4160 Advanced Writing for Theatre
Advanced Writing for Theatre is a required class for all students who are participating in the Stage Managers' Guild. This course is designed to help students improve their writing skills for the stage. Prerequisite: permission of instructor.  4 credit hours

ARTS-4170 Experimental Game Design
This course is an introduction to the design and development of video games. Students will learn the fundamentals of game design, including game mechanics, level design, and storytelling. Prerequisite: permission of instructor.  4 credit hours

ARTS-4180 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.  

**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.  

**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.  

**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 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-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. Fall and spring terms annually.  

**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-6210 Strategic Manifesto: Curatorial Practices**
A graduate-level course focusing on the development of curatorial practices, and will include emphasis research including how curators conceive, organize and execute exhibitions. This course is important for practicing artists, not only to allow them to function as programmers and curators themselves — extending their own area of expertise — but to also give students the opportunity to see what curators need to exhibit work. What kind of press materials, timelines, writing materials are necessary for curators to produce exhibitions? In other words, what do artists need to provide to curators to be successful. Fall 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.  

1 to 9 credit hours
ASTR Astronomy (SOS)

ASTR-1510 Quasars and Cosmology
An introduction to the origin and large-scale structure of the Universe. Topics to be covered include: the contents and geometry of the Universe, the Big Bang model, particle physics and the formation of the elements, galaxy formation, dark matter, black holes, and active galactic nuclei. If ASTR-1510 is taken as a 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.

1 or 2 credit hours

ASTR-1530 Tour of the Solar System
A survey of the solar system based on recent results from ground-based observations and space probes. Topics to be covered include: the sun, moon, Venus, Mars, the giant planets, comets, and the search for life in the solar system. If ASTR-1530 is taken as a 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 nonscience 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 nonphysics and nonscience 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-4250 Interstellar Medium
Thermal structure and dynamics of the interstellar medium. Topics include diffuse nebulae, composition of interstellar dust and relation to extinction and polarization, molecules and interstellar chemistry, physics of star-forming regions. Students cannot obtain credit for both this course and ASTR-6250. Prerequisite: PHYS-2510 and PHYS-4420. Fall 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.

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.

ASTR-4960 Topics in Astronomy and Astrophysics
ASTR-6250 Interstellar Medium
Thermal structure and dynamics of the interstellar medium. Topics include diffuse nebulae, composition of interstellar dust and relation to extinction and polarization, molecules and interstellar chemistry, physics of star-forming regions. Students cannot obtain credit for 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

ASTR-6960 Special Topics in Astronomy and Astrophysics
Supervised reading and study in various fields of astrophysics.

ASTR-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the 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.

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.

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.

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-1010, CHEM-2440, and PHYS-1100 or equivalents. Spring term odd-numbered years.

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.

BCBP-4640 Proteomics
Characterization of patterns and changes in patterns of protein expression with development, aging, and disease. Protein separation and quantification strategies; mass spectrometry and analysis of spectra; protein profiling, biomarkers, post-translational modifications; current applications; emerging technologies and applications.
Individual presentations on relevant topics will be expected. (Students cannot obtain credit for this course and BIOL-4640, BCBP-6460 or BIOL-6460.) Prerequisite: BCBP-4760 or equivalent. Spring term annually.  

**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.  

**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-1010 or equivalent. Fall term annually.  

**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.  

**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.)  

**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 ‘chimeras’ 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.  

**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-6810.) Prerequisite: BCBP-4760 or equivalent. Fall term even-numbered years.  

**BCBP-4870 Protein Structure Determination**  
X-ray crystallography and nuclear magnetic resonance (NMR) are used to determine 3-D structures of biological macromolecules at atomic resolution. The course will cover crystallographic and NMR methods, their theory and practice, along with thermodynamics of structure formation and molecular dynamics. Students will prepare a poster presentation on a protein of their choice. (Students cannot obtain credit for both this course and BCBP-6870.) Prerequisites: BCBP-4760, MATH-1020, and PHYS-1200 or equivalents. Fall term even numbered years.  

**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.  

**BCBP-6170 Advanced Topics in Nuclear Magnetic Resonance**  
Advanced graduate course covering fundamental aspects of NMR common for application in a broad range of fields. Classical and quantum-mechanical descriptions are utilized to explore information content of NMR pulse sequences. The latter approach includes density matrix theory and proceeds with the product-operator formalism.
Practical aspects and data analysis are also described. Subsequent focus is on liquid-state NMR of biological macromolecules, including resonance assignment and determination of molecular structure and dynamics. (Students cannot obtain credit for both this course and CHEM-6170.) Prerequisite: CHEM-4410 or equivalent. Spring term annually. 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 or corequisites: CSCI-1100, BIOL-1010, 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-6640 Proteomics
Characterization of patterns and changes in patterns of protein expression with development, aging, and disease. Protein separation and quantification strategies; mass spectrometry and analysis of spectra; protein profiling, biomarkers, post-translational modifications; current applications; emerging technologies and applications. Individual presentations on relevant topics will be expected. (Students cannot obtain credit for both this course and BCBP-4640, BIOL-4640 or BIOL-6640.) Prerequisite: BCBP-4760 or equivalent. Spring term annually. 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 ‘chimera’ 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-6870 Protein Structure Determination
X-ray crystallography and nuclear magnetic resonance (NMR) are used to determine 3-D structures of biological macromolecules at atomic resolution. The course will cover crystallographic and NMR methods, their theory and practice, along with thermodynamics of structure formation and molecular dynamics. Students will prepare an oral presentation on a protein of their choice. (Students cannot obtain credit for both this course and BCBP-4870.) Prerequisites: BCBP-4760, MATH-1020, and PHYS-1200 or equivalents. Fall term even-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 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-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-1020 Introduction to Biology 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-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, hybridoma 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. 4 credit hours

BIOL-2900 Research in Biology
Independent study program for the purpose of developing research skills under the guidance of a faculty member. This course may be repeated and it cannot count as a biology elective. Prerequisite: permission of instructor. 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

BIOL-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

BIOL-4090 Seminal Developments in Biomedical Research
Recent developments in biomedical research will be discussed in a moderator-led classroom discussion. Topics may vary by semester but will all relate scientific discoveries to clinical applications and research. Students will make presentations during the semester. Open to students in the accelerated physician-scientist program only. Spring semester annually. 2 credit hours

BIOL-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

BIOL-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

BIOL-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

BIOL-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

BIOL-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

BIOL-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

BIOL-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

BIOL-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.

BIOL-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-2120, BIOL-2500. Fall term even-numbered years.

BIOL-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.

BIOL-4400 Bioterrorism, Biowarfare and Biodefense: A Clear and Present Danger
Never in the history of civilization is the use of biological weapons against humanity more likely by individuals or groups. Course material will focus on what constitutes biological weaponry. Topics include a history of biological warfare and the basic biological principles involved in the manipulation of biological agents: pathogenic microorganisms (bacteria and viruses), their toxins and their comparative lethality. Modes of environmental dissemination of agents and countermeasures that constitute biological defense will be presented. Course will include class discussion and internet homework. Fall term annually.

BIOL-4410 Plagues, Politics, and People
The origin of plagues old and new are the main theme of this course. Through 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. Students cannot obtain credit for both this course and 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-4640 Proteomics
Characterization of patterns and changes in patterns of protein expression with development, aging, and disease. Protein separation and quantification strategies; mass spectrometry and analysis of spectra; protein profiling, biomarkers, post-translational modifications; current applications; emerging technologies and applications. Individual presentations on relevant topics will be expected. (Students cannot obtain credit for both this course and BCBP-4760.) Prerequisites: BCBP-4760 or BIOL-6460. Spring 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-1010. 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-4760 or CHEM-4760.) Prerequisites: CHEM-2250 or CHEM-2210 and BIOL-1010 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. 3 credit hours

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. 1 to 4 credit hours

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. 3 credit hours

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. 4 credit hours, 6 contact hours

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. 3 credit hours

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.

**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 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.

**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 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

**BIOL-9990 Dissertation**
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.

Variable credit hours

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**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.

1 credit hour

**BMED-2100 Biomaterials Science and Engineering**
Presents structure-property relationships of implant materials including metals, polymers, ceramics, and composites, with an emphasis on mechanical and surface properties in the broader context of implant design. Biological performance of biomaterials, case studies of traditional implants—as well as emerging, tissue-engineered materials—are emphasized. Spring term annually.

4 credit hours

**BMED-2200 Dynamic Systems for Biomedical Engineering**

4 credit hours

**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.

4 credit hours
BMED-4240 Tissue-Biomaterial Interactions
Relationships between structure and properties of synthetic implant materials, including metals, polymers, ceramics, and composites. The emphasis is on mechanical, corrosion, and surface properties of materials. Detailed review of blood-material interactions. An introduction to bio compatibility with special emphasis on the interaction of biomaterials with cells and tissues in the context of implant surface design and tissue engineering. Spring term annually.

3 credit hours

BMED-4420 Biology and Engineering of the Extracellular Matrix
Comprehensive examination of cellular interactions with the extracellular matrix (ECM), as well as analysis of the structure and function of the ECM in a variety of tissues. Topics to be covered include: ECM proteins, cell-matrix interactions, ECM signaling, mechanics of the ECM, ECM pathology and recent advances in ECM research. There are no formal prerequisites, but students should have a rudimentary knowledge of cell biology and protein structure (readings to provide this can be requested from the instructor). Limited to students with junior or senior standing. Spring term of even-numbered years.

4 credit hours

BMED-4500 Advanced Systems Physiology
Applications of control theory and systems techniques to physiology. Emphasis is on entire systems and their interactions rather than isolated phenomena. Areas covered include 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.

4 credit hours

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.

4 credit hours

BMED-4600 Biomedical Engineering Design
A guided approach to development of design skills. Students work individually and in teams to tackle a biomedical design problem using methods drawn as necessary from engineering and from the physical and mathematical sciences. Discussion sessions involve students in presentations of work. This is a writing-intensive course. Prerequisite: senior standing. Spring term annually.

3 credit hours

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 pseudoeLASTICITY approach and 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-6420 Biology and Engineering of the Extracellular Matrix**

Comprehensive examination of cellular interactions with the extracellular matrix (ECM), as well as analysis of the structure and function of the ECM in a variety of tissues. Topics to be covered include: EMC proteins, cell-matrix interactions, ECM signaling, mechanics of the ECM, ECM pathology and recent advances in ECM research. There are no formal prerequisites, but students should have a rudimentary knowledge of cell biology and protein structure (readings to provide this can be requested from the instructor). Limited to students with junior or senior standing. Spring term of even-numbered years. 4 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. Spring alternate years. 3 credit hours

**BMED-6590 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-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-6980 Master’s Project**

Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the Master’s Project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 9 credit hours

**BMED-6990 Master’s Thesis**

Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of 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. Prerequisite for CHEM-1200: CHEM-1100. A fall-spring sequence annually. 4 credit hours

CHEM-2030 Inorganic Chemistry I
Descriptive chemistry of the elements. Properties, structures, and typical reactions of the elements of the periodic table and their compounds; basic principles of inorganic chemistry. Prerequisite: CHEM-1200 or ENGR-1600. 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. 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-1100 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 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. 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 applications, 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 CHME-2020. 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-2220 or CHEM-2260 and CHEM-2030 or permission of the instructor. Students cannot get credit for both this course and CHEM-6800. Fall 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-4620 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-4640 Experimental Techniques in Macromolecular Chemistry
Laboratory techniques and experiments in synthesis, characterization, physical and mechanical properties of synthetic and natural macromolecules. Some commercial macromolecules as well as those synthesized in the laboratory are investigated. Techniques for predicting the engineering and physical properties of macromolecules from their molecular structures are introduced. Lectures provide a state-of-the-art description of synthesis and characterization methods. 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-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-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 BCBP-4760.) Prerequisites: CHEM-2250 or CHEM-2210, and BIOL-2120 or equivalent. Fall term annually.

4 credit hours

CHEM-4770 Molecular Biochemistry II

The second semester of the Molecular Biochemistry sequence. Topics include lipids and lipid metabolism, amino acid metabolism and the coenzymes involved in this metabolism, nucleic acid synthesis and chemistry, protein synthesis and degradation, integration of metabolism, photobiology, and photosynthesis. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BIOL-4770 or BCBP-4770.) Prerequisite: CHEM-4760 or equivalent. Spring term annually.

4 credit hours

CHEM-4780 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-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 semisynthesis. Prerequisite: CHEM-4760 or BCBP-4760 or BIOL-4760 or equivalent; CHEM-6190 or BCBP-4810 is an asset. Students cannot receive credit for both 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 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 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-4950 Senior Experience

An independent project that utilizes the student’s education as a Chemistry professional and results in the preparation of a formal report. Examples are a laboratory research project or an in-depth, critical literature review in a specific area of chemistry. Students intending research should arrange this with a faculty member well before the beginning of the semester to allow time to plan for a proper project. Students who have performed research in earlier semesters may continue or extend their original project. 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-6010 Perspectives in Chemistry
The objective of this course is to prepare graduate students for research in chemistry. Topics will include general and universal aspects of research in science, such as the written and oral presentation of scientific findings and the ethical considerations involved in the publication of these findings, and a survey of the current research topics of the department including emphasis on the fundamental science that underlies these topics. Fall term annually.

3 credit hours

CHEM-6020 Advanced Inorganic Chemistry I
Structure and bonding in inorganic molecules and crystals; stabilities of inorganic compounds; coordination chemistry and organometallic compounds; acid-base concepts; nonstoichiometry and phase relationships. 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-6110 Modern Methods in Chemistry
A selective survey of physical and analytical methods contemporary to the practice of modern chemistry. The topics selected for inclusion reflect the instructors’ interests and expertise. 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-6170 Advanced Topics in Nuclear Magnetic Resonance
Advanced graduate course covering fundamental aspects of NMR common for application in a broad range of fields. Classical and quantum-mechanical descriptions are utilized to explore information content of NMR pulse sequences. The latter approach includes density matrix theory and proceeds with the product-operator formalism. Practical aspects and data analysis are also described. Subsequent focus is on liquid-state NMR of biological macromolecules, including resonance assignment and determination of molecular structure and dynamics. (Students cannot obtain credit for both this course and BCBP-6170.) Prerequisite: CHEM-4410 or equivalent. Spring term annually.

4 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 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. Fall term annually. 3 credit hours

CHEM-6540 Equilibrium Statistical Mechanics
Principles of classical and quantum statistical mechanics with applications to thermodynamics, gases, and crystals. Included are topics related to phase and chemical equilibria, chemical kinetics, imperfect crystals, surface layers, and electrolyte solutions. Prerequisite: CHEM-6530 or permission of instructor. 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-4620 or permission of instructor. Fall term even-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. Fall 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 determination, spectroscopy, and mechanical property analysis 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-6670 Polymer Separation and HPLC
An advanced graduate level course covering fundamental aspects of polymer coils in solution emphasizing polymer solution theory and its application in polymer separations and high performance liquid chromatography. Topics such as random walk model, self-avoiding walk model, statistical segment length, Gaussian coils, and Flory-Huggins Theory, will be applied to size exclusion chromatography and advanced polymer HPLC techniques, such as adsorption-based interaction chromatography and liquid chromatography at critical conditions, for the analysis of chemically heterogeneous polymers. Spring term. 2 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 BCBP-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 ‘chimeras’ 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-6800 Chemical Information Sources
An introduction to chemical information science for chemistry graduate students, providing a survey of print- and electronic sources and their effective use. Students will do literature searches and prepare a bibliography on potential or actual research topics. Students cannot obtain credit for both this course and CHEM-4520. Spring term annually. 1 credit hour

CHEM-6900 Chemistry 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
1 to 3 credit hours
CHEM-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A professional project often serves as a culminating experience for a professional master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one professional project. Professional projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

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. May be used interchangeably with CHEM-9990 for students presenting a doctoral dissertation.

