

SCHOOL OF SCIENCE AND COMPUTER ENGINEERING

COURSE ROSTER

ASTRONOMY AND SPACE SCIENCE

(See also PHYSICS)

Please note: All ASTR graduate courses (5000 or 6000 level) assume the student has a solid background in physics and mathematics, at least, through differential equations.

- ASTR 5131: GRADUATE ASTRONOMY**
Quantitative introduction to physics of the stars, interstellar medium, cosmochemistry, the Galaxy, and Universe as determined from a variety of astronomical observations and models.
- ASTR 5231: STELLAR STRUCTURE AND EVOLUTION**
Prerequisites: Core Physics courses or instructor approval. Principal concepts, equations, methods and results of the theories of stellar atmosphere and interiors and their relation to observations.
- ASTR 5331: REMOTE SENSING INSTRUMENTATION AND TECHNIQUES**
Prerequisite: Core physics courses or instructor approval. Fundamentals of remote sensing; radiative quantities; radiative transfer theory and applications; interaction mechanisms, applications to the development of uses for remote sensing systems from spacecraft and aircraft.
- ASTR 5431: FUNDAMENTALS OF ASTRODYNAMICS**
Prerequisite: Core physics courses or instructor approval. Development of the two-body problem and universal formulation of all types of orbits, initial value problems, two-point boundary value problems, coordinate transformations and trajectory perturbations.
- ASTR 5432: PERTUBATION METHODS IN ASTRODYNAMICS**
Prerequisite: ASTR 5431 or instructor approval. A study of the methods of the solution to the perturbed two-body problem with applications to the motion of satellites.
- ASTR 5531: PLANETARY SCIENCE**
Prerequisite: Physical geology or equivalent. Planetary dynamics, planetary interiors, atmospheres and surfaces; magnetism; models of solar system origin.
- ASTR 5631: UNIVERSAL ORIGINS AND LIFE**
Origin of the universe, including an overview of the fundamental particles and forces as well as relativity, the Big Bang, the inflationary universe, the accelerating universe, and origin and evolution of life.
- ASTR 5632: ASTROBIOPHYSICS AND SETI**
The search for life in the universe, including origin of the universe, evolution of Earth as a habitable planet, possibilities for finding life on Mars and other solar system bodies, discovery of extra-solar planets, and the Search for Extra-Terrestrial Intelligence (SETI).
- ASTR 5931: RESEARCH TOPICS IN SPACE SCIENCE**
Identified by specific title each time course is offered.
- ASTR 5939: INDEPENDENT STUDY IN SPACE SCIENCE**
Prerequisites: Approval of instructor, chair and associate dean required.

BIOLOGY

*Pending Coordinating Board approval

- BIOL 5131: MEMBRANE BIOLOGY**
Prerequisite: Biochemistry. Study of synthesis and function of cellular membranes.
- BIOL 5132: CELL SIGNALING**
Prerequisites: BIOL 4431 and 4437 or equivalent. Detailed study of signal transduction in living cells. Concentration on current knowledge regarding the manner in which cells communicate with one another, integrate incoming signals and respond in appropriate manner.
- BIOL 5136: PHYSIOLOGY OF HUMAN AGING**
Prerequisite: Human physiology. Biological changes in human organ systems with advancing age; theoretical and empirical aspects of aging processes.
- BIOL 5215: LABORATORY FOR ICHTHYOLOGY**
Corequisite: BIOL 5235. Advanced laboratory course on identification, anatomy and ecology of fish. Fisheries methods also emphasized. Weekend or weekday field trips and collections required.
- BIOL 5233: ECOTOXICOLOGY**
Prerequisite: BIOL 4235 or BIOL 5332 or equivalent. Study of environmental pollutants and effects on ecosystems.
- BIOL 5234: POPULATION AND COMMUNITY DYNAMICS**
Prerequisites: Ecology and Genetics. Application of basic population modeling and analysis methods used in the management of animal populations. Emphasis placed on harvested populations and fisheries.
- BIOL 5235: ICHTHYOLOGY**
Corequisite: BIOL 5215 Advanced study of biology, ecology and evolution of marine and freshwater fishes.
- BIOL 5332: TOXICOLOGY**
Prerequisite: BIOL 4235 or BIOL 4431 or BIOL 4434 or BIOL 4435 or equivalent. Evaluation of the effects of poisons and other toxic substances.
- BIOL 5333: INDUSTRIAL MICROBIOLOGY**
Prerequisites: Microbiology and biochemistry. Microbial processes having economic interest to man; fermentation, deterioration, waste disposal: food spoilage and drug preparation.
- BIOL 5336: NEUROPSYCHOLOGY PRACTICUM**

- Prerequisite: Permission of instructor. Laboratory investigation of drug/brain/behavior relationships in the rat. Readings from primary research literature, laboratory experiments and research report.
- BIOL 5432: PRINCIPLES OF PHARMACOLOGY**
Prerequisite: BIOL 4431, BIOL 4434, or BIOL 4435. Emphasis on principles for evaluating the effects of drugs.
- BIOL 5433: ENZYMOLOGY**
Prerequisite: BIOL 4431 or equivalent. Study of enzyme isolation, purification, assay and characterization. Emphasis on kinetics of enzyme catalyzed reactions and on the use of enzymes in medicine and industry.
- BIOL 5434: HUMAN STRESS**
Prerequisites: BIOL 4435, BIOL 4436 or equivalent. Stressors and the characteristic physiological manifestations of stress in nervous and hormonal mechanisms.
- BIOL 5435: ADVANCED IMMUNOLOGY**
Prerequisite: BIOL 4631 or equivalent. Course will allow students to explore published research that supports currently accepted mechanisms of the immune function. Students will be expected to correlate basic principles of the immune system to the advances in medicine and pathology.
- *BIOL 5436: PHYSIOLOGICAL BASIS OF DISEASE**
Prerequisite: An introductory Human Physiology course or equivalent. The effects of diseases on normal physiologic functions and the physiologic basis of medical treatments for these diseases will be discussed.
- BIOL 5530: RESEARCH METHODS IN BIOLOGY**
Prerequisite: Graduate standing. Students will develop a research proposal, which allows integrating knowledge and standard procedures in a chosen area of Biology. A written proposal and an oral presentation are required to complete the course.
- BIOL 5531: AQUATIC TOXICITY TESTING**
Prerequisite: BIOL 4235 or equivalent. Theory of toxicity testing, statistical analysis procedures and laboratory practice in standard aquatic toxicity tests.
- BIOL 5532: ESTUARINE ECOLOGY**
Prerequisite: BIOL 4131. Study of physical, chemical and biological nature of estuarine ecosystems, Includes one or more weekend or weekday field trips and lab experiments.
- BIOL 5533: ECOLOGICAL METHODS**
Field methods for analysis of ecological systems. Field work and laboratory are required.
- BIOL 5534: CONSERVATION BIOLOGY**
Prerequisite: Genetics or Evolution. Analysis of evolutionary forces that generate and shape biodiversity and the biological, sociopolitical and economic issues faced in the conservation of biodiversity.
- BIOL 5535: TROPICAL RAINFOREST ECOLOGY**
Study of neotropical rain forests, including their physical, chemical and geological characteristics and plant /animal ecology. Students completing course qualify for discounted optional ecology study trip to the Amazon flooded forest areas of Brazil.
- BIOL 5632: BIOENERGETICS**
Prerequisite: BIOL 4431 or equivalent. Mechanisms of ATP Synthesis and other aspects of biological energy transduction.
- BIOL 5634: APOPTOSIS**
Prerequisite: BIOL 4437. Students in this course will study the stimuli and pathways involved in programmed cellular death.
- BIOL 5635: NEUROSCIENCE**
Prerequisites: Anatomy, Physiology. This course introduces basic and advanced concepts in neuroscience. The course covers a wide range of topics in this exciting field of science from the molecular level through the anatomical organization of sensory and motor systems.
- BIOL 5731: ADVANCED CANCER BIOLOGY**
Prerequisite: BIOL 3431 or BIOL 4531 or equivalent. Cancer, genetics and heredity; prevention, detection and treatment of cancer. Literature research and presentation on molecular basis of various cancers required.
- BIOL 5732: ADVANCED MOLECULAR BIOLOGY**
Prerequisite: Genetics. Study of eukaryotic DNA replication, post transcriptional processing, eukaryotic gene regulation, overexpression and repression, protein structure.
- BIOL 5734: ONCOGENES**
Prerequisite: Molecular biology. Study of cancer at the level of the gene.
- BIOL 5736: BIOETHICS**
Prerequisite: General Biology. Study of complex situations in biology and medicine that require moral reflection, judgment or decisions.
- BIOL 5737: MOLECULAR VECTORS**
Prerequisite or corequisite: Molecular biology. Properties, construction and use of vectors for molecular cloning and manipulation.
- BIOL 5738: GENE THERAPY**
Prerequisite or corequisite: Molecular biology. Gene technologies with applications to disease, cancer, neurological and genetic disorders, cardiovascular and infectious diseases.
- BIOL 5833: PROTEOMICS**
Prerequisite: Molecular Biology. Analysis of gene function of mRNA expression profiling with cDNA arrays, protein interactions by genome-side two hybrid screening and more direct analysis of protein expression, sequence and structure.

- BIOL 5915: COOPERATIVE EDUCATION WORK TERM**
Prerequisites: Approved Candidate Plan of Study, completed cooperative education file and approval of associate dean and Director of Cooperative Education. Educational paid work assignment by a student in the field of his/her career interest and course of study. Technical report will be required at the end of the semester.
- BIOL 5919, 5939: INDEPENDENT STUDY IN BIOLOGICAL SCIENCE**
Prerequisites: Approval of instructor, chair and associate dean.
- BIOL 5931: RESEARCH TOPICS IN BIOLOGY**
Identified by specific title each time course is offered.
- BIOL 6838: RESEARCH PROJECT AND SEMINAR**
Prerequisite: 24 hours completed in approved graduate program. Students will complete a study of the current literature, including methodology and techniques, used in a selected area of Biology. A written review paper and an oral presentation will be required.
- BIOL 6939: MASTER'S THESIS RESEARCH**
Prerequisites: Approval of advisor, master's committee and dean.

BIOTECHNOLOGY

*Pending Coordinating Board approval

- BIOT 5031: APPLIED BIOTECHNOLOGY**
Prerequisite: Molecular Biology. How recombinant DNA technology can be used to create various useful products using experimental results and actual methodological strategies to illustrate basic concepts. Course is designed for students with backgrounds in biochemistry, molecular genetics or microbiology.
- BIOT 5131: ADVANCED METHODS IN BIOTECHNOLOGY I**
Prerequisite: BIOL 4531. Designed to provide advanced practical training in current techniques of molecular and cellular biology, including recombinant DNA technology, Southern and Northern analysis of nucleic acids, PCR, DNA sequencing and analysis using current computer programs, Western blotting, etc. Intended for students who have prior background in molecular biology.
- BIOT 5132: ADVANCED METHODS IN BIOTECHNOLOGY II**
Prerequisite: BIOL 4531. Will focus on describing latest techniques of molecular biology and proteomics, including chromatographic separations of proteins, His-tagged protein and Ni-column purification, design and analysis of dual expression plasmids, RTPCR, 2-D gel electrophoresis and mass spec analysis of proteins, yeast two-hybrid assay.
- BIOT 5530: RESEARCH METHODS IN BIOTECHNOLOGY**
Students will develop a research proposal, which allows integrating knowledge and standard procedures in a chosen area of Biotechnology. A written research proposal and oral presentation will be required.
- BIOT 5733: BIOINFORMATICS**
Prerequisite: BIOL 4531 or equivalent. Examination of the tools and sequence databases for all known genomes.
- BIOT 5736: BIOETHICS**
Prerequisite: General Biology. Study of complex situations in Biology, Biotechnology and Medicine that require moral reflection, judgment or decisions.
- BIOT 5915: COOPERATIVE EDUCATION WORK TERM**
Prerequisites: Approved Candidate Plan of Study, completed cooperative education file and approval of associate dean and Director of Cooperative Education. Educational paid work assignment by a student in the field of his/her career interest and course of study. Technical report will be required at the end of the semester.
- *BIOT 5919, 5929, 5939: INDEPENDENT STUDY IN BIOTECHNOLOGY**
Prerequisites: Approval of instructor, chair and associate dean.
- BIOT 5931: RESEARCH TOPICS IN BIOTECHNOLOGY**
Identified by specific title each time course is offered
- BIOT 6838: RESEARCH PROJECT AND SEMINAR**
Prerequisite: 24 hours completed in approved graduate program. Students will complete a study of the current literature, including methodology and techniques used in a chosen area of Biotechnology. A written review paper and oral presentation will be required
- BIOT 6939: MASTER'S THESIS RESEARCH**
Prerequisites: Approval of advisor, master's committee and dean

COMPUTER ENGINEERING

- CENG 5011: LAB FOR COMPUTER ENGINEERING FUNDAMENTALS**
Corequisite: CENG 5031. Laboratory experiments in digital circuits and computer architecture.
- CENG 5031: COMPUTER ENGINEERING FUNDAMENTALS**
Corequisite: CENG 5011. Fundamentals of logic systems and computer architecture.
- CENG 5131: ENGINEERING APPLICATIONS**
Prerequisite: Linear Systems Analysis or equivalent. Study of modern engineering techniques emphasizing mathematical methods currently used in industry. The MATLAB software package will be used for problem solving.
- CENG 5132: ADVANCED ENGINEERING APPLICATIONS**
Prerequisite: CENG 5131. Presentation of modern mathematical and analysis techniques used for problem solving in engineering and other disciplines. Topics include state-space solutions, Fourier and Laplace analysis and probability and statistics. Each topic area will be completed with a solution of a practical example that is of

current interest in various areas of technology. The MATLAB software package will be used for solving certain problems.

CENG 5231: NETWORK SYSTEM SPECIFICATION

The procedures and approaches used to evaluate and specify systems will be covered. Case studies will include systems that combine data acquisition, engineering workstation capability and small-business aspects in a networked group of computers. Laboratory instruction.

CENG 5232: SYSTEMS ENGINEERING ANALYSIS & MODELING

Prerequisites: SENG 5231 and SENG 5232 or permission of instructor and advisor. Use of computing tools to analyze, model and simulate solutions to complex systems engineering problems.

CENG 5331: THEORY OF INFORMATION & CODING

Prerequisites: Background in digital logic, statistics and linear systems analysis. Shannon's theory of information and coding applied to discrete communications channels; theory of finite fields applied to error detection and correction codes.

CENG 5333: NETWORK PERFORMANCE ANALYSIS

Prerequisites: Background in data communications and probability theory. Queuing theory, data link control, routing and flow control, polling and line control, LANs, circuit switching and call processing. Laboratory instruction.

CENG 5334: FAULT TOLERANT COMPUTING

Prerequisites: Background in probability, computer hardware and computer software. Lectures and research projects involving: design techniques for fault tolerant computers; fault modes; failure mechanisms; failure, fault and error relationship; architectural and software options for fault tolerance; modeling and evaluation techniques.

CENG 5431: DIGITAL SIGNAL PROCESSING

Prerequisite: CENG 5131 or equivalent. Sampling, Fourier analysis, FFT's and digital filtering. Laboratory instruction.

CENG 5432: DIGITAL CONTROL SYSTEMS

Prerequisite: CENG 5131 or equivalent. Analysis and synthesis of digital control systems and a comparison of continuous and discrete control systems. Laboratory instructions.

CENG 5433: PRINCIPLES OF DIGITAL COMMUNICATIONS SYSTEMS

Prerequisites: Linear systems theory and calculus -based probability. Analysis and synthesis of digital communications systems.

CENG 5434: MICROCOMPUTER SYSTEMS DESIGN

Prerequisites: Computer architecture and assembly language. Software design and use of 32-bit microcomputers and microcontrollers as used in modern computer systems and products. Laboratory instruction.