CHEM-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of 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 9 credit hours can be used in place of CHEM-6990 for students submitting a master’s thesis.

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.

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.

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.

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.

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. 3 credit hours

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-4040. Prerequisites for CHME-4160: CHME-4150, CHME-4040, and CHME-4500. Fall and spring terms annually. 3 credit hours each

CHME-4170 Bioprocessing Laboratory Course
A one-term laboratory course covering the fundamentals of biotechnology and bioprocessing including molecular biology, fermentation, and protein purification. Prerequisite: Senior standing in Chemical & Biological Engineering. CHME-4430 strongly recommended. Spring term annually. 2 credit hours

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. 3 credit hours

CHME-4430 Introduction to Biochemical Engineering
Description, fundamentals, and engineering features of processes using microbial, plant, or animal cells or their enzymes. Topics include review of biochemistry, review of microbiology, computer simulation, growth, death, aseptic techniques, continuous culture, fermenter design, sterilization, mixed cultures, process scale up, immobilized cells and enzymes, recovery of products, and process economics. Weekly exercises requiring personal computers. Prerequisite: background in chemical engineering or microbiology. Biochemistry strongly recommended. Fall term annually. 3 credit hours

CHME-4500 Chemical Reactor Design
Principles of kinetics, reactor design, and analysis for both homogeneous and heterogeneous (catalytic) systems. Topics include design for multiple reaction networks (optimum selectivity), analysis of simple reactor combinations, and design of isothermal, adiabatic, and optimum temperature profile reactor. Prerequisites: CHME-2010, CHME-4010, and CHME-4020. Fall term annually. 3 credit hours

CHME-4600 Introduction to Semiconductor Processing
The basic processes of fabrication of silicon-based semiconductor devices with emphasis on the chemical principles and systems involved. Topics include materials preparation, oxide growth, lithography, diffusion, ion implantation, epitaxial growth, chemical-vapor deposition, vacuum deposition, reactive ion etching, and packaging technologies. Fabrication of both bipolar and FET devices is discussed with emphasis on manufacturing process flow and control. Process design methodology. Prerequisite: senior standing in chemical engineering or permission of instructor. Fall term annually. 3 credit hours

CHME-4940 Readings in Chemical Engineering
1 to 3 credit hours

CHME-4960 Topics in Chemical Engineering
3 credit hours

Graduate courses with Biochemical Engineering emphasis

CHME-6410 Advanced Membrane Concepts
An in-depth and comprehensive treatment of membrane technology. Membrane preparation and morphology. Models for transport through membranes. Fluid-dynamic phenomena across membrane systems. Particle dynamics, membrane fouling, and concentration polarization. Applications to chemical and biochemical separations. Critical reviews of the current literature. Prerequisite: a general knowledge of transport phenomena. Fall term even-numbered years. 3 credit hours

CHME-6420 Separation and Recovery Processes
The application of theoretical and fundamental principles and pilot plant data to the design and operation of biochemical separation processes and advanced waste treatment systems. Topics covered include characterization and dispersion, coagulation and flocculation, sedimentation, filtration, adsorption, ion exchange, membrane processes, aeration and gas transfer, centrifugation, and related subjects. 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. 3 credit hours

CHME-6650 Advanced Process Control
Application of modern control theory to chemical processes. Introduction to on-line data acquisition and computer control. Real-time process optimization and optimal control theory. Estimation theory and adaptive control. Introduction to stochastic control and to the control of large-scale distribution systems. Case studies via computer-aided design programs. Prerequisite: CHME-4030 or equivalent. Offered on sufficient demand. 3 credit hours

CHME-6670 Advanced Process Design
Process synthesis with applications to heat exchange networks, energy-integrated separation sequences, and reactor networks. Analysis, design, and optimization of large-scale systems. Prerequisite: chemical engineering degree or permission of instructor. Offered on sufficient demand. 3 credit hours
CHME-6830 Combustion
Review of fundamentals of thermodynamics, chemical kinetics, fluid mechanics, and modern diagnostics. Discussion of flame propagation, thermal and chain explosions, stirred reactors, 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. 3 credit hours

CHME-6840 An Introduction to Multiphase Flow and Heat Transfer I
This course is intended to give students a state-of-the-art understanding about single and multicomponent boiling and condensation heat transfer phenomena. Applications include the analysis of nuclear reactors, oil wells, and chemical process equipment. Students satisfactorily completing this course are expected to be able to thoroughly understand the current thermal-hydraulics literature on multiphase heat and mass transfer and be able to conduct independent research in this field. (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. 3 credit hours

CHME-6850 An Introduction to Multiphase Flow and Heat Transfer II
This course is intended to give students a state-of-the-art understanding in multicomponent flow phenomena. Applications in the chemical process, petroleum recovery, and fossil/nuclear power industries will be given. Specific areas of coverage include two-phase: fluid mechanics, pressure drop, modeling and analysis, stability analysis, critical flow and dynamic waves, flow regime analysis, and phase separation and distribution phenomena. (Cross listed as MANE-6850. Students cannot obtain credit for this course and MANE-6850.) Prerequisite: CHME-6840 or MANE-6840. Spring term annually. 3 credit hours

CHME-6940 Readings in Chemical Engineering
1 to 3 credit hours

CHME-6960 Topics in Chemical Engineering
State-of-the-art formal courses in specialized areas suitable for master's and doctoral programs. Usually two topics offered per term. Typical topics include colloidal dynamics, dispersion and mixing, fluidization, heterogeneous catalysis, polymer reaction engineering, stochastic processes, and statistical mechanics. Fall and spring terms annually. 1 to 3 credit hours

CHME-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the 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, 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

* This is an “immigration” course which will not count towards the M.S. in Computer Science, M.S. in Information Technology, or M. Eng. in Computer and Systems Engineering degrees. Such courses may count towards other degrees but consult your adviser before registering.
CISH-4030 Structured Computer Architecture*
Introduction to computer architecture; the structure and function of a computer system consisting of processors, memory, I/O modules, and its internal interconnections. Primary focus on the attributes of a system visible to an assembly level programmer. Topics include: digital logic, VLSI components, instruction sets, addressing schemes, memory hierarchy, cache and virtual memories, integer and floating point arithmetic, control structures, buses, RISC vs. CISC, multiprocessor and vector processing (pipelining) organizations. Examples are drawn from contemporary (e.g., Intel Pentium, PowerPC) microcomputers.

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; 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, fall, spring; 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 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, fall, spring; G, on sufficient demand.

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-4030. 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.

3 credit hours

CISH-6230 Network Management
Introduction to methods, techniques, and tools for the management of telecommunication systems and networks. Major topics covered in the course are: Simple Network Management Protocol (SNMPv2, SNMPv3), Remote Monitoring (RMON1, RMON2), Standard Management Information (SMIs), and Telecommunications Management (TMN, CMS/CMIP); configuration and name management; fault and performance management; security; accounting management; and Web-based

to process, software validation, risk mitigation, and software engineering economics.

3 credit hours

* This is an "immigration" course which will not count towards the M.S. in Computer Science, M.S. in Information Technology, or M. Eng. in Computer and Systems Engineering degrees. Such courses may count towards other degrees but consult your adviser before registering.
network management. Prerequisite: ECSE-4670 or equivalent basic concept computer and communication networks course.

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.

CISH-6900 Computer Science Seminar
For students near the end of their program, a two semester course that meets once per month from September through March and one Saturday in April when students give their presentations. Registration is accepted during fall registration only. Students are required to attend all eight meetings in order to fulfill the Seminar requirement. This course, combined with two additional graduate credit hours, will be the equivalent of one advanced three-credit-hour elective.

CISH-6940 Readings in Computer and Information Sciences 1 to 3 credit hours

CISH or CSCI-6960 Topics in Computer and Information Sciences 1 to 3 credit hours

CISH-6960H09 Research Methods
Course will review the major considerations and tasks involved in conducting scientific research, particularly in the area of computer science. It introduces the essential aspects of designing, supporting, and conducting a research project. Those who successfully complete the course will be able to: produce a well-developed research proposal; select an appropriate methodology with which to conduct the research and defend the methodology of their selection; understand the various tasks required to carry out the research; find the resources needed to guide them through the research process and the documentation of its findings. 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.

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.

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.

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.

CIVL-2130 Surveying
The organization, planning, instrumentation, and execution of surveys for engineering projects including precise control systems for both horizontal and vertical control, astronomical 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.

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, 6 contact hours

CIVL-2670 Introduction to Structural Engineering
Introduction to the elastic behavior of structural components. Analysis of statically determinate systems. Deflection calculations by virtual work and elastic load methods. Analysis of simple statically indeterminate structures. Influence lines. Interaction of structural components. Typical structural engineering loads. Prerequisite: ENGR-2530 or equivalent. Fall term annually. 4 credit hours

CIVL-2940 Readings in Civil Engineering
Introduction to the elastic behavior of structural components. Analysis of statically determinate systems. Deflection calculations by virtual work and elastic load methods. Analysis of simple statically indeterminate structures. Influence lines. Interaction of structural components. Typical structural engineering loads. Prerequisite: ENGR-2530 or equivalent. Fall term annually. 4 credit hours

CIVL-4010 Foundation Engineering
Subsurface investigation. The application of the principles of soil mechanics to the design of footings, retaining walls, pile foundations, bulkheads, cofferdams, bridge piers and abutments, and underpinnings. Prerequisites: ENGR-2530 and CIVL-2630 or equivalent. 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 and spring terms annually. 3 credit hours

CIVL-4070 Steel Design
Analysis and design of metal structures. Structural materials and loads. Design of beams, columns, bolted and welded connections. Composite construction. Prerequisite: CIVL-2670. Fall term annually. 3 credit hours

CIVL-4080 Concrete Design
Analysis and design of reinforced concrete structures using ultimate strength methods. Design of beams, columns, slabs, and footings. Development and anchorage of reinforcing bars. 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 credit for both this course and MANE-4240.) Prerequisites: ENGR-2250 or ENGR-2530 or ECSE-4160 and senior standing. Fall and spring terms annually. 3 credit hours

CIVL-4270 Construction Management
Application of engineering principles to planning construction operations. Network scheduling (CPM, PERT), resource allocation. Cost engineering and control. Prerequisite: senior standing. Spring term annually. 3 credit hours

CIVL-4440 Advanced 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, project-and 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 alternates 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-4940 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

CIVL-6180 Mechanics of Composite Materials
Micromechanics of elastic heterogeneous solids. Plasticity of composite materials. Thermoelastic and thermoplastic behavior. Mechanics of distributed damage. Mechanical behavior. (Cross listed as MANE-6180. Students cannot obtain credit for both this course and MANE-6180.) Prerequisite: one graduate course in mechanics of solids. Fall term annually. 3 credit hours

CIVL-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 MANE-6200. Students cannot obtain credit for both this course and MANE-6200.) Annually. 3 credit hours

CIVL-6210 Structural Stability
Concepts of stability pertaining to structural and mechanical systems. Static and dynamic theories of stability. Configurations include bars, plates, shells, and structural complexes. (Cross listed as MANE-6210. Students cannot obtain credit for both this course and MANE-6210.) Annually. 3 credit hours
CIVL-6230 Transportation Economics
Economic concepts, drawn from micro- and macroeconomic theory, as they apply to transportation. Location theory, demand analysis, cost analysis, pricing, regulation, pertinent current problem areas, cost/benefit analysis. Prerequisites: CIVL-2030, ECON-2010, and DSES-4140 or their equivalents. Fall term even-numbered years. 3 credit hours

CIVL-6240 Intelligent Transportation Systems
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. 3 credit hours

CIVL-6250 Transportation Systems Planning
The analysis and planning of transportation systems. Study of the basic interaction between transportation supply and demand. 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. 3 credit hours

CIVL-6260 Transportation Algorithms
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. 3 credit hours

CIVL-6270 Traffic Control Systems
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, Vissim, and Sim Traffic. An ITS perspective maintained and stressed. Prerequisite: CIVL-4660. Spring term odd-numbered years. 3 credit hours

CIVL-6280 Infrastructure Asset Management Systems
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. 3 credit hours

CIVL-6310 Advanced Concrete Structures
Advanced analysis and design of reinforced concrete structures. Design of deep beams, slender columns, two-way floor systems. Deflection computations. Design for torsion. Prestressed concrete fundamentals. Prerequisite: CIVL-4080 or equivalent. Fall term annually. 3 credit hours

CIVL-6320 Advanced Steel Design
Advanced analysis and design of complex metal structures. Flexible, semi-rigid, and rigid connections. Plate girders, torsional design. Effects of semi-rigid connections on structural stability. Prerequisite: CIVL-4070 or equivalent. Spring term annually. 3 credit hours

CIVL-6450 Structural Dynamics

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 geomembranes. 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-4150. 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
The applications of the principles of soil mechanics to the design of foundations, at the graduate level. Subsurface investigation. Design of footings, retaining walls, pile foundations, flexible retaining structures, anchor tie-backs, bridge piers, abutments, embankments and natural slopes. Slope stability analysis and landslidie prevention. Earthquake effects. Case studies. Prerequisites: CIVL-4010, CIVL-4150. Spring term annually. 3 credit hours

CIVL-6530 Seeage, 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-
CIVL-6660 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.

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.

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.

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.

CIVL-6900 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.

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, or C are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

CIVL-6980 Master’s Project
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the Master’s Project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.

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. 4 credit hours

COGS-6200 Cognition
This course covers reasoning, decision making, and behavioral game theory, which are major domains in human higher order cognition. For each topic, we start from normative theories, go through formal and mathematical models, and introduce empirical studies. The course emphasizes integrations of competing approaches within a domain, integration between reasoning and decision making, and integration between individual decision making and game-theoretic interactions. Each year, the course has a theme. The theme for this year is quantum cognition, which applies quantum theory in cognitive modeling. This course is designed as self-contained, and no pre-requisites. A middle term presentation and a final term paper are required for each student. Graduate students only. Fall and spring terms annually. 4 credit hours

COGS-6240 Logic and Artificial Intelligence
This course is about the connection between logic and artificial intelligence (AI). It may be partitioned into three general sections: 1) the straightforward application of first-order logic (FOL) in AI; 2) the broadening of FOL to enable a robot to reason in a commonsense way (nonmonotonic reasoning, induction, etc.) and to formalize a robot agent’s belief and knowledge system (modal logics, etc.); and 3) using a logical approach to the Frame Problem and to building a planner. Spring term annually. 4 credit hours

COGS-6570 Advanced Behavioral Statistics
An accelerated course covering important behavioral statistical concepts including probability, sampling distributions, hypothesis testing, ANOVA, and multiple regression. Course requires usage of statistical software package and is taught using the general linear model framework. Prerequisite: graduate status and one course in undergraduate statistics. Fall term annually. 4 credit hours

COGS-6690 Seminar in Research Design
An in-depth study of quasi-experimental and experimental design of behavioral research. Topics include test construction and development, factor analysis, meta-analysis, repeated measures, and MANOVA. Prerequisite: COGS-6570 or permission of instructor. Spring term annually. 4 credit hours

COGS-6940 - Readings in Cognitive Science
An individually arranged independent study course under the supervision of a member of the Cognitive Science Department. The topic is selected by consultation between student and faculty member. Prerequisite: graduate status and permission of supervising faculty member. Fall and spring terms annually. 1 to 4 credits

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. 1 to 4 credits

COGS-6980 - Master's Project
Active participation in a Master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will be listed as S. Fall and spring terms annually. 1 to 9 credits

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. 1 to 9 credits

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. Variable credit hours

COMM Communication (HSSH)

COMM-1510 Introduction to Communication Theory
This course introduces students to basic topics in communication theory, including interpersonal, small group, organizational, and mass communication. Students
will study a variety of theories related to these topics and will also study the cultural impact of new communication technologies and contemporary media systems. 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-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-2620 Color Theory**

Color — the most relative of all visual attributes—is explored in this studio course through a series of exercises and graphic design problems. Investigations will include: recollection (i.e. visual memory), reading and contexture, relativity and subjectivity, color and light, color and communication, and "cultural" color. An emphasis on the work and theories of Joseph Albers will be examined. Prerequisite: COMM-2610. Fall term odd 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. Additional assignments required for students at the 6000 level. Prerequisite: COMM-4750, COMM-4770, or COMM-4710. Spring term annually.

4 credit hours

**COMM-4180 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

4 credit hours
listed with COMM-4310 and COMM-6300. Fall and spring terms annually.  

4 credit hours

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.  

4 credit hours

COMM-4400 Cross-Cultural Design Research
This course examines user research in visual communication. Discussions analyze how culture affects the interpretation of visual aesthetics and how reasoning informs intuition. Students use a research method to design a term-long project. Systematically, they derive a visual communication problem, determine user-requirements, and create aesthetics based upon audience input. Prerequisite: COMM-4570. Cross listed with COMM-6400. Students cannot obtain credit for both courses. Fall term annually.  

4 credit hours

COMM-4420 Foundations of HCI Usability
In this course, students will consider methods of gathering users’ requirements for product functions and information, ways to test products and information for usability and suitability, and procedures for incorporating the results learned through testing. Students will design and conduct usability tests on products, documents, and interfaces of interest. 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.  

4 credit hours

COMM-4460 Visual Design: Theory and Application
This course introduces students to the theoretical and practical use of graphics as a form of visual communication. Discussions include topics such as the psychology of visual perception, design theory, creative process, formatted text, and graphics. Students have an opportunity to put theory into practice using computer graphics. Prerequisite: COMM-2610 or permission of instructor. Cross listed with COMM-6560. Students cannot obtain credit for both courses. Fall term annually.  

4 credit hours

COMM-4470 Information Design
This course examines methods of graphic representation of data. Course work requires graphing of information derived from researched databases. Visual presentations of historic data will be examined to determine the most efficient way to represent complex information without distorting the data within. Information designers clarify these displays and enrich our understanding of our modern world. Prerequisite: COMM-2610. Fall term annually.  

4 credit hours

COMM-4550 Religion, Culture, and Media
How are religious fundamentalists using new media? Can religious conversion take place in a theme park? How are 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 'the return of religion' within the secular consensus of modernity. Prerequisite: COMM 1510 or permission of instructor. Fall term annually.  

4 credit hours

COMM-4560 Media and Popular Culture
A survey of the historical origins and cultural impact of several mass media, including television, film, radio, the Internet, and print media. The course aims to increase media literacy through analysis of specific media products as well as discussion of broad topics such as: advertising and commercialization; politics and censorship; gender, race, and social identity. Prerequisites: any COMM or LITR course, graduate standing, or permission of instructor. Spring term annually.  

4 credit hours

COMM-4570 Typography
This course examines typography—the design of text. Students learn the fundamentals of how to choose appropriate fonts, design with type, and integrate text with graphics in print and screen-based compositions. Discussion topics include type anatomy, classification, measurement, readability, and legibility; typographic grids; type and technology; copy fitting and editing type. Prerequisite: COMM-2610. Cross listed with COMM-6570. Students cannot obtain credit for both courses. Spring term annually.  

4 credit hours

COMM-4580 Advertising and Culture
An examination of the cultural impact of advertising in various media: TV, radio, print, and the Web. How does advertising inform 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.  

4 credit hours

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 hits, and other forms of direct and obtrusive data. Prerequisite: at least one previous 4000-level research course; one course in statistics is advisable. Offered upon availability of instructor.  

4 credit hours
COMM-4610 Rhetorical Analysis
A study of the persuasive use of language. Some basic theories of argument and style are explored as a means of improving the students’ ability to both analyze and create rhetorical discourse. Prerequisite: WRIT-2110 or permission of instructor. Offered on availability of instructor. 4 credit hours

COMM-4650 Marketing Communication Design
This course examines communication design for marketing purposes. It evaluates the effectiveness of designs for information, persuasion, education, and administration. Discussions on denotation and connotation, gestalt theory, and semiotics aim to investigate how theory influences design and the political, social, and cultural dimensions of visual language. In a term-long project, students analyze how design from an entrepreneurial perspective can provide marketable solutions to communication problems. Prerequisites: COMM-2610 and COMM-4570. Spring term annually. 4 credit hours

COMM-4660 Visual Literacy
This course examines the notion of visual literacy—the ability to create effective visual layouts and analyze visual language for meaning. Through readings, discussions, and praxis exercises, students learn the lexicon of visual communication, how to critically evaluate a visual argument, and how to apply visual literacy theory to practice. Prerequisite: COMM-2610. Cross listed with COMM-6660. Students cannot obtain credit for both courses. Fall term annually. 4 credit hours

COMM-4670 Advanced Typography
This advanced design studio course will explore individual approaches to typographic problems in both print and digital mediums. Projects will investigate typographic metaphor and illustration, designing typography for texts, and typography in-motion. Emphasis will be on communication and typographic hierarchy while encouraging experimentation to create your own typographic voice. This is an advanced course and students will be expected to work independently. Prerequisite: COMM-4570. Offered even years. 4 credit hours

COMM-4690 Interface Design: Hypermedia Theory and Application
This course focuses on the design theory and research behind effective interface design for hypermedia programs (multimedia computer programs with interactive inks). These interactive programs are the standard form of communication on the WWW, CDs, and DVDs. Students apply theory and research by designing and developing an interactive multimedia program (for WWW or CD). Prerequisites: 1) an introductory course in communication or another social science course or permission of the instructor; and 2) knowledge of authoring software for multimedia or Web development. Spring term annually. 4 credit hours

COMM-4710 Communication Design for the WWW
In this course students will examine the design and use of web sites from initial gathering of user requirement, through design, development, and evaluation of a site’s graphic and textual content and the assessment of customer satisfaction with the site. Cross listed with COMM-6750. Students cannot obtain credit for both courses. Prerequisite: COMM-4420. Fall 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 Interactive Narrative
Lectures and class discussions will analyze narrative theory and interactive narratives in a variety of genres such as oral storytelling, literature, poetry, film, radio programs, artists' books, historical narrative, hypertext fiction, Net Art, and computer games. Students will have the opportunity to apply theory by designing and developing an interactive electronic program OR completing a research paper on interactive narrative. Cross listed with COMM-6780. Students may not receive credit for both courses. Extra assignments are required in the graduate course. Prerequisites: Knowledge of interactive authoring software and either COMM-2610 or COMM-4460. 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. Spring term annually. 4 credit hours

COMM-4830 Organizational Communication
Focuses on the central role of communication in organizations by exploring the way that communication is used in exercising authority, power, and control. Organizations with hierarchical and nontraditional structures are considered. The course also examines the role of communication in the social construction of organizational life. Prerequisite: an introductory course in the social sciences or management or permission of instructor. 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.

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-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-6400 Cross-Cultural Design Research
This course examines user research in visual communication. Discussions analyze how culture affects the interpretation of visual aesthetics and how reasoning informs intuition. Students use a research method to design a term-long project. Systematically, they derive a visual communication problem, determine user-requirements, and create aesthetics based upon audience input. Cross listed with COMM-4400. Students cannot obtain credit for both courses. Fall term annually.  3 credit hours

COMM-6420 Foundations of Human-Computer Interaction Usability
In this course, we will consider methods for gathering users’ requirements for product functions and information, ways to test products and information for usability and suitability, and procedures for incorporating the results learned through testing. We will design and conduct usability tests on products, documents, and interfaces of interest. 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-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-4660. Students cannot obtain credit for both courses. For graduate students, one additional assignment will be required and their work will be evaluated at a higher level.) Fall term annually.  3 credit hours
COMM-6570 Typographic Design
This course examines typography—the design of text. Students learn the fundamentals of how to choose appropriate fonts, design with type, and integrate text with graphics in print and screen-based compositions. Discussion topics include type anatomy, classification, measurement, readability, and legibility; typographic grids; type and technology; copy fitting and editing type. Cross listed with COMM-4570. Students cannot obtain credit for both courses. Fall 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 course examines the notion of visual literacy—the ability to create effective visual layouts and analyze visual language for meaning. Through readings, discussions, and praxis exercises, students learn the lexicon of visual communication, how to critically evaluate a visual argument, and how to apply visual literacy theory to practice. Cross listed with COMM-4660. Students cannot obtain credit for both courses. Fall 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 upon availability of instructor. 3 credit hours

COMM-6730 Computer-Mediated Communication
This seminar examines the social uses and impacts of computer-mediated communication in contexts such as education, industry, and informal social interaction. Students may examine traditionally important variables such as self-disclosure, rules, status, power, message sequencing, etc., as well as processes such as reality construction, learning, decision making, and group development. The course introduces analytic procedures that are as useful for spoken or written discourse as for computer-mediated discourse. Fall term alternate years. 3 credit hours

COMM-6740 Hypermedia Design and Development
This seminar course will investigate issues in hypermedia design and development. Class discussions will include topics such as designing the structure of a hypermedia program and designing the user interface. Students will have an opportunity to put theory into practice by designing and developing an interactive program. Prerequisite: COMM-4750, COMM-6400, COMM-6600, 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 Interactive Narrative
Lectures and class discussions will analyze narrative theory and interactive narratives in a variety of genres such as oral storytelling, literature, poetry, film, radio programs, artists’ books, historical narrative, hypertext fiction, Net Art, and computer games. Students will have the opportunity to apply theory by designing and developing an interactive electronic program or completing a research paper on interactive narrative. Cross listed with COMM-4780. Students may not receive credit for both courses. Extra assignments are required in the graduate course. Prerequisites: Knowledge of interactive authoring software or permission of instructor. Fall term annually. 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

COMM-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 6 credit hours

COMM-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

CSCI Computer Science (SOS)

CSCI-1010 Introduction to Computer Programming
Computer programming is a way of thinking. A successful programmer needs to take a word problem, generate a pseudocode algorithm, and convert it to the syntax of a specific programming language. This course is an alternative to CSCI-1100 and is intended for students who want an introduction to this programming process but do not intend to do further course work in programming or computer science. Emphasis will be on the generation of the algorithms. Rather than using the complex syntax of a production language such as C or C++, this course will use Visual Basic. This allows 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-1100 Computer Science I
An introduction to computer programming algorithm design and analysis. Additional topics include basic computer organization; internal representation of scalar and array data; use of top-down design and subprograms to tackle complex problems; abstract data types. Enrichment material as time allows. Interdisciplinary case studies, numerical and nonnumerical applications. Prerequisites: none. Students who have passed CSCI-1200 cannot register for this course. Fall and spring terms 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.  
2 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
4 credit hours

CSCI-4020 Computer Algorithms
Basic algorithm design strategies such as greedy, dynamic programming, backtracking, and branch-and-bound; main approaches, including exact, probabilistic, approximate, and heuristic algorithms; sequential and parallel algorithms; algorithms for networks, string matching, matrix operations, and cryptography; learning algorithms. Prerequisite: CSCI-2300. 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-4070 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.  
4 credit hours

CSCI-4100 Machine and Computational Learning
Introduction to the theory, algorithms, and applications of automated learning (supervised, reinforcement, and unsupervised), how much information and computation are needed to learn a task, and how to accomplish it. Emphasis will be given to unifying approaches coming from statistics, function approximation, optimization and pattern recognition. Topics include: Decision Trees, Neural Networks, RBF’s, Bayesian Learning, PAC Learning, Support Vector Machines, Gaussian processes, Hidden Markov Models. Prerequisites: familiarity with probability, linear algebra, and calculus. Offered 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.

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.

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.

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.

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.

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.

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.

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.

CSCI-4430 Programming Languages
This course is a study of the important concepts found in current programming languages. Topics include language processing (lexical analysis, parsing, type-checking, interpretation and compilation, run-time environment), the role of abstraction (data abstraction and control abstraction), programming paradigms (procedural, functional, object-oriented, logic-oriented, generic), and formal language definition. Prerequisite: CSCI-2400. Fall and spring terms annually.

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.
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-4650 Networking Laboratory I
A studio course with an interactive learning style that utilizes a lab of over 139 routers, switches, and firewalls. Configuration labs include: Virtual LANs, Spanning Tree, and inter-switch communication on Gigabit switches; Class A, B, and C IP addressing using VLSM; Routing protocols including Static, Default, OSPF, EIGRP, IS-IS, and BGP routing; WAN protocols including Frame Relay and ISDN. Self-paced video demonstrations are used in conjunction with hands-on lab experiences. Fall and spring terms annually. Prerequisite CSCI-2300 Data Structures and Algorithms.  

4 credit hours

CSCI-4660 Networking Laboratory II
A studio course with an interactive learning style that utilizes a lab of over 139 routers, switches, and firewalls. Configuration labs include: Virtual Private Network (VPN) tunnels; Network Address Translation (NAT); Class-Based Weighted Fair Queuing over Frame Relay; Inter-VLAN routing, Multi-Layer Switching, and Quality of Service for Voice-Over-IP (VOIP). Self-paced video demonstrations are used in conjunction with hands-on lab experiences. Fall and Spring terms annually. Prerequisite: CSCI-4650.  

4 credit hours

CSCI-4670 Networking Security Laboratory
A studio course with an interactive learning style. Students download tools to compromise (“hack”) a network. Students will then set up defense strategies in an extensive lab of advanced routers and PIX firewalls. Configuration will include: IPSec, VPN tunnels, Authentication, Authorization, and Accounting (AAA), TACACS+ and RADIUS, Intrusion Detection, Context-Based Access Control (CBAC), Nested Object groups, Attack Guards, and Shunning. Self-paced video demonstrations are used in conjunction with hands-on lab experiences. Spring term annually. Prerequisite: CSCI-4650.  