***CENG 5531: MACHINE LEARNING AND APPLICATIONS**

Prerequisite: MATH 3334. Fundamentals of machine learning and pattern recognition. Topics covered include neural networks, Bayesian inference and non-parametric techniques.

***CENG 5534: ADVANCED DIGITAL SYSTEM DESIGN**

Prerequisite: CENG 4534 or equivalent. Behavioral and structural design methods and examples using hardware description languages, including control, arithmetic, bus systems, memory systems and logic synthesis from hardware descriptions.

CENG 5634: ARTIFICIAL NEURAL NETWORKS

Prerequisite: Senior or graduate standing in computing, mathematics, business or other majors. Knowledge of computer algorithms, programming and a basic understanding of calculus, linear algebra, probability and statistical theory. A course covering artificial neural network (ANN) models and computation. The emphasis is on the rationale, theory, modeling, analysis, methodology, evaluation and representative applications of ANN. The computational capabilities and limitations of several popular ANN models are analyzed.

CENG 5915: COOPERATIVE EDUCATION WORK TERM

Prerequisites: Approved Candidate Plan of Study, completed cooperative education file and approval of associate dean and Director of Cooperative Education. Educational paid work assignment by a student in the field of career interest and course of study. A technical report will be required at the end of the semester. (Specific requirements are noted in the Cooperative Education Catalog description.)

CENG 5931: RESEARCH TOPICS IN COMPUTER ENGINEERING

Identified by specific title each time course is offered.

CENG 5939: INDEPENDENT STUDY IN COMPUTER ENGINEERING

Prerequisites: Approval of instructor, chair and associate dean.

CENG 6332: HIGH PERFORMANCE COMPUTER ARCHITECTURE

Prerequisite: Background in computer architecture. Introduction to systems architecture design and tuning techniques for High Performance Computing; RISC's, cache, pipelines, hypercubes, data-flow and supercomputers. Laboratory instruction.

CENG 6431: DSP IMPLEMENTATIONS

Prerequisites: CENG 5431 and C Programming. Implementation techniques of digital signal processing applications emphasizing Code Composer Studio and the TI DSP 320 family of digital signal processors. Laboratory instruction.

CENG 6434: ADVANCED MICROCOMPUTER SYSTEM DESIGN

Prerequisite: CENG 5434 or equivalent. System and product design with modern microcomputers and micro controllers. Laboratory instruction.

CENG 6532: PARALLEL PROCESSING

- Prerequisites: Background in computer architecture and programming. Integrated discussion of the software and hardware design issues involved in parallel processing. Laboratory instruction.
- CENG 6533: ROBOTICS**
Topics of current interest in robotics applied to the study of mechanical systems for robots, robotics control and sensors for robotics. Laboratory instruction.
- CENG 6838: RESEARCH PROJECT**
Prerequisite: 24 hours completed in graduate program. Students will be assigned a research project which requires integrating knowledge and standard procedures in the discipline. A written paper and a presentation will be required.
- CENG 6939: MASTER'S THESIS RESEARCH**
Prerequisites: Approval of advisor, master's committee and dean.

CHEMISTRY

*Pending Coordinating Board approval

- *CHEM 5130: MATHEMATICAL METHODS AND PHYSICAL CONCEPTS IN CHEMISTRY**
Prerequisites: CHEM 4231, CHEM 4232. Prepares chemistry graduate students for math and physics concepts they will encounter in graduate physical chemistry courses.
- *CHEM 5131: INDUSTRIAL NUCLEIC ACID CHEMISTRY AND BIOTECHNOLOGY**
Prerequisites: CHEM 3233, Biology and/or Biochemistry. Designed for those students who are interested in industrial applications in chemical and biotechnology areas.
- CHEM 5133: SPECTROSCOPIC IDENTIFICATION OF ORGANIC COMPOUNDS**
Prerequisite: CHEM 4635 or equivalent. Theory and practice of structure determination using IR, UV-VIS, PMR and MS techniques. Lecture and laboratory instruction.
- CHEM 5134: SYNTHETIC ORGANIC CHEMISTRY**
Prerequisites: CHEM 3233, CHEM 3234. Modern synthetic methods used in organic chemical synthesis. A mechanistic approach is used.
- CHEM 5235: KINETICS OF CHEMICAL REACTIONS**
Prerequisites: CHEM 4231, CHEM 4232 or equivalent and CHEM 5130. The study of chemical bonding and structure as applied to practical chemical problems.
- CHEM 5335: ADVANCED INORGANIC CHEMISTRY**
Prerequisite: CHEM 4335 or equivalent. The comprehensive study of the theory and properties of compounds containing the main groups of elements in the periodic table.
- CHEM 5336: ORGANOMETALLIC CHEMISTRY**
Prerequisites: CHEM 3233, CHEM 3234; CHEM 4231, CHEM 4232. Systematic study of the compounds containing a carbon-metal bond. Synthesis, structural types and typical reactions of both main group and transition metal compounds are discussed.
- CHEM 5337: PHYSICAL ORGANIC CHEMISTRY**
Prerequisites: CHEM 3233, CHEM 3234; CHEM 4231, CHEM 4232. Advanced study of the relationships between structure and reactivity of mechanisms operating during organic chemical transformations.
- CHEM 5431: CONTAMINANT FATE AND TRANSPORT**
Prerequisite: CHEM 3333 or equivalent. Principles of contaminant behavior in the environment. Case studies on important toxic chemicals including heavy metals, petroleum hydrocarbons, soap and detergents, pesticides, and polycyclic aromatic hydrocarbons. Suitable for non-majors.
- CHEM 5535: SAMPLING & ANALYSIS OF ENVIRONMENTAL CONTAMINANTS**
Prerequisite: MATH 3038. Field sampling techniques, US EPA/OSHA/USGS/ASTM standard methodology, field and lab quality assurance/quality control (QA/QC), wet chemical methods and instrumentations for the analysis of environmental contaminants.
- CHEM 5631: ENVIRONMENTAL CHEMODYNAMICS**
Prerequisite: CHEM 3333. Focus on the kinetic and thermodynamic mechanisms for chemical movement across air/soil, soil/water, water/sediment and water/air interfaces and how natural processes affect movement of chemicals in air, water, sediment and soil; information vital to performing human and ecological risk assessments.
- CHEM 5632: QUANTUM MECHANICS I**
Prerequisites: Calculus I, II and either University Physics (calculus-based) I, II or CHEM 4231, CHEM 4232 and either CHEM 5130 or PHYS 5531. Foundations and techniques of Quantum Mechanics and their application to atomic and molecular properties.
- CHEM 5633: ORIGINS OF LIFE**
Prerequisites: General Chemistry and University or College Physics. Origin of the universe, the chemical elements, the Earth and life, including pre-biotic chemistry. The nature of the first replicators, origin of the genetic code and the origin of biomolecular chirality.
- CHEM 5634: ASTROBIOCHEMISTRY AND SETI**
Prerequisites: General Chemistry and University or College Physics. The search for life in the universe including origin and evolution of the chemical elements and life, chemistry of habitable planets, chemical signatures of life on other planets and the Search for Extra-Terrestrial Intelligence. (SETI)
- CHEM 5635: INTRODUCTION TO POLYMER CHEMISTRY**
Prerequisite: CHEM 3233. Introduction to the chemistry, structure and properties of polymers.
- CHEM 5636: GAS CHROMATOGRAPHY – MASS SPECTROMETRY**
The study of combined analytical methods such as GC/MS, LC/MS and MS/MS.
- CHEM 5637: MODERN SPECTROSCOPY**

- Prerequisites: General Chemistry I, II, CHEM 4231, CHEM 3233, CHEM 3234 and CHEM 5130. Theory and application of spectroscopy including modern laser techniques.
- CHEM 5638: TOTAL SYNTHESIS OF NATURAL PRODUCTS**
Prerequisite: Approval of instructor. A mechanistic-based approach to the total synthesis of organic natural products.
- CHEM 5639: SYMMETRY IN CHEMISTRY**
Prerequisites: CHEM 3233, CHEM 3234; CHEM 4231, CHEM 4232, CHEM 4335 and CHEM 5130. Applications of group theory in physical, inorganic and organic chemistry.
- CHEM 5915: COOPERATIVE EDUCATION WORK TERM**
Prerequisites: Approved Candidate Plan of Study, completed cooperative education file and approval of associate dean and Director of Cooperative Education. Educational paid work assignment by a student in the field of career interest and course of study. A technical report is required at the end of the semester. (Specific requirements are noted in the Cooperative Education catalog description.)
- CHEM 5919, 5939: INDEPENDENT STUDY IN CHEMISTRY**
Prerequisites: Approval of instructor, chair and associate dean required.
- CHEM 5931: RESEARCH TOPICS IN CHEMISTRY**
Identified by specific title each time course is offered.
- CHEM 6731: GRADUATE SEMINAR**
Advanced seminar where an in-depth perusal of a chemical topic shall be undertaken and a research proposal and formal presentation shall be completed.
- CHEM 6837: RESEARCH PROJECT AND SEMINAR I**
Prerequisite: Admission to graduate program in chemistry. Students will develop a research proposal which allows integrating knowledge and standard procedures in the discipline. A written paper and a presentation will be required.
- CHEM 6838: RESEARCH PROJECT AND SEMINAR II**
Prerequisites: CHEM 6837 and 24 hours completed in approved graduate program. Students will develop a research proposal which allows integrating knowledge and standard procedures in the discipline. A written paper and a presentation will be required.
- CHEM 6939: MASTER'S THESIS RESEARCH**
Prerequisites: Approval of faculty advisor, master's committee and dean.

COMPUTER INFORMATION SYSTEMS

- CINF 5915: COOPERATIVE EDUCATION WORK TERM**
Prerequisites: Approved Candidate Plan of Study, completed cooperative education file and approval of associate dean and Director of Cooperative Education. Educational paid work assignment by a student in the field of career interest and course of study. A technical report will be required at the end of the semester. (Specific requirements are noted in the Cooperative Education Catalog description.)
- CINF 5919, 5939: INDEPENDENT STUDY IN COMPUTER INFORMATION SYSTEMS**
Prerequisites: Approval of instructor, chair and associate dean.
- CINF 5931: RESEARCH TOPICS IN COMPUTER INFORMATION SYSTEMS**
Identified by specific title each time course is offered.
- CINF 6838: RESEARCH PROJECT AND SEMINAR**
Prerequisite: 24 hours completed in graduate program. Attendance at the orientation meeting on the first class day required. Students will be assigned a research project which requires integrating knowledge and standard procedures in the discipline. A written paper and a presentation will be required.
- CINF 6939: MASTER'S THESIS RESEARCH**
Prerequisites: Approval of faculty advisor, master's committee and Dean.

COMPUTER SCIENCE

- CSCI 5037: TOPICS IN COMPUTER SCIENCE FOR NON-MAJORS**
Identified by topics each time the course is offered. Not to be taken by majors in computing programs. Laboratory instruction.
- CSCI 5061: PROGRAMMING LANGUAGES AND PROBLEM SOLVING**
Credit may not be applied toward a degree in Computer Science. Problem-solving techniques including in-depth coverage of Assembly Language and C. Principles and survey of programming languages, such as Pascal, Ada, C++, Java, Prolog, Lisp and Smalltalk. Laboratory instruction.
- CSCI 5131: SIMULATION TECHNIQUES**
Prerequisites: Computer language proficiency, numerical methods and probability; linear systems analysis recommended. Modern software techniques in continuous and discrete model construction for industrial and scientific applications. Laboratory instruction.
- CSCI 5132: INTERNET PROTOCOLS**
Prerequisites: CSCI 3331, CSCI 3333 and CSCI 3532 or equivalents. Interconnection of heterogeneous networks and the layering principles of TCP/IP which make it possible. A brief look at underlying hardware technologies. Internet addressing and routing, reliable and unreliable transport protocols. Application level services available in the Internet.
- CSCI 5232: CONCEPTS OF PROGRAMMING LANGUAGES**
Prerequisite: CSCI 3333. The course assumes knowledge of at least one imperative language such as C, C++, or Java. Study of various programming languages from conceptual standpoint; topics will include formal

- language definition, data storage techniques, design techniques and implementation issues for compilers. Both numeric and string processing languages will be covered.
- CSCI 5233: COMPUTER SECURITY & INTEGRITY**
Prerequisites: CSCI 4333, CSCI 4534 or equivalents. Introduction to encryption and decryption; security mechanisms in computer architectures, operating systems, databases, networks and introduction to security.
- CSCI 5234: WEB SECURITY**
Prerequisites: CSCI 5233 and CSCI 4230 or instructor's approval. Fundamental coverage of issues and techniques in developing secure web-based applications and related topics such as network security, web server security, application-level security and web database security, etc.
- CSCI 5235: NETWORK SECURITY**
Prerequisites: CSCI 5233 or CSCI 4233 and CSCI 5132 or CSCI 4132. Advanced cryptography, access control, distributed authentication, TCP/IP security, firewalls, IPsec, Virtual Private Networks, intrusion detection systems and advanced topics such as wireless security, identity management, etc.
- CSCI 5331: COMPUTER GRAPHICS**
Prerequisites: CSCI 3532, CSCI 4530 or equivalent, linear algebra and analytic geometry. Interactive graphics techniques, three dimensional graphics including 3-D projections, hidden line elimination and shading. Stereo graphics, Virtual Reality and Animation. Laboratory instruction.
- CSCI 5332: ADVANCED GRAPHICS WINDOWING SYSTEMS**
Prerequisites: CSCI 3532, CSCI 4530 and C programming. Analysis and design of graphics techniques for windowing systems. Development of graphical user interfaces (GUIs) using the X Window System. Laboratory instruction.
- CSCI 5333: DATABASE MANAGEMENT SYSTEMS (DBMS)**
Prerequisite: CSCI 4333. Database management systems (DBMS), relational DBMS, object-oriented DBMS, knowledge base management systems, database language, query optimization, security and integrity, concurrency control and recovery, design theory of databases. Laboratory instruction.
- CSCI 5431: CLIENT-SERVER BASED NETWORK PROGRAMMING**
Prerequisites: CSCI 3133; CSCI 4531 or CSCI 4534. Principles and issues related to the development of client-server based applications. Detailed study of networking API to the TCP/IP protocol suite in a suitable multitasking platform (Unix or Windows NT). Concurrency issues in the design of client and server programs. Trade-offs of different architectures and usage of Remote Procedure Calls. Broadcasting and Multicasting. Interoperability of IPv4 and IPv6 clients and servers. Laboratory instruction.
- CSCI 5432: DESIGN AND ANALYSIS OF ALGORITHMS**
Prerequisite: CSCI 3532. Review of advanced data structures and algorithm design. Focus on analysis techniques for complex algorithms and data structures, including amortized analysis, randomized algorithms and NP approximations. Includes survey of parallel analysis and complexity theory.
- CSCI 5433: OBJECT-ORIENTED DATABASE SYSTEMS**
Prerequisite: CSCI 4333; CSCI 4230 recommended. Integration of object-oriented technology with database and Internet technologies, topics include modeling and design for object-oriented database systems, their development processes, implementation of online web database applications using object-oriented languages, scripting languages and object-oriented DBMS to store and retrieve objects in an object-oriented database. Laboratory instruction.
- CSCI 5530: PATTERN CLASSIFICATION**
Prerequisites: Calculus, linear algebra, probability, statistics and a compiler language. Introduction to the basic concepts of pattern classification including Bayes decision theory, parametric and non-parametric techniques, linear discriminant functions and clustering. Laboratory instruction.
- CSCI 5531: ADVANCED OPERATING SYSTEMS**
Prerequisites: CSCI 4534, familiarity with C and UNIX system calls. Study of current methodologies used in the design of distributed operating systems including issues related to the design of distributed file systems, interprocess communication and synchronization facilities, process, processor and memory management within the context of distributed operating systems. Case studies and review of current literature. Basic introduction to network programming and its application to the design of a simplified component of a distributed operating system. Laboratory instruction.
- CSCI 5532: PATTERN RECOGNITION AND IMAGE PROCESSING**
Prerequisites: Calculus, linear algebra, probability, statistics and a compiler language. An introduction to basic concepts and techniques for digital image processing, including software and hardware techniques for statistical pattern recognition and extracting useful information from pictures by automatic means. Laboratory instruction.
- CSCI 5533: DISTRIBUTED INFORMATION SYSTEMS**
Prerequisite: CSCI 5333. Distributed transparency, distributed database design, distributed query processing, distributed concurrency control and recovery, distributed DBMS. Laboratory instruction.
- CSCI 5631: N-TIER CLIENT SERVER ARCHITECTURES**
Prerequisite: CSCI 5431 or CSCI 5531. Principles and issues related to the development of interface based software components as the foundation for developing scalable multitier architectures. Topics include: interface definition and design, language integration (VB, C++ and Java), concurrency and threading issues, type libraries, distributed components, connectable components and persistence.
- CSCI 5633: WEB DATABASE DEVELOPMENT**
Prerequisites: CSCI 4230 and CSCI 4333. Principles of design and implementation of web database systems for storing, updating and retrieving data on the web: web database development techniques, database modeling, SQL development, web database connectivity, web database application programming. Scripting languages, exchanging data with XML, user authentication, user tracking, session management, e-commerce and web database administration will be covered. Laboratory instruction.