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
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 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

4 credit hours
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; 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. 3 credit hours
CSCI-6360 Parallel Computing
A survey of fundamental issues in design of efficient programs for parallel computers. The topics discussed include models of parallel machines and programs, efficiency of parallel algorithms, programming styles for shared memory, message passing, data parallelism, and using MPI in scientific parallel programs. Parallel programming project required. Prerequisite: CSCI-4210 or equivalent. Offered on availability of instructor. 3 credit hours

CSCI-6390 Database Mining
This course will provide an introductory survey of the main topics in data mining and knowledge discovery in databases (KDD), including: classification, clustering, association rules, sequence mining, similarity search, deviation detection, and so on. Emphasis will be on the algorithmic and system issues in KDD, as well as on applications such as Web mining, multimedia mining, bioinformatics, geographical information systems, etc. Prerequisites: CSCI-2300 and MATH-2800. Fall term annually. 3 credit hours

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. 3 credit hours

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. 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 or equivalent or permission of instructor. Offered on availability of instructor. 3 credit hours

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-6050 or equivalent and knowledge of PASCAL, C, or LISP. Offered on availability of instructor. 3 credit hours

CSCI-6500 Distributed Computing Over The Internet
This course studies theoretical foundations—namely Petri nets, process calculi, actors, join calculus, and mobile 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 context is reviewed. Prerequisites: CSCI-4430 and CSCI-4220 or equivalent or permission of instructor. Spring term annually. 3 credit hours

CSCI-6510 Distributed Algorithms and Systems
This course covers fundamentals of distributed computing algorithms. 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. 3 credit hours

CSCI-6820 Numerical Solution of Ordinary Differential Equations
Numerical methods and analysis for ODEs with applications from mechanics, optics, and chaotic dynamics. Numerical methods for dynamic systems include Runge-Kutta, multistep and extrapolation techniques, methods for conservative and Hamiltonian systems, methods for stiff differential equations and for differential-algebraic systems. Methods for boundary value problems include shooting and orthogonalization, finite difference and collocation techniques, and special methods for problems with boundary or shock layers. (Cross listed as MATH-6820. Students cannot obtain credit for both this course and MATH-6820.) Prerequisite: MATH-4820 or CSCI-4820 or permission of instructor. Fall term even-numbered years. 4 credit hours

CSCI-6820 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-4820 or CSCI-4820 or permission of instructor. Fall term even-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. 4 credit hours

CSCI-6990 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. 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 datasets. Students cannot obtain credit for both this course and ENGR-2600 and MGMT-2100. Prerequisite: MATH-1010. Spring term annually. 4 credit hours

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, ENGR-4700 and DSES-2210. Prerequisite: MATH-1020 or equivalent. Spring term annually. 3 credit hours

DSES-2210 Project Management for Industrial Engineers
...
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
1 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. 3 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-4700) or equivalent. Spring 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-4610 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 analysis are covered in relation to a system's design, development, test, evaluation, and operation. Decisions concerning a system's reliability, maintainability, usability, disposability, and affordability are systematically considered. A range of systems, including service systems, is also considered. Spring odd numbered years. Pre-or co-requisite: ENGR-2600. 3 credit hours

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-4620. 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. 4 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 investments. 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. 3 credit hours

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. 4 credit hours

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-4720. Students cannot obtain credit both for this course and MATP-4720.) Prerequisites: MATH-1020 and MATH-2010 or ENGR-1100 or equivalent, or permission of instructor. Fall term annually. 4 credit hours

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 both for this course and MATP-4820.) Prerequisites: MATH-4700 or DSES-4770, and MATH-2010 or ENGR-1100 or equivalent, or permission of instructor. Fall term annually. 4 credit hours

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. 3 credit hours

DSES-4940 Readings in DSES 1 to 6 credit hours

DSES-4960 Topics in DSES 3 credit hours
DSES-4980 Senior Design Project 1 to 4 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. 3 credit hours

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-4620) and DSES-4760 (MATP-4620), or DSES-6110, or permission of the instructor. Spring term annually. 3 credit hours

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. 3 credit hours

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. 3 credit hours

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.

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 related to reliability.
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. Full 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 Design of Manufacturing System Supply Chains
Dynamics of manufacturing systems and supply chains, lean manufacturing, lead time reduction in manufacturing and service operations, advanced pull systems, concurrent design of products and supply chains, rapid new product introduction, remanufacturing and reverse supply chains, and integration of information technology in supply chain operations. Analysis of models and their application to design and planning problems in manufacturing as well as service systems is emphasized. Prerequisites: DSES-6610 or DSES-4770 (MATP-4700) or equivalent, 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-6640. Students cannot obtain credit for both this course and MATP-6620.) Prerequisite: DSES-4770 (MATP-4700). Spring term odd-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 even-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-6640. Students cannot obtain credit for both this course and MATP-6640.) Prerequisite: DSES-4770 (MATP-4700). Spring term even-numbered years. 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. 4 credit hours

DSES-6820 Queueing Systems and Applications
A course on fundamentals of stochastic processes and queuing theory emphasizing applications. Poison 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 annually. 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-4300 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 map, 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. Students develop a research paper or proposal under the guidance of a selected faculty adviser and present research findings in class. It is anticipated that the research paper will lead to identification of the broad area of dissertation research. The proposal should be of a quality that can be submitted to an external funding agency. Prerequisite: DSES doctoral student or permission of instructor. Fall term annually.

3 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
Applies the microeconomic theory of the firm to price, cost, and output decisions of business enterprises under
different market structures. Regression analysis of demand and cost, linear programming of production and simulation analysis of risk, and capital budgeting are also presented. Prerequisite: ECON-1200 or permission of instructor. 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
4 credit hours

ECON-2960 Topics in Economics
Selected topics in economics designed to acquaint students with modern economic problems and analysis in special areas beyond the introductory level. Prerequisite: ECON-1200 or equivalent. 4 credit hours

ECON-4110 Economic Analysis of Technological Change
An examination of the economic considerations that influence the creation and assimilation of new products and processes, and of the impact of technological change on the structures and evolution of the American economy and environment. Topics include productivity growth, the organization and management of industrial research and development, the interaction between technological change and industrial structure, diffusion of innovations, and technological unemployment. Prerequisite: ECON-1200 or permission of instructor. Offered on availability of instructor. 4 credit hours

ECON-4120 Quantitative Analysis
Application of mathematical techniques to economic modeling and analysis. Construction of models to describe aspects of the economy and to analyze potential policies. Solution methods for issues including optimal choice with and without constraints, equilibria among multiple actors, marginal effects of policies, and dynamic economic models. Some mathematical maturity is assumed, and mathematical skills are taught throughout the course. Prerequisite: ECON-2010 or ECON-2020, or permission of instructor. 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. Fall term annually. 4 credit hours

ECON-4180 Development of Economic Thought
A critical examination in which comparisons are made and contrasts emphasized between different schools of economic thinking such as classicism, marginalism, socialism, institutionalism, neoclassicism, and Keynesianism. Special attention is given to historical theories and attitudes of economists toward technological change and its impact on human welfare. Prerequisite: ECON-1200 or permission of instructor. Offered 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.  
4 credit hours

ECON-4940 Readings 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-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 or permission of instructor.  
4 credit hours

ECON-4975 Advanced 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 or 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 Advanced Econometrics
Application of statistical and mathematical techniques to analyze economic data. The formulation and interpretation of mathematical models that involve quantifiable economic relationships. The role of probability theory and statistical inference in the solution of model systems. Small-sample and asymptotic OLS regression, instrumental variables and GMM, multi-equation systems, panel data analysis, and maximum likelihood estimation including for binary, censored, and truncated dependent variables. Some mathematical facility is assumed. 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: EEVP 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 3 credit hours
Selected topics in economic analysis and problems to meet the special needs of graduate students in various curricula throughout the Institute. This allows students to pursue more in-depth work in their areas of study. Prerequisites: ECON-2010 and permission of instructor. 3 credit hours

ECON-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F 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

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 Introduction to Electronics
The physics and operation of semiconductor diodes, bipolar junction transistors, and field-effect transistors in elementary analog circuits. Amplifier biasing, small-signal analysis, and frequency response. Elementary bipolar and MOSFET digital circuits, analog-to-digital and digital-to-analog conversion. Prerequisite: ECSE-2010. Fall, spring, and summer terms annually. 4 credit hours, 6 contact hours

ECSE-2100 Fields and Waves I
Development and application of Maxwell’s equations in free space and within materials. Introduction to vector calculus and computer-aided analysis and design methods in electromagnetics. Applications include calculation of lumped circuit elements from field theory, plane wave propagation in various materials, and reflection from boundaries. Transmission line concepts, Smith charts, and other design tools for distributed circuits. 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**
Time and frequency-domain representation of continuous-and discrete-time signals and systems, and solutions of their response. Simulation of linear systems. Fourier series and transform. Laplace transform and z-transform. Stability, feedback systems, and root-locus analysis and design. Applications involving communication and control systems. Prerequisite: ECSE-2010. Fall, spring, and summer terms annually. 4 credit hours

**ECSE-2610 Computer Components and Operations**
Design-oriented introduction to computer components and operations. Standard codes, number systems, base conversions, and computer arithmetic. Boolean algebra, minimization and synthesis techniques for combinational and sequential logic. Races, hazards, and asynchronous behavior. Registers, arithmetic logic units, memory structure, buses, and control units. Machine language programming, instruction fetch and execution, input-output devices, interrupts, and microprogram sequencers. Software and hardware tools. Prerequisite: CSCI-1100. Corequisite: ENGR-2350. Fall, spring, and summer terms annually. 4 credit hours, 6 contact hours

**ECSE-2660 Computer Architecture, Networks, and Operating Systems**
Quantitative basis of modern computer architecture, processor design, memory hierarchy, and input/output methods. Layered operating system structures, process and storage management. Layered network organization, network protocols, switching, local and wide area networks. Examples from Unix and the Internet. Prerequisite: ECSE-2610. 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-4040 Digital Electronics**
Analysis and design of switching-mode circuits: NMOS, CMOS, RTL, DTL, TTL, and ECL digital-logic families. Topics include: basic logic gates (voltage-transfer characteristics, noise margin, fan out, propagation delay, power dissipation), flip flops, Schmitt triggers, oscillators, timers, memories, A/D and D/A converters, and optional advanced topics. Prerequisites: ECSE-2050 and ECSE-2610. Spring term annually. 3 credit hours, 5 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. 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-4040, 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-4600. Offered on sufficient demand. 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-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-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. Fall term annually. 3 credit hours

ECSE-4260 Physical Design in Microelectronics
A capstone design course. The conversion of circuit schematics to integrated-circuit chip layouts. Emphasis is on integrated circuits, device design, and the electrical performance of interconnected devices. Projects will involve the use of CAD software for process simulation, electrical analysis, physical placement, and interconnect routing. Prerequisites: ECSE-2050 or ECSE-4040, and ECSE-2610. Corequisites: ECSE-2210, ENGR-4010 and senior standing; ECSE-4220 recommended. Spring term annually. 3 credit hours

ECSE-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 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 control system. Prerequisite: ECSE-4510 or ECSE-4440. Corequisites: ENGR-4010 and senior standing. Spring term annually. 3 credit hours

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

†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-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, Vocoder, 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-optics 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 IXP platform). Each tool is developed in a networking protocol context such as TCP reliable transport, TCP 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

†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-4750 Computer Hardware Design
Introduction to Digital Design. Topics include digital logic design, computer architecture, computer organization, and computer arithmetic. Prerequisites: ECSE-2610 and ENGR-2350 or equivalent. Fall term annually. 4 credit hours

ECSE-4760 Computer Applications Laboratory
Experiments and lectures demonstrate the design of 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

ECSE-4770 Computer Hardware Design
Digital design methodologies including timing chain and counter-based “hardware” 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 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

†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.
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. 3 credit hours

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. 3 credit hours

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. 3 credit hours
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.

3 credit hours

ECSE-6400 Systems Analysis Techniques
Methods of analysis for continuous and discrete-time linear systems. Convolution, classical solution of dynamic equations, transforms and matrices are reviewed. Emphasis is on the concept of state space. Linear spaces, concept of state, modes, controllability, observability, state transition matrix. State variable feedback, compensation, decoupling. Prerequisite: ECSE-2410 or equivalent. Fall and summer terms annually.

3 credit hours

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.

3 credit hours

ECSE-6420 Nonlinear Control Systems

3 credit hours

ECSE-6430 Optimization Methods
Linear programming, nonlinear programming, iterative methods, and dynamic programming are presented, especially as they relate to optimal control problems. Discrete and continuous optimal regulators are derived from dynamic programming approach, which also leads to the Hamilton-Jacobi-Bellman Equation and the Minimum Principle. Linear quadratic regulators, linear tracking problems, and output regulators are treated. Linear observer and the separation theorem are developed for feedback controller implementation. Prerequisite: ECSE-2410. Corequisite: ECSE-6400. Fall term annually.

3 credit hours

ECSE-6440 Optimal Control Theory
The concepts, techniques, and tools related to optimal control for dynamical systems. Major topics include calculus of variation, minimum principle, dynamic programming, optimal estimation, and differential games. Both discrete time systems and continuous times are addressed. Particular consideration is given to linear time invariant systems in terms of linear quadratic regulator and Kalman filter. Prerequisite: ECSE-6400. Spring term even-numbered years.

3 credit hours

ECSE-6460 Multivariable Control Systems
Tools and methods for the analysis and design of linear multivariable feedback systems. Topics include the connection between frequency domain and state space models and methods, model identification, model reduction, model uncertainty and closed loop performance, convex analysis and design methods, optimal controller synthesis using $H_2$, $H_{\infty}$, and structured singular value criteria. Prerequisite: ECSE-6400. Fall term even-numbered years.

3 credit hours

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.

3 credit hours

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

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 tradeoffs. Prerequisite: ECSE-6510. Spring term annually. 3 credit hours

ECSE-6590 Principles of Wireless Communications
A comprehensive description of the concepts used in modern wireless and cellular systems. The general topics covered will be wireless channel models, multi-access issues, such as FDMA/TDMA and CDMA with a brief view of GSM, descriptions of digital transmission methods in wireless, receiver diversity, channel estimation and multi-user detection, and wideband communications. We will address the topics of system capacity and the effects of automatic power control, wireless networks, and DSP applications for wireless. Prerequisites: ECSE-6510 and ECSE-6560. Spring term annually. 3 credit hours

ECSE-6600 Internet Protocols
This course will cover concepts and protocols which enable heterogeneous computer networks to work with
each other, including transport (TCP, UDP), network (IP, IPng), routing (RIP, OSPF), network management (SNMP, SNMPv2, RMON), and other important protocols like ARP, ICMP, DNS, BOOTP, DHCP and HTTP. Advanced topics like Mobile IP, Real-time and reservation protocols (RTP, RSVP), IP multicast (IGMP, MBONE) and network security will also be examined. Emphasis will be on breadth of coverage, as well as hands-on programming experiences. Prerequisite: ECSE-4670.

3 credit hours

**ECSE-6610 Pattern Recognition**


3 credit hours

**ECSE-6620 Digital Signal Processing**

A comprehensive treatment of the theory, design, and implementation of digital signal processing structures. The sampling, quantization, and reconstruction process. Design of digital filters in both the time and frequency domains. Analysis of finite word length effects. Theory and applications of discrete Fourier transforms and the FFT algorithm. Applications from the communication, control, and radar signal processing areas. Prerequisites: ECSE-4500, ECSE-4510. Fall term annually.

3 credit hours

**ECSE-6630 Digital Image and Video Processing**

Theory of multidimensional signal processing and its application to digital image and video processing. The first half will cover signals and systems, Fourier transform, z-transform, discrete Fourier transform, FIR and IIR filters and their design. The emphasis will be on the unexpected and important differences from the one-dimensional case. The second half consists of applications in image and video signal processing, e.g., compression coding, noise reduction, motion estimation, deblurring, and restoration. Prerequisites: ECSE-6510, ECSE-6620. Spring term annually.

3 credit hours

**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.

3 credit hours

**ECSE-6650 Computer Vision**

Image formation and visual perception. Images, line structures, and line drawings. Preprocessing, boundary detection, texture, and region growing. Image representation in terms of boundaries, regions, and shape. Three-dimensional structures and their projections. Analysis, manipulation, and classification of image data. Knowledge-based approaches to image understanding. Applications from fields of robot vision, biomedical-image analysis, and satellite and aerial image interpretation. Offered on sufficient demand.

3 credit hours

**ECSE-6660-Broadband & Optical Networking**

Review of fundamental concepts and protocols of broadband and optical networking. Convergence of telephony, Internet and cable networks lead to new architectural and protocol concepts. Concepts and architectures covered in this course include: high-speed switching & 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.

3 credit hours

**ECSE-6667 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 report and project 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 Neural Networks in Engineering Applications
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-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-6770 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, haloved 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 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 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. 3 credit hours

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 PIN and photodiodes. Also includes applications of optical fibers in telecommunications, 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 sketching, and computer-generated design documentation. Fall, spring, and summer terms annually. 1 credit hour

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

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

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 this context. Prerequisite: CHEM-1100. 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-2720 Computer Aided Machining
This course will introduce students to the basic concepts associated with computer numerical controlled (CNC) machining. Specifically, the student will be introduced to the processes and operations associated with CNC milling, drilling, and turning. All of these processes will be controlled by code written by the students. Students are expected to apply their knowledge of computer-aided engineering as well as manufacturing processes to class exercises, homework assignments, tests, and a final project. Annually.

3 credit hours

ENGR-2940 Engineering Project
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.

4 credit hours

ENGR-2960 Topics in Engineering
1 to 3 credit hours

ENGR-2990 Engineering Project
1 to 3 credit hours

ENGR-4010 Professional Development III
Students will study issues associated with working in teams in a modern work environment. Various styles of leadership, the definitions of power and empowerment and their applications in industry and team settings will be studied. Additionally, other topics to be explored include vision, values and attitudes, and organizational culture. The course format will include small and large group discussions, case studies, experiential exercises, and regular participation from industry guests. Offered in conjunction with senior courses.

1 credit hour

ENGR-4100/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
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-2100. Prerequisite: MATH-2400 and PHYS-1200. 3 credit hours

ENGR-4700 Introduction to Manufacturing Planning
A survey of the basic concepts and analytical methodologies used to plan and control a manufacturing system. Topics include forecasting, production scheduling, facility layout, inventory control, and project planning. Admission by application. Restricted to juniors in engineering. Students cannot obtain credit for both this course and DSES-2210. 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. 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. 4 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. 3 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. Full 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, phytoremediation, composting of solid waste and soil columns, and microbial respirometry. Spring term annually. 3 credit hours

ENVE-4310 Applied Hydrology and Hydraulics
Physical processes governing occurrence and distribution of precipitation, infiltration, evaporation, and surface water runoff. Groundwater hydrology, mechanics of flow, and well hydraulics. Statistical hydrology, unit hydrograph theory, and watershed modeling. Floodplain hydrology and open channel hydraulics. Urban hydrology, hydraulics and design of storm sewers, and design of detention structures for flood control. Design project using the Army Corps of Engineers Hydraulic Engineering Center HEC-1 flood hydrograph package. Prerequisite: CHME-4010. Spring term annually. 3 credit hours

ENVE-4320 Environmental Chemodynamics
The movement of chemicals in air, water, and soil is presented to demonstrate the relation of physiochemical principles in the behavior of chemicals in the environment. Topics include chemical and thermal equilibrium at environmental interfaces, transport fundamentals, and the fate and transport of chemicals in various environmental compartments. Prerequisites: ENVE-2110 or CHME-2010. Corequisite: CHME-4010. Spring term annually. 3 credit hours

ENVE-4330 Introduction to Air Quality Control
Quantitative introduction to the engineering methods for the study of air quality. Topics include: estimation procedures for air pollution emissions; indoor air quality problems, impacts and control strategies; sources, impacts and control strategies for greenhouse gases; dispersion modeling for point sources; pollutant acidification of lakes; urban source apportionment modeling; chemistry of stoichiometric and non-stoichiometric combustion; regulations for mobile and stationary pollution sources; control devices
ENVE-4340 Physicochemical 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. 3 credit hours

ENVE-4350 Biological Processes in Environmental Engineering
The study of biochemical and biological processes common to environmental engineering. Introductory physiology, biochemistry and ecology of bacteria, yeasts, fungi. Laboratory work in microbial techniques. Development of reaction rate and mass balances on biological 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. 3 credit hours

ENVE-4940 Studies in Environmental Engineering
1 to 4 credit hours

ENVE-4960 Topics in Environmental Engineering
1 to 4 credit hours

ENVE-4980 Senior Project
1 to 4 credit hours

ENVE-6110 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. 3 credit hours

ENVE-6130 Land Applications of Wastewater
Treatment efficiency and design parameters for different methods of treatment of wastewaters by land application. Methods considered include irrigation, rapid infiltration, overland flow, septic-tank leach field systems, and deep well injection. Soil geology and groundwater flow maintenance, monitoring of systems, and public health considerations. Evaluation of sludge disposal. Offered on availability of faculty. 3 credit hours

ENVE-6140 Stream Pollution Control
Principles of limnology applied to the ecological conditions of streams and bodies of fresh water relative to capacity to stabilize organic materials. The economic aspects of water pollution; health aspects of bacterial pollution. Spring term alternate years. 3 credit hours

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. Offered on availability of faculty. 3 credit hours

ENVE-6160 Environmental Impact Analysis
Studies related to the evaluation of the impacts of major actions by state and federal agencies on the quality of human environment. Consideration is given to the preparation of impact statements. The impacts of various types of action are discussed; the adverse effects produced and alternatives to proposed action considered, and the tradeoffs between short-term uses and long-term productivity are evaluated. Case studies are presented and analyzed. 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 atmosphere. 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.

**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.

**ENVE-6200 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.

**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.

**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. Prerequisites: permission of instructor. ENVE-4330. Spring term annually.

**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.

**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.

**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**

**ENVE-6960 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-6970 Professional 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-6980 Master’s Project**
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
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.

†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.
dealing with some aspect of power electronics is required.
Prerequisite: EPOW-4080 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
Basic relaying philosophy. Current and potential transformers. Operating principles of electromagnetic, electronic, and digital relays. Application of relays to protect generators, busses, transformers and transmission lines. Prerequisite: EPOW-4010. Corequisite: EPOW-6810. Fall term annually. 3 credit hours

EPOW-6840 Power Generation Operation and Control

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, 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
EPOWER-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.

EPOWER-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.

EPOWER-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 master's project has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.

EPOWER-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.

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 not 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 to fulfill a distribution requirement. This restriction does not apply to students majoring in computer science, mathematics, chemistry, or physics. Prerequisites: ERTH-1030 or recent course work in basic physics and chemistry. 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. 1 credit hour

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. Prerequisites: MATH-4600 or equivalent, ERTH-4710 or ERTH-6710 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, geoequation, 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 4 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.

**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.  

**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.

**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.

**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.  

**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.

**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.

**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.

**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.
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
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-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 cooperations 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 Design 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. Full 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 placements, 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. 3 credit hours

IHSS-4850 The Phelan Seminar on Technology and Society
An undergraduate honors-style seminar examining interactions between technology and modern society. Particular attention will be given to the historical origins and contemporary contexts of technological change in America, especially the Hudson/Mohawk region of New York. The specific topic of the seminar will change each year, coordinated with visiting lecturers and other scholarly events, publicized during the fall term. This course cannot be used towards the H&SS depth requirement. Prerequisite: any 2000-level STS course and permission of instructor. Spring term annually. 4 credit hours

IHSS-4960 Topics in Interdisciplinary Humanities and Social Science Studies
3 credit hours

IHSS-6960 Topics in Interdisciplinary Humanities and Social Science Studies
3 credit hours

ISCI General Interdisciplinary Courses (SOS)

ISCI-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 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

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. 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

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.

1 to 9 credit hours

ITEC-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 Web Systems Development
This course involves a study of the methods used to extract and deliver dynamic information on the World Wide Web. The course uses a hands-on approach in which students actively develop Web-based software systems. Additional topics include installation, configuration, and management of Web servers. Students are required to have access to a PC on which they can install software such as a Web server and various programming environments. 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. 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
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.

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.

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.

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 the instructor. Spring term annually.

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 the development of listening, speaking, 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 German culture which constitutes the foundation for an end of the semester paper (in English). Fall term annually.
knowledge of German grammar and vocabulary such as acquired in German I. Spring term annually.  

**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 grammar through grammatical exercises and by providing audio-visual materials and texts that focus on various aspects of French culture while raising cross-cultural awareness. The learning and practice of an extensive vocabulary give the student the wherewithal to write an end of the semester essay in French on an aspect of French culture. Prerequisite: LANG-1120 or permission of the instructor.  

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-2210 Japanese III**  
Continuation of Japanese II. The course reinforces fundamental skills introduced in Japanese I and II and further develops functional ability to communicate in Japanese beyond the elementary level. The class consists of short lectures with various communication activities, written and spoken. Aspects of contemporary Japanese culture will also be discussed. Approximately 45 new Kanji characters will be introduced. Prerequisites: LANG-1210 and LANG-1220 or consent of instructor. Fall 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-2220 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, resumptive 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-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-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-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

LIGHTING 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
LGBT-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

LGBT-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

LGBT-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

LGBT-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

LGBT-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

LGBT-6980 Master's Project
Active participation in a master's level project, under the supervision of a faculty adviser, leading to a master's project report. The course is the culminating experience in the Masters of Science in Architectural Sciences with a Concentration in Lighting. It is taught by faculty at that Lighting Research Center (LRC). The course allows students to work independently with a member of faculty to synthesize the information provided in formal course work by undertaking a master's level lighting project in lighting. Grades of IP are assigned until the master's project has been approved by the faculty adviser. Grades will then be listed as S. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the library. 1 to 6 credit hours

LGBT-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 30-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-2770 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-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 annually. 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-4440 Film Theory
This course explores the work of indigenous writers and filmmakers 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, spacecraft 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-1500. 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
methods. Systems compensation and controller design. Design case study. Corequisites: MATH-2400, PHYS-1200. Fall and spring terms annually. 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 multisectional sections. Stability of beam and membrane elements. Prerequisite: ENGR-2530. Fall term annually. 3 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
Performance, stability, and control of airplanes. General equations of motion for rigid aircraft, aerodynamic forces and moments, quasi-steady and nonsteady flight paths. Generalized performance methods, flight envelope. Small disturbance theory, stability derivatives, longitudinal and lateral static stability. Basic airplane motion, response to control actions and to atmospheric disturbances. Automatic flight control. Simulation of aircraft performance and dynamics. Prerequisite: MANE-4070 or permission of instructor. Fall term annually. 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

MANE-4150 Stresses in Machine Elements
Application of the principles of strength of materials to the analysis and design of machine parts. Curved bars, multipurpose 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
This course acquaints students with all the phases of the MANE-4260 Design of Mechanical Systems. Prerequisite: MANE-4070 or equivalent. Fall 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-2530 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, multiojective 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, 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.
4 credit hours

MANE-4380 NEEP Senior Design Project I
This is the first of a two-semester sequence for seniors intended to be a “capstone” design project where students have the opportunity to utilize the broad range of their undergraduate experience in an interdisciplinary design project. Projects are selected to provide interaction between nuclear engineering and engineering physics majors to provide exposure to cross-fertilization of ideas and team interaction, which simulates anticipated future professional 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.
1 credit hour

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, nuclear fusion devices and systems, and radiation technology. Engineering aspects of 1st and 2nd Laws of Thermodynamics will be emphasized. Characteristics and safety aspects of nuclear power equipment will be discussed. Prerequisite: ENGR-2250. 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, and annular flows, and combinations, homogeneous, 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 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, quadrupole sources; geometrical acoustics; acoustical impedance, energy density, source strength, intensity flux; near and far field approximations; stationary and moving boundary interaction (viscous, dilational boundary layers, streaming, scattering). Applications include propeller, turbulent noise; total- and semi-anechoic chambers; loudspeakers; microphones, straight, tapered fluidic transmission lines; water hammer; musical instruments; room acoustics; sound absorbing, transmitting, and reflecting solid, liquid, gaseous media property determination. Prerequisites: ENGR-2090 and MATH-2400. Spring term alternate years.  
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. Juniors and seniors only. Fall term annually.  
3 credit hours

MANE-4860 Introduction to Helicopter Design  
Aerodynamics and dynamics of lifting rotors. Design concepts by which rotor weight and stress are minimized and vehicle control is provided. Weight and engine power trends for configuration definition. Center of gravity and aerodynamic lift and moment for equilibrium and desired aircraft attitude. Methods for determining size, weight, and cost for a given payload, useful volume, and specified performance. 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. 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

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 rotordynamic phenomena. Seniors and graduate students only. Prerequisite: MANE-4170. Offered on availability of faculty. 

3 credit hours

MANE-6150 Advanced Structural Analysis
Development and application of the variational formulation to structural dynamics problems involving effects such as rotary inertia, shear deformation, extensionality, and nonlinearities. Several papers published in the technical journals are also discussed during the semester. Offered 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 and boundary conditions. Interlaminar stresses. Introduction to and use of constrained numerical optimization program. Statistical effects on failure. Saint Vénant’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-
MANE-6180 Mechanics of Composite Materials
Mechanics of elastic heterogeneous solids. Plasticity of composite materials. Thermoeelastic 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. Fall 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-6210.) 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, Kohenen 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. Radioactive 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 zircalloy 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 alternate years. 3 credit hours

MANE-6490 Plasticity
Stress invariants. Polyaxial 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-6560 Incompressible Flow
Graduate fluid mechanics course on classical and modern approaches to hydrodynamics. Topics cover three areas, (1) surface waves, (2) flow instability, and (3) vortex dynamics. Wave topics include linear dispersive and non-dispersive waves, weakly nonlinear waves, and viscous effects, with special attention to surface tension phenomena. Flow instabilities include gravitational, capillary, thermal, centrifugal, and viscous instabilities. Topics in vortex dynamics include vortex laws and flow invariants, generation and decay of vorticity, and vortex-boundary interaction. Fall term odd-numbered years. 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 aerophysics. 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 heat transfer in laminar and turbulent internal and external flows. Unsteady flows, combined heat and mass transfer, conjugated unsteady heat transfer, and buoyancy induced convection. Selected applications from aeronautics and heat exchanger design. Prerequisite: MANE-4800 or equivalent. 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-6660. Spring term odd-numbered years.

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: CIVL-6660 or MANE-6660. Spring term odd-numbered years. 3 credit hours

MANE-6660 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-6670 Finite Element Methods in Structural Dynamics
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.

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
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 issues include: the discrete formulation, nonlinear equation iteration (steady)/marcher (time-accurate), linear equation formation, boundary condition prescription and linear equation solution. Prerequisite: MANE-6660 or equivalent. Spring term odd-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-6770 Multiscale-Multiphysics
Computational Science and Engineering
Topics include two categories of multiscale approaches: information-passing and concurrent-bridging approaches. Among the information-passing approaches, the course covers generalized mathematical homogenization theory, multiscale enrichment based on partition of unity, heterogeneous multiscale, coarse-grained molecular dynamics, and kinetic Monte Carlo methods. Among the concurrent-bridging approaches, the course covers domain bridging, local enrichment, and multigrid-based methods. Prerequisite: MANE-4240 or equivalent. Fall term even-odd 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.

MANE-6820 Finite Deformation Plasticity: Theory and Applications


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.

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.

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.

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.

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.

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 mechanisms; 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.

MANE-6900 Seminar

Fall and spring terms annually.

MANE-6940 Individual Projects in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics

Prerequisite: permission of instructor. Fall and spring terms annually.

0 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, 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.

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 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-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

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-1010 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. Prerequisite: 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 or 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. Spring term annually. 1 credit hour

MATH-2010 Multivariable Calculus and Matrix Algebra
Directional derivatives, maxima and minima, double integrals, line integrals, div and curl, and Green's Theorem; matrix algebra and systems of linear equations, vectors and linear transformations in $\mathbb{R}^n$, eigenvectors and eigenvalues, applications in engineering and science. Prerequisite: MATH-1020. 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 cryptography, the perpetual calendar, hashing functions, computer operations and complexity; continued fractions, multiplicative functions, primitive roots, pseudo-random numbers, nonlinear Diophantine equations, Fermat’s last theorem, algebraic numbers, and approximation of numbers by rationals. Prerequisite: MATH-1020. Spring term odd-numbered years.