- CSCI 5635: PARALLEL PROCESSING**
Prerequisite: Background in computer architecture and programming. Integrated discussion of the software and hardware design issues involved in parallel processing. Laboratory instruction.
- CSCI 5733: XML APPLICATION DEVELOPMENT**
Prerequisites: CSCI 3134, CSCI 4230. XML standards including XML, DTD, DOM, XSL, XSLT, Xpath, Xpointer and XML Schema. XML related technologies including XML parsers, JAXP, XSL parsers, XML servers, XML databases, SOAP and Web services. Laboratory instruction.
- CSCI 5833: DATA MINING: TOOLS AND TECHNIQUES**
Prerequisites: CSCI 3333 and CSCI 4333. CSCI 5333 recommended. Overview of the data mining process (e.g., CRISP-DM) including issues of data cleansing and data modeling. Characterization of data (structured, unstructured, time series). Examination of machine learners (neural networks, decision trees, genetic programs). Critique of various data mining tools regarding functionality and application. Assessment of data mining domains using financial, bioinformatics and web-based repositories.
- CSCI 5915: COOPERATIVE EDUCATION WORK TERM**
Prerequisites: Approved Candidate Plan of Study, completed cooperative education file and approval of associate dean and Director of Cooperative Education. Educational paid work assignment by a student in the field of career interest and course of study. A technical report will be required at the end of the semester. (Specific requirements are noted in the Cooperative Education Catalog description.)
- CSCI 5919, 5939: INDEPENDENT STUDY IN COMPUTER SCIENCE**
Prerequisites: Approval of instructor, chair and associate dean.
- CSCI 5931: RESEARCH TOPICS IN COMPUTER SCIENCE**
Identified by specific title each time course is offered.
- CSCI 5933: COMPUTATIONAL BIOINFORMATICS**
Prerequisite: CSCI 5833. Course assumes students have very little or no prior Biological background. The course examines computational approaches to understanding and predicting the structure, function, interactions and evolution of DNA, RNA, proteins and related molecules and processes. The methods taught focus on developing the structure of the models, on model fitting algorithms (machine learning) and on the application of the resulting models (data mining). Most applications will revolve around DNA, RNA, protein sequence and gene expression-array data, but other types of data may also be considered.
- CSCI 6132: ENTERPRISE NETWORKING**
Prerequisite: CSCI 5132. Seminar in enterprise networking; groupware, workflow and workgroup computing. Laboratory instruction.
- CSCI 6530: RESEARCH METHODS IN COMPUTER SCIENCE**
A study of current methods and techniques in computer science research, including writing research proposals, conducting research, technical writing and presentations.
- CSCI 6532: REAL-TIME SYSTEMS**
Prerequisite: Background in operating systems. Major issues in the design and implementation of predictable real-time systems including cyclic executives, fixed priority executives, dynamic priority executives, priority inversion, object-oriented design, real-time transaction systems, real-time programming languages and real-time operating systems. Laboratory instruction.
- CSCI 6838: RESEARCH PROJECT AND SEMINAR**
Prerequisite: 24 hours completed in graduate program. Attendance at the orientation meeting on the first class day required. Students will be assigned a research project which requires integrating knowledge and standard procedures in the discipline. A written paper and a presentation will be required.
- CSCI 6939, 6969: MASTER'S THESIS RESEARCH**
Prerequisites: Approval of faculty advisor, master's committee and Dean.

ENGINEERING MANAGEMENT

*Pending Coordinating Board approval

- EMGT 5130: NEW BUSINESS DEVELOPMENT**
Prerequisites: Foundation courses. The course concentrates on proposal writing; how to write an executive summary; proposal management; proposal process & procedures; proposal training; oral proposal presentations; government contracting and request for proposals.
- EMGT 5131: LEGAL ISSUES IN ENGINEERING MANAGEMENT**
Prerequisites: Foundation courses. This course will provide an overview of warranty law, deceptive trade practices law, product liability and class action concepts. Class discussions will focus on legal considerations for engineering managers, risk assessment and the expense and adverse impact of litigation.
- EMGT 5230: NEGOTIATION STRATEGIES**
Prerequisites: Foundation courses. This course will educate the student to better understand the behavior of individuals, groups and organizations in the context of competitive situations. Students develop negotiation skills experientially and understand negotiation in useful analytical frameworks.
- EMGT 5231: ENGINEERING MANAGEMENT PLANNING**
Prerequisites: Foundation courses. This course offers engineering management planning; design and implements systems concepts that are involved with government contracting. The course focuses on the production of a system engineering management plan.
- *EMGT 5330: SERVICE AND OPERATIONS MANAGEMENT**
Prerequisites: Foundation courses. This course provides an overview, concepts and methods that are useful in understanding the management of a firm's operations. This course will concentrate on operations strategy, process improvement, forecasting, lean and just-in-time and supply chain management.
- *EMGT 5331: SIX-SIGMA QUALITY**

Prerequisites: Foundation courses. This course will cover the knowledge areas of six sigma green belt. Topics include six sigma goal, lean principles, theory of constraints, design for six sigma, quality function deployment, process management, data and process analysis and design of experiments.

EMGT 5931: RESEARCH TOPICS IN ENGINEERING MANAGEMENT

Identified by specific title each time course is offered.

EMGT 6837: ENGINEERING MANAGEMENT CAPSTONE PROJECT

Prerequisites: At least 18 hours of graduate work in EMGT. Students will be grouped into teams to undertake a software project utilizing the tools, techniques and skills acquired during their previous course work. Each team will be assigned to a client and will interact with that client to establish requirements, agree upon a design and achieve a successful acceptance test of the resulting software system. Teams will meet on a weekly basis with their faculty mentor to discuss progress.

***EMGT 6939: MASTER'S THESIS RESEARCH**

Prerequisites: Approval of faculty advisor, thesis committee and dean.

ENVIRONMENTAL SCIENCE

ENSC 5031: TEACHING ENVIRONMENTAL SCIENCE

The course is designed for K-12 teachers to enhance their own knowledge, awareness and understanding of environmental issues (air, water and waste) of national and regional importance. It is also designed to equip teachers of all grades with the appropriate educational resources so that they may effectively teach their own students about issues of environmental sciences through classroom instruction, laboratory assignment, site visit, observations and field demonstration.

ENSC 5530: RESEARCH METHODS: ENVIRONMENTAL SCIENCE

Prerequisites: STAT 5135, advisor approval and approved research topic. Development of proposal for master's project or thesis research.

ENSC 5915: COOPERATIVE EDUCATION WORK TERM

Prerequisites: Approved Candidate Plan of Study, completed cooperative education file and approval of associate dean and Director of Cooperative Education. Educational paid work assignment by a student in the field of career interest and course of study. A technical report will be required at the end of the semester. (Specific requirements are noted in the Cooperative Education Catalog description.)