4 credit hours

MATH-4030 Computability and Logic
A team-based, project-oriented, hands-on introduction to great concepts and discoveries in logic and computability, including Turing Machines, first order logic, the limitations of computing machines, Godel’s incompleteness results and so forth. A hands-on laboratory component is included. (Cross-listed as PHIL-4420. Students cannot obtain credit for both this course and PHIL-4420.) Prerequisite: PHIL-2140. Spring term annually. 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, 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, convergence, uniform convergence, functions of one variable, continuity, differentiability, Riemann integration, functions of several variables, line, surface, and volume integrals. Qualified as a writing-intensive course. Prerequisites: 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-4450 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-4590 Senior Research
Undergraduate mathematics projects that utilize students' mathematical knowledge will result in formal reports and final presentations. Examples are research projects or critical in-depth mathematical literature reviews. Information about projects will be exchanged in weekly meetings. Students 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-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

1 to 4 credit hours

MATH-4960 Topics in Mathematics

1 to 4 credit hours

MATH-4980 Undergraduate Project in Mathematics

1 to 4 credit hours

MATH-6190 Topics from Pure Mathematics
The course is intended to provide a mathematical perspective on one or more topics chosen from algebra, geometry, and/or topology. Topics may include combinatorial matrix theory, classification of surfaces, Lie groups, Galois theory, geometric analysis, computational geometry, homology, and/or fixed point theorems. Prerequisites: vary with topic. 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. Spring term odd-numbered years. 4 credit hours

MATH-6400 Ordinary Differential Equations
A basic graduate course introducing the fundamental concepts of modern evolution equations theory in the setting of ordinary differential equations. Topics include existence and uniqueness, integral equations, stability of equilibria, stable manifolds, Floquet theory, Poincare-Bendixson theory, bifurcation theory, center manifolds, normal forms, averaging theory, Hamiltonian mechanics and calculus of variations, chaotic dynamics, KAM theory, and soliton theory. Prerequisite: MATH-4400 or permission of instructor. 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
mathematics, and finance. Prerequisites: vary with topic. Spring 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-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. Possible topics include computational fluid dynamics, parallel computing, computational acoustics, and computer applications in medicine and biology. Possible topics include computational fluid dynamics, parallel computing, computational acoustics, and computer applications in medicine and biology. Possible topics include computational fluid dynamics, parallel computing, computational acoustics, and computer applications in medicine and biology. Possible topics include computational fluid dynamics, parallel computing, computational acoustics, and computer applications in medicine and biology. Possible topics include computational fluid dynamics, parallel computing, computational acoustics, and computer applications in medicine and biology. Possible topics include computational fluid dynamics, parallel computing, computational acoustics, and computer applications in medicine and biology. Possible topics include computational fluid dynamics, parallel computing, computational acoustics, and computer applications in medicine and biology. Possible topics include computational fluid dynamics, parallel computing, computational acoustics, and computer applications in medicine and biology. Possible topics include computational fluid dynamics, parallel computing, computational acoustics, and computer applications in medicine and biology.
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 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.
0 to 6 credit hours

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 master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.
1 to 6 credit hours

MATH-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

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.
4 credit hours

MATP-4620 Mathematical Statistics
A course in the theory of statistics that will provide students with a basic foundation for more specialized statistical methodology courses. Topics include sampling and sampling distributions; point estimation including method of moments, maximum likelihood estimation, uniform minimum variance estimation, and properties of the associated estimators; hypothesis testing including uniformly most powerful, likelihood ratio, chi-square goodness-of-fit tests, and tests for independence. The course concludes with an introduction to linear statistical models. (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.
4 credit hours

MATP-4700 Mathematical Models of Operations Research
Introduction to deterministic models of operations research including linear programming formulations, the simplex algorithm, degeneracy, geometry of convex polyhedra, duality theory, and sensitivity analysis. Special linear programming models for assignment, transportation, and network problems. Integer programming formulations along with branch and bound solution. Dynamic programming. (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.
4 credit hours

MATP-4820 Computational Optimization
An introduction to nonlinear programming. Models, methods, algorithms, and computer techniques for nonlinear optimization are studied. Students investigate contemporary optimization methods both by implementing these methods and through experimentation with commercial software. Nonmajors wishing to gain practical optimization skills are welcomed in this course. A course project will allow students to explore optimization methods and practical problems directly related to their interests. (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.
4 credit hours

MATP-4940 Readings in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

MATP-4960 Topics in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

MATP-4980 Undergraduate Project in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

MATP-6600 Nonlinear Programming
Convex sets and functions, optimality conditions in nonlinear programming, Lagrangian duality, quadratic programming; algorithms for nonlinear programming
including Newton's method, quasi-Newton methods, conjugate gradient methods, together with proofs of convergence. (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-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.

**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: 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 work force 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 annually. 4 credit hours

**MGMT-4160 Telecommunications for Business**
Rapid advancements in telecommunications technology and the convergence of computing and telecommunications have created unique opportunities for organizations
to derive competitive advantage. Telecommunications technology has become an essential feature of the business environment and is embodied in both operations and products/services of organizations. This course aims to analyze how telecommunications can be employed to enhance the benefits and reduce the costs through the value web. A wide variety of telecommunications technologies ranging from narrowband to broadband and from wired to wireless will be examined in detail. The primary emphasis will be on issues related to their application in different business contexts. 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 in options and futures markets. 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-4350 Financial Markets and Institutions**
This course investigates the roles financial markets and financial intermediaries play in the flow of funds in the world economy. This course provides a conceptual framework for why markets exist and the important functions of intermediaries in the global markets. Major topics include interest rates; roles of Central Bank; debt, equity and derivatives; commercial banking; and the increasing importance of non-bank financial intermediaries such as pension funds, insurance companies and mutual funds. Prerequisite: MGMT-2320. Students cannot receive credit for both this course and MGMT-6340. Fall term. 4 credit hours

**MGMT-4370 Risk Management**
Analysis and management of some nonspeculative 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. 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-4540 Venture Capital Finance
This course covers the theory and practice of venture capital financing of entrepreneurial firms. Topics to be discussed include the structure and governance of venture capital funds, venture capital financial contracting, valuation of entrepreneurial firms, staging, syndication, capital structure, and exits (IPOs, acquisitions, secondary sales, buybacks and liquidations). International differences in venture capital markets will also be studied. Prerequisite: MGMT-2320. Fall term. 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 Financial Management I
The purpose of this course is to develop a working understanding of the major investment and financial decisions of the firm. Emphasis will be placed upon identifying and solving the problems commonly faced by financial managers. The course presents the needed theory and develops financial problem solving skills through individualized problem solving, structured case analysis, and industry and company analysis using Internet sources. Fall term. 3 credit hours

MGMT-6030 Financial Management II
This course, built on the Economic & Financial Analysis I, provides a conceptual framework whereby accounting, corporate finance and investment decisions can be viewed and understood in a unified context of risk and return as it is applicable to all types of businesses and organizations. The course prepares students for future specialized courses in advanced accounting, corporate finance, financial institutions and markets, investment theory, and entrepreneurial finance. The contemporary issues covered in this course include risk and diversification; asset pricing models; capital structure and financing alternatives; dividend and stock repurchases; corporate governance; mergers, acquisitions and takeovers; financial distress and reorganization; and different international financial topics. 3 credit hours

MGMT-6040 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 new models of value creation and business growth being introduced across different industries and examines such critical issues as product and process technology strategy, operational innovation, IT strategies and infrastructures, networks and organization, and finance. Utilizing a series of case studies from across a range of industry networks, students will have a chance to learn how companies can participate in such networks and what unique business resources and capabilities they can employ to enhance their probability of commercial success. 3 credit hours

MGMT-6090 Networks, Innovation and Value Creation II
This course focuses on the execution and implementation issues arising from the growing role of networks as the organizing concept for business value creation. Topics include analyzing the different opportunities, how and where value can be created, the alternative 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, 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 of 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. 3 credit hours

MGMT-6140 Information Systems for Management
Analyzes the use of information and communications technology to improve performance and to achieve organizational goals. Examines information systems in sales, marketing, finance, and operations. Provides a framework for understanding and evaluating IS contributions to product services and managerial effectiveness. Focuses upon 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. 3 credit hours

MGMT-6170 Advanced Systems Analysis and Design
This is an advanced course in systems analysis and design that presents conceptual material about both traditional approaches to systems development such as process oriented and data-oriented methodologies and evolving approaches such as object-oriented development methods. Key stages of the systems development life cycle including planning, analysis, and design are the focus of this course. Models and procedures for understanding and modeling an organization’s existing and planned information systems are presented. Computer-aided software engineering tools are used to provide hands-on experience in designing information systems. A case-based approach is used to provide students an opportunity to apply the analytical and design techniques covered in the course. In addition, students are expected to do a real-life systems development project. The course also focuses on the issues and challenges in managing systems development. (Prerequisite: MGMT-6140 or equivalent. Spring term. 3 credit hours

MGMT-6180 Strategic Information Systems Management
Information technology (IT) is a strategic asset that is being used to mold competitive strategies and change organizational processes. As IT and its uses become more complex, developing strategies and systems to deliver the technology has become more difficult. The net result is a growing need for guidance on the issues, strategies, and tactics for managing the use of information technology. This course is designed to partially fulfill this need and to enable students to integrate concepts and theories learned in previous IT courses. Prerequisite: MGMT-6140. Spring term. 3 credit hours

MGMT-6200 Advanced Financial and Managerial Accounting
This course teaches students advanced theory and practice of contemporary accounting issues. The course deals with advanced financial accounting, inter-corporate investments, business combinations, financial statements, foreign currency translation, leases, pensions, and stock options. Advanced managerial accounting, accounting information systems, advanced costing models, activity-based costing, balanced scorecard, and economic value added (EVA) will also be studied. Prerequisite: MGMT-6020 or equivalent. Spring term. 3 credit hours

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. 3 credit hours

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. 3 credit hours

MGMT-6240 Financial Trading and Investing
This course introduces interactive trading in financial instruments. Students learn the principles of asset price discovery through real-time trading in a variety of markets, including equities, bonds, options, derivatives. Topics
addressed include asset valuation, portfolio management and risk management in the context of real-time trading of financial instruments. The course uses the facilities of the Lally School's Virtual Trading Room. Students will work in teams of two in many trading assignments. Prerequisites: MGMT-6020 and MGMT-6030, MGMT-6020, 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-6280 Seminar in Economic Theory**

This course covers the tools and concepts used in microeconomic analysis and will study the behavior of the basic building blocks of a market – consumers and firms and different market structures and their welfare properties. These models help with understanding the functioning of a capitalist market system and provide a useful framework to analyze various policy interventions. This course also provides a foundation for studying public finance, game theory, labor economics, etc. 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. Summer 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-6020. 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-6020 and MGMT-6300. Fall 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-6020 and 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-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-6420 Financial Theory
This is an introductory course of theoretical research in corporate finance. The course will examine the fundamentals of corporate finance theory (e.g., capital structure choice, dividend policy, etc.), as well as various tool areas (e.g., moral hazard and agency problems, and adverse selection and signaling). Knowledge of corporate finance at the MBA level, or its equivalent, is required. Students should have basic calculus and statistics knowledge at the undergraduate level or permission of the instructor. Prerequisite: Doctoral student standing or permission of the instructor. Fall 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.
3 credit hours
MGMT-6540 Marketing Communication and Branding Strategies
Advanced study of the promotion management process including market situation analysis, media selection, spending plans, copy strategy, and advertising research methods. The focus is on integrating promotion strategies with buyer needs in terms of unifying brand strategies. Other brand elements include product conceptualization, distribution strategies, and new communication technologies. Prerequisites: permission of instructor. Fall term. 3 credit hours

MGMT-6550 Marketing Research
Marketing strategy decisions are developed in the framework of many case studies. Marketing research techniques, including questionnaire development and data analysis, are introduced and utilized in a team project. Prerequisites: MGMT-6100 or permission of instructor. Spring term. 3 credit hours

MGMT-6580 Marketing High-Tech Products
This course deals with the peculiarities of marketing products and services in high-tech environments. High-tech environments are characterized by high dynamism, high uncertainty, and compressed time cycles. The course consists of case studies, computer simulations, and a team project. Prerequisites: permission of instructor. Spring term. 3 credit hours

MGMT-6600 Research and Development Management
The course deals with the responsibilities of and operating problems faced by managers of research and development. The following areas are included: technology forecasting, technology planning, selection and evaluation of R&D projects, resource allocation, planning, control, and measuring results of R&D. Particular attention is given to creative problem solving, motivating and managing creative individuals, barriers to innovation, and organization alternatives for R&D, including matrix and project organizations. Spring term. 3 credit hours

MGMT-6610 Global Strategic Management of Technological Innovation
The course helps develop an understanding of and the method for managing technology as a strategic resource of the firm. In doing so, an understanding of the process, roles, and rewards of technological innovation are developed. Integrating the strategic relationship of technology with strategic planning, marketing, finance, engineering, and manufacturing are covered. Governmental, societal, and international issues are briefly covered. The course uses a variety of cases, readings, reports, and lectures. (Cross listed as DSES-6470; students cannot obtain credit for both this course and DSES-6470). Fall term. 3 credit hours

MGMT-6620 Principles of Technological Entrepreneurship
An introductory graduate course in initiating new technology-based business ventures and developing them into self-sustaining and profitable enterprises. Examines the process whereby a person decides to become an entrepreneur, screens opportunities, selects an appropriate product/market target, and obtains the necessary resources. Provides the theoretical and practical knowledge for the preparation of formal business plans. Students enrolled in the full-time MBA program cannot use this course on the Plan of Study. This course is intended for students enrolled in the part-time MBA, M.S. in MGT or those seeking degrees in other schools at Rensselaer. Fall term. 3 credit hours

MGMT-6630 Starting Up A New Venture
An understanding of the critical issues related to starting up a new business is gained through team-based experiential learning. Small teams of students develop a comprehensive business plan that can be used to raise money for a new or relatively new venture. The experiential learning process is enhanced through team meetings with faculty and/or course advisers and through oral presentations to the entire class. Prerequisite: MGMT-6620. Spring term. 3 credit hours

MGMT-6640 Invention, Innovation, and Entrepreneurship
Creativity is the starting point for technological entrepreneurship. Through interaction with faculty and guest speakers, students increase their understanding of the creative process and some of the tools that can be implemented to stimulate and/or manage individual and collective creativity. In addition, through application of these techniques in course activities, students explore and attempt to enhance their own creativity. 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 systems. 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 entrepreneurialism 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-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. 3 credit hours

MGMT-6730 Technological Change and International Competitiveness
Analysis of the differences among technical systems and interactions with industrial growth is undertaken with regard to nation states, industrial sectors, and companies. To develop tools of analysis regarding technological change, industrial policy, and corporate performance. The impact of technological change on industrial growth and competitiveness is viewed from three perspectives: the general manager, the technical professional, and the public official. This course is available to Hartford students only. Fall term. 3 credit hours

MGMT-6740 Technology and Organization
This course explores the 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. 3 credit hours

MGMT-6750 Legal Aspects of E-Business and Information Technology
Legal, regulatory and public policy issues related to e-commerce/e-business, the Internet, and information technology are explored through an analytic, critical thinking approach. Topics include: e-contracts, digital signatures, B2B and B2C agreements; ownership, protection, and exploitation of intellectual capital including patents, trademarks, copyrights and trade secrets; regulatory issues; ISP and Web site liability including defamation; copyright infringement, securities regulation, and criminal acts; policy issues including privacy, security and encryption, and obscene materials. Global e-commerce will be explored. This course is available to Hartford students only. Fall term. 3 credit hours
MGMT-6770 Complex Organizations and Organization Theory
A macro approach to understanding organizations. Topics include organizational design, contingencies of design, organizational processes, such as culture, environmental interfaces and influences, information processing approaches to design, decision making, and organizational change and development. Doctoral course or permission of instructor.  

3 credit hours

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 program. Prerequisite: under graduate degree in any engineering discipline, environmental management policy. Projects are conducted in collaboration with companies in the Rensselaer Incubator Center, the Technology Park, and the Capital Region. Project teams make presentations before a panel. Prerequisite: all first year MBA courses and faculty adviser approval.  

3 to 6 credit hours

MGMT-6850 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.  

3 credit hours

MGMT-6870 Empirical Issues in Management Research
The course focuses on the empirical issues of academic research in different business disciplines. It broadly encompasses a number of key research topics emphasizing the theoretical underpinnings and the empirical frontiers. The course will concentrate on the use of statistical approaches relevant for engaging in empirical research. Overall, the course attempts to develop skills such as synthesizing research, developing research designs, building theories, and using appropriate empirical methodology and techniques. Fall term.  