ENSC 5931: RESEARCH TOPICS IN ENVIRONMENTAL SCIENCE

Identified by specific title each time course is offered.

ENSC 5939: INDEPENDENT STUDY IN ENVIRONMENTAL SCIENCE

Prerequisites: Approval of instructor, chair and associate dean.

ENSC 6731: GRADUATE SEMINAR

Prerequisites: ENSC 5530, STAT 5135 and 24 hours completed in an approved graduate program. Advanced seminar where an in-depth perusal of an environmental science topic shall be undertaken and a formal paper and presentation shall be completed.

ENSC 6838: RESEARCH PROJECT

Prerequisites: ENSC 5530, 24 hours completed within a CPS and approval of graduate advisor. Students complete their research project; write the research paper and present research findings in a public forum.

ENSC 6939: MASTER'S THESIS RESEARCH

Prerequisites: Master's degree candidacy as well as approval by advisor, master's committee and dean.

GEOLOGY

Please note: All GEOL graduate courses (5000 and 6000 level) assume the student has completed (or is currently enrolled in) courses equivalent to physical geology, mineralogy and petrology, plus stratigraphy or sedimentology.

GEOL 5233: ENVIRONMENTAL GEOCHEMISTRY

Prerequisites: GEOL 3034, 3137 or equivalent; Inorganic and organic chemistry. Basic solution geochemistry and equilibria concepts to formation and alteration of sedimentary materials of low temperature origin. Geochemistry of fluids in natural aqueous environments with emphasis on diagenesis and weathering.

GEOL 5331: ENVIRONMENTAL GEOLOGY

Relationships and interactions between pollutants and earth materials, land instability hazards, resource exploitation problems; and other topics of current interest.

GEOL 5333: WETLANDS

Prerequisite: GEOL 4233. Survey of wetlands types including coverage of environmental importance of wetlands, interaction of soils, geomorphology and biological community in wetlands formation, wetlands protection and wetlands creation.

GEOL 5531: HYDROLOGY OF GROUNDWATER

Prerequisite: GEOL 3034, 4531. Course emphasizes principles of occurrence and movement of ground water. Factors applying to pollution, estimates of supply and engineering aspects will be emphasized. Local case studies will be included. Laboratory exercises included.

GEOL 5532: HYDROLOGY OF SURFACE WATER

Prerequisite: GEOL 3034 or equivalent. Course will emphasize principles of occurrence and movement of surface water. Factors applying to pollution, estimates of supply and engineering aspects will be studied. Local case studies of water resources, flooding and effects included. Laboratory exercises included.

GEOL 5631: REMOTE SENSING: APPLICATIONS IN GEOLOGY

Prerequisites: GEOL 3034, 4222, 4234 or equivalent. Course emphasizes principal sensors and products of spacecraft remote sensing. Emphasizes applications of remote sensing to geology, hydrology, oceanography and biology. Land use and other environmental applications are also included. Laboratory exercises included.

- GEOL 5632: HAZARDOUS MATERIALS IN THE GEOLOGIC ENVIRONMENT**
Prerequisite: GEOL 5531. Study of the environmental problems arising from use of the geologic environment as a waste repository. Course includes such topics as landfills, clay lined waste pits, underground storage tanks, deep well injection, role of salt deposits in waste disposal and ordinance contamination of Department of Defense sites.
- GEOL 5730: PLANETARY GEOLOGY**
Prerequisites: GEOL 3034 or equivalent, GEOL 3137, GEOL 4234. Comparison of the planets and the solid surface satellites with emphasis on the terrestrial planets. Latest space probe data included.
- GEOL 5931: RESEARCH TOPICS IN GEOLOGY**
Identified by specific title each time course is offered.
- GEOL 5939: INDEPENDENT STUDY IN GEOLOGICAL SCIENCES**
Prerequisites: Approval of instructor, chair and associate dean.
- GEOL 6838: RESEARCH PROJECT AND SEMINAR**
Prerequisite: 24 hours completed in approved graduate program. Students will develop a research proposal which allows integrating knowledge and standard procedures in the discipline. A written paper and a presentation will be required.
- GEOL 6939: MASTER'S THESIS RESEARCH**
Prerequisites: Approval of advisor, master's committee and dean.

INDUSTRIAL HYGIENE AND SAFETY

- INDH 5131: CONTROL OF OCCUPATIONAL AND ENVIRONMENTAL HAZARDS**
Prerequisites: INDH 4131, 4133, 4135 or equivalents. Engineering and control technology used to eliminate and reduce hazards. Includes ventilation design, shielding, heat and cold stress, noise control, emissions control and waste management.
- INDH 5233: RECOGNITION OF OCCUPATIONAL DISEASES**
Prerequisite: BIOL 4235. Incidence and patterns of occupational diseases in the U.S. Approaches to recognition and prevention. Workplace exposures and effects. Occupational disorders by organ systems.
- INDH 5333: AIR POLLUTION**
Background, sources and fate of atmospheric pollutants. Air pollution episodes, meteorology, dispersion modeling, air quality measurements, controls, criteria, guidelines and health standards.
- INDH 5334: HUMAN FACTORS ENGINEERING**
Provides an analysis of the principles of human factors and ergonomics. The course covers human information processing, man-machine systems, information design, display and control design, static and dynamic anthropometrics and fundamentals of biomechanics, musculoskeletal injuries, including Cumulative Trauma Disorders such as Carpal Tunnel Syndrome, hand tool design, back injuries, vibrations, shift work, biological rhythms and workload assessment. Emphasis is placed on ergonomic methods and techniques to assess the design of modern work environments.
- INDH 5335: ERGONOMIC METHODS AND ANALYSIS TECHNIQUES**
Provides students with a variety of methods to analyze tasks and make accommodations and redesigns based on the principles of human factors and ergonomics. Emphasis is placed on Human Factors/Ergonomic methods and techniques to assess the design of modern work environments to accommodate people with disabilities or provide suitable redesigns to enhance human performance.
- INDH 5739: INTERNSHIP IN INDUSTRIAL HYGIENE AND SAFETY**
Prerequisites: Master's degree candidacy as well as approval by advisor and dean. Supervised work experience in an approved industrial firm or governmental agency. Written and oral report required.
- INDH 5915: COOPERATIVE EDUCATION WORK TERM**
Prerequisites: Approved Candidate Plan of Study, completed cooperative education file and approval of associate dean and Director of Cooperative Education. Educational paid work assignment by a student in the field of career interest and course of study. A technical report will be required at the end of the semester. (Specific requirements are noted in the Cooperative Education Catalog description.)
- INDH 5919, 5939: INDEPENDENT STUDY IN INDUSTRIAL HYGIENE & SAFETY**
Prerequisites: Approval of instructor, chair and associate dean.
- INDH 5931: RESEARCH TOPICS IN INDUSTRIAL HYGIENE AND SAFETY**
Identified by specific title each time course is offered.
- INDH 6135: RADIATION PROTECTION**
Advanced principles of ionizing and non-ionizing radiation are presented to provide the students who already have a basic understanding of radiation protection with an enhanced competence to solve theoretical and practical problems in radiation protection.
- INDH 6232: ANALYTICAL METHODS FOR EVALUATION OF HEALTH HAZARDS**
Prerequisite: INDH 4232 or equivalent. Survey procedures and instrumental methods of analysis for atmospheric and occupational hazards. Optical microscopy, noise, radiation, colorimetry, gas chromatography, atomic absorption, infrared and mass spectrometry.
- INDH 6332: SAFETY ENGINEERING**
Prerequisite: INDH 3430 or equivalent. Application of engineering principles to produce design, plant layout, construction, maintenance, pressure vessels, power tools, electric equipment, confined spaces and transportation systems. Includes consensus standards and governmental regulations.