3 credit hours

MGMT-6880 Management Research Workshop
The course focuses primarily on empirical issues in academic research. Students will learn to use theoretical and empirical skills acquired in previous courses and seminars in developing research in general, and academic papers in particular, in their respective fields. Prerequisite: Empirical Issues in Management Research. Spring term.  

3 credit hours

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 economics, psychology, sociology, anthropology, evolutionary biology, and political science. This puts the field at the nexus of all management studies. Prerequisites: doctoral student standing, Doctoral Research Methods sequence or permission of doctoral program director. Fall 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.  

3 credit hours

MGMT-7030 Strategy, Technology & Competition I
This course covers the fundamentals of business and corporate strategy, integrating these concepts into an environment of technological change, competition, and entrepreneurship. The course includes the following areas of emphasis: concepts of strategy, industry environment, resources and capabilities of the firm, organization and systems of the firm, the dynamics of competitive advantage, strategic alternative analysis, and strategies in different contexts. The course uses business cases and a project to enrich the theoretical concepts.  

3 credit hours

MGMT-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.  

3 credit hours

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.  

3 credit hours
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.

3 credit hours

MGMT-7070 Managing on the Edge: Corporate Innovation for the Coming Years
This course investigates the challenges of managing and leading organizations in situations characterized by their non-linear, unpredictable nature. Students will be challenged to develop innovative responses and solutions, drawing upon the full array of knowledge, skills, and insights they have gained from their two years of MBA study. Along with learning to deal with risk and uncertainty, the soon-to-be MBA graduates will be prepared for addressing the increasing degrees of fluidity and turbulence found in today’s business, economic and competitive environments.

3 credit hours

MGMT-7080 Succeeding in Knowledge Intensive Organizations
This course focuses on those behavioral skills needed for working and succeeding among the stresses and pressures endemic to high technology organizations. Through simulations and case studies, students learn how to handle the unique challenges of dealing with conflict management, negotiation, workplace diversity, and motivation and rewards in a knowledge-intensive organization.

1 credit hour

MGMT-7230 Professional Development Workshop I
This course is the first in a three part series of Professional Development Workshops that teach practical skills in laboratory settings. Over the first three semesters, the MBA cohort student will be exposed to professional skills training, Distinguished Speakers, and Leadership Development. This first part will concentrate on building writing and presentation skills, and practicing those skills in the conceptual environment of Leadership, Follower-ship and Membership. Prerequisite: MBA Cohort. Fall semester of the first year of the MBA cohort, every other week, for six weeks.

0 credit hours

MGMT-7240 Professional Development Workshop II
This course is the second in a three part series of Professional Development Workshops that teach practical skills in laboratory settings, in the context of Leadership, Follower-ship, 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, Follower-ship, 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-7730 Economics and Institutions
main course objective is to introduce students to basic economics principles and establish economics as a managerial decision-making framework. The course will draw on economic analysis of such concepts as cost, demand, profit, competition, pricing strategy, and market protection and tie them to operational business decisions. Fall term.

3 credit hours

MGMT-7740 Accounting for Reporting and Control
This course introduces theories and practices of financial as well as managerial accounting. The financial accounting sessions provide an overview of external financial statements. The managerial accounting sessions focus on how accounting information is used in the internal managerial decision making process within a firm as well as cover cost accounting, budgeting, and performance evaluation tools. Fall term.

3 credit hours
The course examines different responses of American, European and Asian firms to a global economy, within an historic and evolving context. Models of economic, social, political, technological, and national development will be introduced. Various conflicting demands of national governments, interest groups, corporations, unions, NGOs and consumers are often expressed in terms of ethical and social responsibility. Cases will be analyzed in terms of models of global business practices and conflicting claims will be critically evaluated. Fall term. 3 credit hours

MGMT-7760 Risk Management
This is a combination seminar and reading course, with special emphasis on construction of operations and strategies for dealing with virtually ubiquitous risk. If one must deal with a future which can only be dimly known at best, we must identify potential futures and develop strategies so that the influence of the future may be managed. In a sense, much of the course can be regarded as an excursion into financial engineering and financial management. A significant amount of time is also spent on a) the role of insurance in corporate and personal risk management, and b) employee benefits and retirement planning and investment. Fall term. 3 credit hours

MGMT-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

MTLE Materials Science and Engineering (SOE)
MTLE-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. 3 credit hours

MTLE-2100 Structure of Engineering Materials
The first course in Materials Science and Engineering. Structures of metals, ceramics, and polymers and experimental techniques for their determination are discussed. Laboratory experience is included. Prerequisite: ENGR-1600 or equivalent. 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 equilibrium, defects. Prerequisites: ENGR-2250, CHEM-1100, 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-1100, ENGR-1600. Spring term annually. 4 credit hours

MTLE-4160 Semiconducting Materials
Review of electronic properties of materials. Growth and structure of semiconductors. Diffusion, ion implantation, oxidation, microlithography, plasma etching, thin film deposition, metallization, with emphasis on Si technology. Introduction to compound semiconductors. Students cannot obtain credit for both this course and ECSE-4250. Prerequisite: MTLE-4200 or equivalent. Spring term. 3 credit hours
MTLE-4200 Properties of Engineering Materials I 

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 laboratory 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. 4 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. 3 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 performances indices, assessment and optimization of performance, processing routes and manufacturing issues, role of reverse engineering and failure analysis in design are covered. Generic design against yielding, fracture, flexure, buckling, fatigue, creep, corrosion, and wear are addressed, as opposed to design of specific products or in specific areas. A semester-long team design project is a principal focus. Team-building and leadership skills are
developed. Non-technical issues of environmental impact, cultural and societal impact, safety and health, ethics, and cost are discussed. Writing assignments and oral reports develop communication skills. Enrollment for MS&E majors is restricted to seniors or graduates. Prerequisite: CHEM-1100 and ENGR-1600 or ENGR-2010. Fall term annually.

**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 structure -property -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 annually.

**3 credit hours**

**MTLE-4960 Topics in Materials Engineering**
Spring term annually.

**3 credit hours**

**MTLE-6010 Defects in Solids**
Point defects, nonstoichiometry, diffusion and defects, electronic defects, elastic properties of dislocations, dislocation-point defect interactions, dislocation arrays, grain boundaries, stacking faults, phase stability, twin boundaries, epitaxial interfaces. Prerequisite: MTLE-2100 or equivalent. Fall term.

**3 credit hours**

**MTLE-6030 Advanced Thermodynamics**
Review of classical thermodynamics. Development of basic concepts of statistical thermodynamics. Application of both classical and statistical techniques to the determination of phase and chemical equilibrium in real systems. Prerequisite: MTLE-4100 or equivalent. Fall term.

**3 credit hours**

**MTLE-6040 Principles of Crystallography and X-Ray Diffraction**
Symmetry operations, point groups and space groups, X-ray and electron diffraction techniques, reciprocal lattice, Ewald sphere, mathematics of diffraction, crystal chemistry, crystal structure-property relationships. Spring term.

**3 credit hours**

**MTLE-6060 Kinetics of Materials Reactions I**

**3 credit hours**

**MTLE-6080 Electron Microscopy of Materials**
Introduction to electron optics, electron diffraction contrast mechanisms, specimen preparation, and microanalysis. Theory and operating fundamentals of the SEM, TEM, STEM, and the electron microprobe. Analysis of images from crystalline materials using kinematical and dynamical theories of electron diffraction. Prerequisite: MTLE-2100 or MTLE-6040. Fall term.

**3 credit hours**

**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.

**3 credit hours**

**MTLE-6110 Diffusion in Solids**

**3 credit hours**

**MTLE-6150 Fracture of Solids**

**3 credit hours**

**MTLE-6220 Advanced Semiconducting Materials and Processing**
Discussion of selected advanced and emerging topics in microelectronics materials and fabrication. These may include metallization, thin film deposition, interconnection technology, microlithography, plasma etching and processing.

**3 credit hours**

**MTLE-6300 Integrated Circuit Fabrication Laboratory**
Theory and practice of IC fabrication in a research laboratory environment. Test chips are fabricated and the resulting devices and circuits evaluated. Processes and fabrication equipment studied and used include oxidation/diffusion, CVD reactors, photolithography, plasma etching, vacuum evaporator, ion implantation, etc. Instruments used in process monitoring and final testing include thin film profilometer, ellipsometer, resistivity probe, scanning electron microscope, capacitance-voltage probe, scanning electron microscope.
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 materials 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 non-linear 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
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-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 doctoral dissertation. Grades of IP are assigned until the dissertation 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. Variable 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. 3 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. 4 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 they 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 annually. 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. 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 storyboarding 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.

**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. Summer. 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 exercises 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-6340 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 exercises 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-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 interactional teaching contexts including their own classes and interactive multimedia learning environments. 3 credit hours
PHIL Philosophy (HSSH)

PHIL-1110 Introduction to Philosophy
An introduction to the major areas of philosophy (ethics, theory of knowledge, philosophy of religion, etc.) and to some of the main problems treated within these fields. Selections from contemporary as well as classical authors are studied and discussed. Students are encouraged to develop a disciplined approach to intellectual problems. Emphasis varies with the instructor. Fall and spring terms annually. 4 credit hours

PHIL-2100 Methods of Reasoning
This course provides tools for the identification, analysis, and evaluation of the various patterns of reasoning as they occur in the real world. Patterns of reasoning include deductive reasoning, inductive reasoning, scientific reasoning, statistical reasoning, and causal reasoning. The course also covers some basic psychology and sociology of reasoning and belief, and concludes with a critical discussion of science and the scientific method. No prerequisites. (Cross listed as PSYC-2100. Students cannot obtain credit for both this course and PHIL-2100.) Spring term annually. 4 credit hours

PHIL-2120 Introduction to Cognitive Science
This course is an introduction to the new and quickly growing field of Cognitive Science which studies the various aspects of cognition, including reasoning, learning, memory, and perception and action. Cognitive Science is a highly interdisciplinary field of study at the intersection of philosophy, psychology, computer science, linguistics, neuroscience, and anthropology, and the course hosts a number of guest lectures given by experts in these respective fields. No prerequisites. (Cross listed as PSYC-2120. Students cannot obtain credit for both this course and PSYC-2120.) Spring term 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-4140 Intermediate Logic
This course is a continuation of PHIL-2140, covering basic metatheory of logic (including formal syntax and semantics, model theory, and soundness and completeness of proof systems), applications of logic (including automated theorem proving, deductive problem solving, and the axiomatization of various branches of mathematics), and alternative systems of logic (including sequent systems, diagrammatic logic, and modal logic). Prerequisite: PHIL-2140. Spring term every two years. 4 credit hours

PHIL-4220 Social and Political Philosophy
An exploration of such concepts as freedom, rights, and consent and their interrelationship; and a consideration of their bearing on questions of justice, law, and human welfare. 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. 4 credit hours

PHIL-4260 Philosophy of Artificial Intelligence
This course may be roughly divided into two general areas: philosophical problems in AI and philosophical issues that arise because of AI. An example from the first area is the Knower Paradox, a paradox in which an apparently desirable formalism for handling an agent's knowledge leads to inconsistency; an example from the second area is John Searle's attack on so-called "Strong" AI by way of his Chinese Room argument, wherein he claims that because a computer at bottom just manipulates symbols it cannot genuinely understand. Prerequisite: PHIL-2140. Fall term annually. 4 credit hours

PHIL-4300 Environmental Philosophy
While concepts such as quality of life, environment, nature, global ecology, and the like figure heavily in contemporary discussions, they are seldom integrated into an environmental philosophy. The course tries to achieve this integration by understanding some of the religious, mythic-poetic, and scientific dimensions of the man-nature matrix. Some specific environmental problems are examined in order to illustrate the system of values implied by various solutions. (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. 4 credit hours

PHIL-4310 Scientific Revolutions
What is progress in science? How has our concept of progress been influenced by science? Are there significant differences between scientific and technological revolutions? These questions are explored in order to shed light on the complex dynamics of academic and industrial research. (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. 4 credit hours

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. 4 credit hours

PHIL-4380 Philosophy of Mathematics
Basic schools of thought about the nature of mathematical reality are described and critically analyzed. Special topics include artificial intelligence, randomness, and the work of George Cantor on transfinite numbers. Prerequisite: PHIL-1110 or PHIL-2130. Offered on availability of instructor. 4 credit hours

PHIL-4420 Computability and Logic
A team-based, project-oriented, hands-on introduction to the great concepts and discoveries in logic and computability, including Turing Machines, first-order logic,
the limitations of computing machines, Godel's incompleteness results, and so forth. A hands-on laboratory component is included. Prerequisite: PHIL-2140. Spring term annually. 4 credit hours

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. 4 credit hours

PHIL-4480 Metaphysics and Consciousness
Daydreams about some tropical paradise ... The smell of freshly baked bread ... The flash of anger when someone cuts you off ... Your seeing of an albino squirrel on the campus green ... We take all of these to involve activities or states of consciousness. But what is this consciousness with which we claim to be so intimately familiar? What are its metaphysical implications and can we reconcile those implications with our current, scientific understanding of the world? Prerequisite: one course in philosophy or permission of instructor. Term: offered upon availability of instructor. 4 credit hours

PHIL-4520 Existentialism
An examination of the works of such writers as Kierkegaard, Nietzsche, Heidegger, Sartre, and Jaspers. Attention is also given to the thought of Husserl and to the phenomenological movement. Prerequisite: one course in philosophy or permission of instructor. Term: offered upon availability of instructor. 4 credit hours

PHIL-4570 Buddhism
A study of the conditions of human suffering and human perfection according to Buddhism. The course ranges from the original teaching of Buddha to the development of Buddhism throughout Asia, including China, Tibet, and Japan. Buddhist, Chinese, and Western views of the nature of causation, freedom, existence, and human nature are compared. Prerequisite: one course in philosophy or senior standing. 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
Reading and study in various fields of physics to develop interest in and ability for independent study. Prerequisite: permission of instructor. 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. 4 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. 4 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 Schrödinger 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. 4 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 as 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-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 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 Computational 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 and Fermi fields. Interacting fields and commutation relations. Interaction representation and S-matrix perturbation theory. Renormalization theory and applications in quantum electrodynamics. Prerequisite: PHYS-6520. Consult department about when offered. 3 credit hours

PHYS-6590 Statistical Mechanics
Review of thermodynamics, probability, and statistics. Statistical basis of thermodynamics, various ensembles, quantum statistics. Ideal Fermi and Bose gases and applications to solids and the black-body radiation. Interacting systems, phase transitions, and critical phenomena. Phase transition in the Van der Waals gas and in the Ising ferromagnet. Mean-field approximation and Landau theory of continuous phase transitions. Prerequisite: PHYS-6510. Spring term annually. 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
An introduction to the theory of solids. Theory of the free-electron metal, band theory, and phonons. Application to the electrical, optical, and thermal properties of solids. Qualitative discussion of cohesion. Prerequisite: PHYS-6520. Fall term annually. 3 credit hours

PHYS-6720 Theory of Solids II
More detailed application of solid-state theory to electrical, magnetic, and optical properties of matter. Consideration of particular materials: semiconductors, ferrites, ferroelectrics, and superconductors. Prerequisite: PHYS-6710. On availability of instructor. 3 credit hours

PHYS-6810 Nonlinear and Quantum Optics
Theoretical framework for analysis of wave propagation in nonlinear media. Classical and quantum theory of nonlinear response. Multi-wave mixing, including second-harmonic generation, optical phase conjugation and optical bistability. Quantization of the electromagnetic field and quantum stochastic processes in atom-field interactions. Applications to amplifiers, lasers, resonance fluorescence, and squeezed state generation. Quantum theory of measurements. Prerequisite: PHYS-6510. Consult department about when offered. 3 credit hours