MATHEMATICS

- MATH 5031: PROBLEM-SOLVING STRATEGIES**

- A focus on the connection between problem-solving, teaching mathematics for understanding and the development of mathematical reasoning. Also highlighted will be the student's own development of problem-solving abilities and ability to communicate their reasoning.
- MATH 5033: INSTRUCTIONAL APPLICATIONS OF ALGEBRA**
A seminar on the content of secondary school courses in algebra and applicable instructional techniques.
- MATH 5034: GEOMETRY SEMINAR**
Topics in Euclidean and Non-Euclidean geometries. An emphasis on the strengthening of proof-writing techniques. Also discussed will be the use of technology and concrete materials in the teaching and learning of geometry.
- MATH 5035: PRECALCULUS COURSES FOR MATHEMATICS TEACHERS OF GRADES 10-14**
A seminar on various current and potential approaches to the content of precalculus mathematics with applicable instructional techniques.
- MATH 5036: CALCULUS FOR MATHEMATICS TEACHERS OF GRADES 10-14**
A seminar on various approaches to the teaching of introductory calculus.
- MATH 5037: TECHNOLOGY FOR MATHEMATICS CURRICULUM**
Prerequisites: Calculus, MATH 3131 and MATH 4131. Current laboratory applications of computers and calculators in the mathematics curriculum. Symbolic, numerical and graphical computing will be applied to various mathematical problems.
- MATH 5131: ABSTRACT ALGEBRA**
Prerequisite: MATH 4232 or equivalent. Groups, rings, fields, modules; ideal theory, polynomial rings, algebraic and free groups.
- MATH 5132: REAL ANALYSIS**
Prerequisite: MATH 4431 or equivalent. General measure and integration theory. Banach and Hilbert spaces; applications to approximation theory, probability theory and summability.
- MATH 5133: COMPLEX ANALYSIS**
Prerequisite: MATH 4633 or equivalent. The theory of analytic functions and analytic continuation. Branched functions; an introduction to homotopy theory and basic metric space topology. Integration theory, Cauch's theorem and residue theory.
- MATH 5134: LOGIC**
Prerequisite: MATH 4231 or equivalent. Propositional and predicate calculus; foundations, computability.
- MATH 5136: ORDINARY DIFFERENTIAL EQUATIONS AND DYNAMICAL SYSTEMS**
Prerequisites: MATH 3131, MATH 3231 and MATH 4131 or equivalent. This course covers the dynamical aspects of ordinary differential equations and the relationship between theory and applications. Fundamental theorems of solutions of ordinary differential equations oriented toward dynamical systems, local phase portrait analyses of nonlinear autonomous systems and the criteria for the existence of periodic solutions are examined along with various applications.
- MATH 5137: TOPOLOGY AND GEOMETRY**
Prerequisite: MATH 4133 or equivalent. Set Theory, Topological Spaces, Connectedness and Compactness, The Fundamental Group and Covering Spaces, Surfaces and their applications.
- MATH 5231: LINEAR ALGEBRA**
Prerequisite: MATH 3131. Fields and vector spaces, determinants and their characterization, adjoints operators, eigenvalues and eigenvectors, diagonalizability, canonical forms and matrix functions.
- MATH 5232: NUMBER THEORY**
Prerequisite: MATH 4132 or equivalent. An introduction to analytic number theory, which uses the tools of analysis (particularly complex function theory) to investigate questions in number theory. The distribution of the primes is of central interest. Some of the tools developed are Dirichlet series, character theory, formal power series and contour integration. Various topics in arithmetical functions are also considered.
- MATH 5330: MATHEMATICAL SOFTWARE AND MODELING SIMULATION**
Prerequisites: MATH 3131 and MATH 4131 or equivalent. Explores computer software in applied Mathematics using Matlab. A variety of programming paradigms are emphasized. A collection of topics in applied Mathematics, chaos and neuroscience modelings, are incorporated into Matlab programming.
- MATH 5333: NUMERICAL ANALYSIS**
Prerequisites: MATH 3131, MATH 3231, MATH 4131 and C/C++ or equivalent. Mathematical analysis and numerical computation of solutions to linear and nonlinear systems, ordinary differential equations, integral equations and boundary value problems.
- MATH 5431: MATHEMATICAL MODELING IN THE APPLIED SCIENCES**
Prerequisite: MATH 4235 or equivalent. Techniques for analyzing and simulating physical, chemical and biological processes.
- MATH 5931: RESEARCH TOPICS IN MATHEMATICS**
Identified by specific title each time course is offered.
- MATH 5939: INDEPENDENT STUDY IN MATHEMATICS**
Prerequisites: Approval of instructor, chair and associate dean.
- MATH 6131: INTRODUCTION TO ALGEBRAIC TOPOLOGY AND GEOMETRY**
Prerequisite: MATH 4133 or equivalent. An introduction to topics in algebraic topology; manifold theory and their applications.
- MATH 6837: RESEARCH PROJECT I**
Student will develop and complete a research project which requires integrating knowledge and standard procedures in the discipline. A written paper and presentation will be required.
- MATH 6838: RESEARCH PROJECT II**

Student will complete research project developed in MATH 6837. A written paper and presentation will be required.

MATH 6939: MASTER'S THESIS RESEARCH

Prerequisites: Approval of faculty advisor, master's committee and dean.

PHYSICS

Please note: All PHYS graduate courses (5000 or 6000 level) assume the student has a solid background in physics and mathematics, at least through differential equations.

PHYS 5311: RECITATION FOR ELECTRODYNAMICS I

Prerequisite or corequisite: PHYS 5331. One hour recitation section to review examples and problems in PHYS 5331.

PHYS 5331: ELECTRODYNAMICS I

Prerequisites: PHYS 5531 or instructor approval and PHYS 4331 or equivalent. Introduction to electrostatics, boundary value problems, multipoles, electrostatics of macroscopic media, magnetostatics, time-vary fields, Maxwell's equations, conservation laws.

PHYS 5332: ELECTRODYNAMICS II

Prerequisite: PHYS 5331 or equivalent. Dynamics of electric and magnetic fields, Maxwell's equations, electromagnetic radiation, special relativity, wave guides, boundary value problems, multipoles, scattering and radiation from moving charges.

PHYS 5411: RECITATION FOR CLASSICAL MECHANICS

Prerequisite or corequisite: PHYS 5431. One hour recitation section to review examples and problems in PHYS 5431. Advanced topics in electrodynamics not normally covered in PHYS 5331 such as radiating systems, diffraction, relativistic particles in electromagnetic fields, collisions of charged particles, radiation damping and radiative beta processes.

PHYS 5431: CLASSICAL MECHANICS

Prerequisite: PHYS 5531 or instructor approval. Introduces concepts such as the Lagrangian dynamics of particles, Hamiltonian mechanics and canonical transformations in order to calculate the classical motion of particles.

PHYS 5511: RECITATION FOR MATHEMATICAL METHODS IN PHYSICS I

Prerequisite or corequisite: PHYS 5531. One hour recitation section to review examples and problems in PHYS 5531.

PHYS 5531: MATHEMATICAL METHODS IN PHYSICS I

Prerequisites: PHYS 4131, PHYS 4132 or equivalent. A review of essential mathematics required to solve graduate level physics problems: differential equations, complex mathematics, linear algebra, infinite series and more.

PHYS 5532: MATHEMATICAL METHODS IN PHYSICS II

Prerequisite: PHYS 5531 or instructor approval. This course is a continuation of Mathematical Methods in Physics I. Course content may include: boundary conditions, perturbation theory, group theory, tensor analysis, using mathematical software packages (such as Mathematica, Matlab or Maple) or other advanced mathematical applications to physics.

PHYS 5533: METHODS IN COMPUTATIONAL PHYSICS

Prerequisites: PHYS 5531 or instructor approval and a working knowledge of a programming language. An introduction to the numerical methods used to solve various physics problems; evolving differential equations, performing Monte-Carlo simulations, simulate fluid flow and more.

PHYS 5611: RECITATION FOR QUANTUM MECHANICS I

Prerequisite or corequisite: PHYS 5631. One hour recitation section to review examples and problems in PHYS 5631.

PHYS 5612: RECITATION FOR QUANTUM MECHANICS II

Prerequisite or corequisite: PHYS 5632. One hour recitation section to review examples and problems in PHYS 5632.

PHYS 5631: QUANTUM MECHANICS I

Prerequisites: PHYS 5531, CHEM 5130 or instructor approval and PHYS 4432 or equivalent. Fundamental concepts of non-relativistic quantum mechanics. Solution of simple one-dimensional problems. Hilbert-space description. Matrix representations. Quantum dynamics. Extension to three dimensions. Spin and orbital angular momentum.