PHYS-6900 Seminar
Selected topics. Credit hours to be arranged

PHYS-6940 Readings in Physics
Supervised reading and study in various fields of physics. 3 credit hours

PHYS-6960 Topics in Physics
Variable credit hours

PHYS-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the 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. Graded 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-2100 Methods of Reasoning
This course provides tools for the identification, analysis, and evaluation of the various patterns of reasoning as they occur in the real world. Patterns of reasoning include deductive reasoning, inductive reasoning, scientific reasoning, statistical reasoning, and causal reasoning. The course also covers some basic psychology and sociology of reasoning and belief, and concludes with a critical discussion of science and the scientific method. No prerequisites. (Cross listed as PHIL-2100. Students cannot obtain credit for both this course and PHIL-2100.) Spring term annually. 4 credit hours

PSYC-2120 Introduction to Cognitive Science
This course is an introduction to the new and quickly growing field of Cognitive Science which studies the various aspects of cognition, including reasoning, learning, memory, and perception and action. Cognitive Science is a highly interdisciplinary field of study at the intersection of philosophy, psychology, computer science, linguistics, neuroscience, and anthropology, and the course hosts a number of guest lectures given by experts in these respective fields. No prerequisites. (Cross listed as PHIL-2120. Students cannot obtain credit for both this course and PHIL-2120.) Spring 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. Spring term 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. 2 credit hours

PSYC-4200 Industrial and Organizational Psychology
A broad introduction to the field of Industrial and Organizational Psychology. Topics covered include personnel selection, job analysis, training, performance appraisal, work-related attitudes, employee motivation, leadership, decision making, and organizational theory. Prerequisite: PSYC-1200. 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-4320 Behavioral Neuroscience
This course is an introduction to the role of physiological mechanisms in behavioral processes. There will be detailed examination and discussion of the involvement of biological systems in feeding and drinking, sexual behavior, sleep and arousal, learning and memory, psychopathology and psychopharmacology. Prerequisite: PSYC-1200. 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-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. 4 credit hours

PSYC-4500 Drugs, Society, and Behavior
This course is an exploration of the social and psychological effects of extensive use of pharmacological agents that are salient to daily behavior. There is an emphasis on the effects of addictive drugs such as alcohol, heroin, and cocaine. Prerequisite: PSYC-1200. Annually. 4 credit hours

PSYC-4510 Cognitive Modeling
Cognitive modeling investigates human cognition by developing computational systems that simulate cognitive processes. Cognitive modeling grew out of Cognitive Psychology and Artificial Intelligence. Cognitive models are used in a number of basic and applied domains including Human-Computer Interaction, Intelligent Tutoring Systems, Computer-Generated Forces, and Synthetic Characters. In this course, students will develop models in ACT-R (a unified theory of cognition) that simulate recent findings in cognitive psychology. Prerequisites: PSYC-1200 and CSCI-2300. Recommended: CSCI-4150 and/or PSYC-4370 or permission of instructor. Spring term annually. 4 credit hours

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. 4 credit hours

PSYC-4600 Cognition and the Brain
Perception and thought are considered in terms of processes represented in the brain. The localization and lateralization of function are examined, drawing upon research on the behavioral effects of brain damage as well as brain-imaging studies and other approaches. Examples of topics include object recognition, memory, language, emotion, spatial ability, and motor processes. Prerequisite: PSYC-1200. Fall term annually. 4 credit hours

PSYC-4720 Abnormal Psychology
The definition, history, major schools of thought, and models of the normal and abnormal personality are presented. Disorders are examined within the framework of D.S.M. and competing schools of thought. The description, etiology, treatment, including pharmacologic, and prevention of each of the disorders are considered. Illustrative cases are presented. Students write a paper on a topic, approved by the instructor, that focuses upon the impact of public policies on psychopathology. Prerequisite: PSYC-1200. Annually. 4 credit hours

PSYC-4740 Psychology and The Law
Since the 1950’s, social science researchers have turned their attention to the courtroom, in order to test theories of human behavior in a real world application. Are the basic assumptions underlying the practice of law in this country valid, given what psychologists know about the fundamentals of human behavior? This course will provide students with instruction regarding how the study of psychology can contribute to a better understanding of the legal system. Prerequisite: PSYC-1200. Fall term annually. 4 credit hours

PSYC-4750 Forensic Psychology
A practical introduction to the field of forensic psychology, a domain within psychology concerned with the production and application of psychological knowledge to the civil and criminal justice systems. In this course, we explore the many ways in which psychological principles play an increasingly important role in influencing various processes and outcomes associated with the field of law. Prerequisite: PSYC-4740. Spring term annually. 4 credit hours

PSYC-4770 Psychopharmacology and Behavioral Toxicology
This course is a detailed examination of the neuroscience and psychology inherent to the development of pharmacological agents for treating psychopathology. There is also an exploration of chemicals that are toxic to the brain as manifest by induction of psychopathology. 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. 4 credit hours

PSYC-4940 Readings in Psychology
An individually arranged independent study course under the supervision of a member of the Psychology Department. The topic is selected by consultation between student and faculty member. Prerequisite: PSYC-1200 and/or permission of supervising faculty member. 1 to 4 credit hours

PSYC-4960 Topics in Psychology
An advanced course concerned with selected topics in psychology. Prerequisite: PSYC-1200 or permission of instructor. 1 to 4 credit hours
PSYC-4990 Undergraduate Thesis
Students conduct original scholarly projects: original research, theoretical or analytical reviews of the literature, or computer simulations. Working either alone or in groups, students prepare written reports relating to this project, under the supervision of a faculty member. Prerequisite: permission of a supervising faculty member. Fall, spring, and summer terms annually.

3 to 6 credit hours

STSH Science and Technology Studies—Humanities Credit (HSSH)
(For Science and Technology Studies-Social Sciences Credit, see STSS.)

STSH-1110 Science, Technology, and Society
An introduction to the social, historical, and ethical influences on modern science and technology. Cases include development of the atomic bomb, mechanization of the workplace, Apollo space program, and others. Readings are drawn from history, fiction, and social sciences; films and documentary videos highlight questions about the application of scientific knowledge to human affairs. The class is designed to give students freedom to develop and express their own ideas. (Cross listed as STSS-1110. Students cannot obtain credit for both this course and STSS-1110.) This course can be used to satisfy either humanities or social sciences distribution requirements. Fall and spring terms annually. 4 credit hours

STSH-2130 Introduction to Philosophy of Science
How does science stimulate philosophical thinking and how has philosophy influenced science? This broad range of interaction is studied with special attention given to the concepts of theory, observation, and scientific method. Special attention is given to issues basic to psychology, in particular, reductionism, behaviorism, functionalism, and cognitivism. (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, co-professionals, and their responsibility for public safety and welfare. Topics include the history of engineering, professionalism vs. the demands of business, engineering vs. management decision making, whistle-blowing, proprietary rights and trade secrecy, and conflicts of interest. Prerequisite: STSH-1110/STSS-1110, STSS-2400, or permission of instructor. 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 forefronts of genetics and biotechnology, and their social and ethical implications, through multiple lenses: writings of scientists and science fiction writers, and historians, philosophers, and anthropologists of the life sciences. Topics may include: genetic testing and gene therapy; sports medicine; cosmetic psychopharmacology; patents and intellectual property; transgenic organisms; organ transplants and artificial organs; stem cell research; genetic enhancement; artificial life; cloning; and other related topics. Prerequisites: any STS course, or permission of the instructor. 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.

4 credit hours

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.

4 credit hours

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.

4 credit hours
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, and therefore an attempt to understand the American culture itself. This is accomplished by a visual study of the architecture and artifacts of America during its formative period. 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. 4 credit hours

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. 4 credit hours

STSH-4800 Public Service/Professional Careers Internships
This course offers an insight into the public policy process from the vantage point of a part-time internship in the public or private sector as well as an opportunity to explore a career option before actually embarking upon it. The following is a partial list of the large number of possible internships: airport planning, architecture, banking, biological research, clinical psychology, computer science, consumer protection, corporate management, engineering, environmental planning, geology, local government, materials and mechanical engineering, noise pollution abatement, personnel management review, premedical, public finance and taxation, public health management, public relations, social work, state legislature, stock market, transportation planning, and urban planning. (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. 4 credit hours

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. 4 credit hours

STSS-4850 The Phelan Seminar on Technology and Society
An undergraduate honors-style seminar examining interactions between technology and modern society. Particular attention will be given to the historical origins and contemporary contexts of technological change in America, especially the Hudson/Mohawk region of New York. The specific topic of the seminar will change each year, coordinated with visiting lecturers and other scholarly events, publicized during the fall term. Prerequisite: any 2000-level STS course and permission of instructor. Spring term annually. 4 credit hours

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. 4 credit hours

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 Death; Fraud and Misconduct in Science; Utopian Thought; Engineering and Society: The Art of Design; Nature/Nurture Controversies; and Warfare: Social Dimensions. Prerequisite: any 2000-level STS course or consent of instructor. 4 credit hours

STSH-4940 Readings in Science and Technology Studies
With an individual faculty member on an agreed-upon topic. 4 credit hours

STSH-4960 Topics in Science and Technology Studies
4 credit hours

STSH-4980 Senior Project
Ordinarily consists of independent research, supervised by a faculty member, culminating in a written thesis. A creative endeavor such as a videotape or computer program may be substituted with departmental permission. 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-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.  

3 credit hours

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 religion. Other topics may include love, crime, political economy, power, population growth, social class, and minority and ethnic relations. Fall and spring terms annually.  

4 credit hours

STSS-1310 Principles and Practices of American Government
An analytical survey of the essential features of American government within the national setting of environmental and historical factors. Among the topics included are the foundations and characteristics of American constitutionalism; the principles of federalism and the boundaries of federal, state, and local governments; the structure and dynamics of political parties; the activities and interrelations of the legislative and executive branches on all levels of American government; the judicial process and judicial review. Offered on availability of instructor.  

4 credit hours

STSS-1330 International Relations
The world today faces enormous problems: the bloody horrors of war, the unconscionable and widening economic gap between rich and poor countries, and the looming threat of catastrophic environmental degradation. This course examines the causes and consequences of these
problems, wonders what a world beyond greed and hate would look like, and considers what it will take to build a better world. Toward these ends, several themes are explored, including the nature of the international system, contemporary challenges to the state system, and alternatives to hunger, exploitation, and international violence. Annually. 4 credit hours

STSS-1510 Cultural Anthropology
An introduction to human societies and cultures in comparative perspective, from tribal societies to complex societies such as the United States. Emphasis on ethnographic descriptions of other cultures such as on the interpretation of cultural symbolism and on topical issues such as medical anthropology. Annually. 4 credit hours

STSS-1960 Topics in Science and Technology
Studies, Anthropology/Archaeology, History, Political Science, or Sociology

STSS-2100 Medicine and Society
The course is to explore the contributions of anthropology, sociology, and history to health and illness. By the end of the course, students will have an overall picture of health fields, problems faced by patients and caregivers, medicine and health in non-Western societies, and the social shaping of disease and therapeutic choices. This course introduces the Medicine and Society Minor Concentration. Annually. 4 credit hours

STSS-2200 Engineering, Design, and Society
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. 4 credit hours

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. 4 credit hours

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. 4 credit hours

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. 4 credit hours

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. 4 credit hours

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. Fall term annually. 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-4350 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-4360 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 STSS-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. Emphasizes on the interrelationships 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 abate-
ment, 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-4850 The Phelan Seminar on Technology and Society
An undergraduate honors-style seminar examining interactions between technology and modern society. Particular attention will be given to the historical origins and contemporary contexts of technological change in America, especially the Hudson/Mohawk region of New York. The specific topic of the seminar will change each year, coordinated with visiting lecturers and other scholarly events, publicized during the fall term. Prerequisite: any 2000 level STS course and permission of instructor. Spring term annually. 4 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-4540, 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 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
The United States Air Force and Air Force Reserve Officer Training Corps. Featured topics include: mission and organization of the Air Force, officer 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).

### AS-2000, AS-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 Force Core Values, through the use of operational examples and historical Air Force leaders, and will continue to develop their communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences. 200 A (fall term) 200 B (spring term).

### 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. 1 to 9 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
studies, advanced leadership ethics, and Air Force doctrine. Special topics of interest focus on the military as a profession, officer, 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).

USAR 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 officer. 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.

4 credit hours

USAR-2020 Applied Leadership II
The course focuses principally on officership, providing an extensive examination of the unique purpose, roles, and obligations of commissioned officers. It includes a detailed look at the origin of the Army's institutional values and their practical application in decision making and leadership. At the core is the Basic Course's Capstone Case Study in Officership. This five lesson exercise traces the Army's successes and failures as it evolved from the Vietnam War to the present, placing previous lessons on leadership and officership in a real world context that directly affects the future of the students who plan on attending the Advanced Course. This course, more than any before it, draws the various components of values, communications, decision making, and leadership together to focus on a career as a commissioned officer. Upon completion of this course, students should possess a fundamental understanding of both leadership and officership, and demonstrate the ability to apply this understanding in real-world situations.

1 credit hour

USAR-2060 Applied Military Leadership I
The course begins with instruction in the Leadership Development Program (LDP), used throughout the academic year to assess and develop leadership. Instruction in principles of war and purposes, fundamentals, and characteristics of the defense provides the necessary knowledge base for meaningful contextual treatment of Troop leading procedures (TLP). Instruction in decision-making, planning, and execution processes of the TLP are followed by a refocus on the critical leadership task of communicating the plan using the standard military format. The course addresses motivational theory and techniques, the role and actions of leaders, and risk assessment. The course closes with instruction in small unit battle drills to facilitate practice application and further leader development during labs and situational training exercises (STX).

2 credit hours

USAR-2070 Applied Military Leadership II
The course continues to focus on doctrinal leadership and tactical operations at the small unit level. It includes opportunities to plan and conduct individual and collective skill training for military operations to gain leadership and tactical experience. The course synthesizes the various components of training, leadership and team building. Students are required to incorporate previous military science instruction for their practical application
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 cadre officers within the ROTC program and after commissioning. At the end of the course, students should possess the fundamental skills, attributes, and abilities to operate as competent leaders.

2 credit hours

USAR-4020 Advanced Military Management and Leadership II
The course focuses on completing the transition from cadet to lieutenant. As a follow-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.

2 credit hours

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.

0 credit hours

USNA-1010 Introduction to Naval Science
The organization of the Department of Defense with emphasis on the Department of the Navy. This course provides a broad overview of all aspects of the operation and administration of today's Navy and Marine Corps. Additionally, the course will introduce naval topics such as rank structure, naval etiquette, naval history, naval warfare platforms and missions as well as basic naval leadership principles. The course will also cover basic military conduct and NROTC rules and regulations. Finally, the course will look at the role of the U.S. military in today's ever changing geopolitical climates and global conflicts.

3 credit hours

USNA-2020 Sea Power and Maritime Affairs
A study in the development of the United States Navy and Marine Corps throughout the history of the United States. This course treats the broad principles, concepts, and elements of seapower with historical and modern applications to the United States and other world powers.

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. Ship 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.

**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.

**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.

**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.

**USNA-2940 Readings in Naval Science**
An individually arranged independent study course under supervision of a member of the Naval Science Department.

**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.

**WRIT Writing (HSSH)**

**WRIT-1110 Writing for Classroom and Career**
This course emphasizes written, visual, and oral communication strategies that will help students succeed in both academic and professional contexts. Principal assignments are based on types of writing required in school and on the job: reporting, evaluating, taking a position, and making a proposal (orally and in writing). Written assignments will include visual elements such as headings, charts/graphs, and page or screen design. Fall and spring terms annually.

**WRIT-1960 Topics in Writing**

**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.

**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.

**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 critique other performances. Fall term annually.

**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-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