PHYS 5632: QUANTUM MECHANICS II

Prerequisite: PHYS 5631 or equivalent. Corequisite: PHYS 5612. Sequel to Quantum Mechanics I, Angular momentum theory. Symmetries and conservation laws. Application of approximation methods to realistic problems. Systems of identical particles. Scattering theory. Relativistic single-particle wave equations. Introduction to quantum computing.

PHYS 5711: RECITATION FOR STATISTICAL MECHANICS AND THERMODYNAMICS

Prerequisite or corequisite: PHYS 5731. One hour recitation section to review examples and problems in PHYS 5731.

PHYS 5731: STATISTICAL MECHANICS AND THERMODYNAMICS

Prerequisites: PHYS 5531, CHEM 5130 or instructor approval and PHYS 4531 or equivalent. An advanced treatment of statistical mechanics and thermodynamics in order to solve problems involving many individual particles. Topics include probability, microcanonical and canonical ensembles and the laws of thermodynamics.

PHYS 5739: INTERNSHIP IN PHYSICS

Prerequisites: Master's degree candidacy as well as approval by advisor and dean. Supervised work experience in an approved industrial firm or government agency. Written and oral report required.

- PHYS 5915: COOPERATIVE EDUCATION WORK TERM**
Prerequisites: Approved Candidate Plan of Study, completed cooperative education file and approval of associate dean and Director of Cooperative Education. Educational paid work assignment by a student in the field of career interest and course of study. A technical report will be required at the end of the semester. (Specific requirements are noted in the Cooperative Education Catalog description.)
- PHYS 5919, 5939: INDEPENDENT STUDY IN PHYSICS**
Prerequisites: Approval of instructor, chair and associate dean.
- PHYS 5931: RESEARCH TOPICS IN PHYSICS**
Identified by specific title each time course is offered.
- PHYS 6132: GENERAL RELATIVITY**
Prerequisite: PHYS 5331 or equivalent. Topics include: Manifolds, Spacetime Curvature, Riemann Geometry, Geodesics, Killing Vectors, Einstein's Equation, The Schwarzschild solution and other Black Hole solutions to Einstein's Equations.
- PHYS 6231: PLASMA PHYSICS**
Prerequisite: Core Physics courses or instructor approval. Computer programming experience and PHYS 5533 are desired but not required. The course provides a basic understanding of plasma physics fundamentals and a review of the state-of-the-art of current research of plasma science and engineering (nuclear fusion, industrial plasmas, advanced space propulsion and space plasmas.
- PHYS 6838: RESEARCH PROJECT AND SEMINAR**
Prerequisites: 24 hours completed in approved graduate program. Students will develop a research project that integrates knowledge and standard procedures in the discipline. A written paper and oral presentation will be required.
- PHYS 6939: MASTER'S THESIS RESEARCH**
Prerequisites: Approval of faculty advisor, master's committee and dean.

SYSTEMS ENGINEERING

- SENG 5130: SYSTEMS ENGINEERING PROCESSES**
Prerequisites: Foundation courses. Detailed coverage of the systems engineering process and system engineering tools that facilitate implementation of the process. Covers the complete systems life cycle from needs assessment and feasibility analysis through requirements, design and testing to system retirement and disposal. The student will gain an in-depth understanding of the International Council on Systems Engineering Capability Maturity Model including assessments and process improvement. The student will also gain proficiency in the use of commercial system engineering tools that facilitate the implementation and management of the systems engineering process.
- SENG 5230: SYSTEMS ENGINEERING ECONOMICS**
Engineering and economic fundamentals, issues and goals of SENG. Life and project cycles of systems, supersystems and subsystems. Trade-off studies involving cost-effectiveness analysis; multiple-goal decision analysis; and dealing with uncertainties, risk and the value of information.
- SENG 5231: CONCURRENT ENGINEERING**
Determining needs and organizing teams from the multiple disciplines required for integrated system and product development. Technical and management issues and methods of involving end users, suppliers, service providers and engineering specialists to work with the SENG team on concurrent activities throughout the system's life cycle.
- SENG 5232: ENGINEERING SPECIALTY INTEGRATION**
Coordination of engineering specialties across multiple disciplines in reliability, quality assurance, maintainability, integrated logistics support, verification, predictability, social acceptability, automated support environments, etc.
- SENG 5233: SYSTEMS ENGINEERING ANALYSIS AND MODELING**
Prerequisites: SENG 5231 and SENG 5232 or permission of instructor & advisor. This course presents the fundamentals of systems analysis and modeling. The emphasis is on solving practical modeling problems for continuous, discrete and hybrid systems, both linear and nonlinear. Systems will be modeled using modern tools such as MATLAB and Simulink.
- SENG 5330: RISK MANAGEMENT**
Prerequisites: Foundation courses. Continuous Risk Management is a system engineering practice with processes, methods and tools for managing risks in a project. It provides a disciplined environment for proactive decision making to assess continuously what could go wrong (risks), determine which risks are important to deal with and implement strategies to deal with those risks. The purpose of this course is to explain what Continuous Risk Management is; to help the student understand the principles, functions, methods and tools; to show what it could look like when implemented within a project; and to show how a project could implement its own adaptation.
- SENG 5332: DECISION ANALYSIS FOR SYSTEMS ENGINEERING**
Prerequisites: Foundation courses. Understanding the theory and learning how to apply, formulate, solve and interpret system engineering problems using decision analysis and operations research techniques. Theory and techniques include decision analysis, linear programming, simplex method, sensitivity analysis, network modeling, integer linear programming and goal programming.
- SENG 5334: HUMAN FACTORS ENGINEERING**
Prerequisite: Foundation courses. This course presents the consideration of whether people serve as operators, maintainers or users in the system. The course advocates systematic use of such knowledge to achieve compatibility in the design of interactive systems of people, machines and environments to ensure their effectiveness, safety and ease of performance.

- SENG 5532: ADVANCED DECISION ANALYSIS FOR SYSTEMS ENGINEERING**
Prerequisite: SENG 5332. Builds upon the fundamentals of Decision Analysis for Systems Engineering, with topics in non-linear methods for decision making, numerical techniques, regression analysis and discriminant analysis.
- SENG 5915: COOPERATIVE EDUCATION WORK TERM**
Prerequisites: Approved Candidate Plan of Study, completed cooperative education file and approval of associate dean and Director of Cooperative Education. Educational paid work assignment by a student in the field of career interest and course of study. A technical report will be required at the end of the semester. (Specific requirements are noted in the Cooperative Education Catalog description.)
- SENG 5931: RESEARCH TOPICS IN SYSTEMS ENGINEERING**
Identified by specific title each time course is offered.
- SENG 5939: INDEPENDENT STUDY IN SYSTEMS ENGINEERING**
Prerequisites: Approval of instructor, chair and associate dean.
- SENG 6837: SYSTEMS ENGINEERING CAPSTONE PROJECT**
Prerequisites: Completion of at least 18 hours of the core curriculum including systems engineering project. Teams will meet on a weekly basis with their faculty mentor to discuss progress.
- SENG 6939, 6969: MASTER'S THESIS RESEARCH**
Prerequisites: Approval of faculty advisor, master's committee and dean.

STATISTICS

- STAT 5135: APPLIED STATISTICAL METHODS**
Not available for mathematics majors. Prerequisite: MATH 3038. One and two sample methods, analysis of variance, correlation and regression, analysis of covariance, statistical modeling and robustness. Introduction to statistical computation using Excel and statistical software packages.
- STAT 5431: THEORY AND APPLICATION OF PROBABILITY**
Prerequisite: MATH 4331 or equivalent. Probability axioms and properties, conditional probability, random variables, probability distributions, moment generating function, laws of large numbers and central limit theorem.
- STAT 5432: THEORY AND APPLICATIONS OF STATISTICS**
Prerequisite: STAT 5431. Point and interval estimation, testing of hypotheses, nonparametric methods, regression, analysis of variance, robustness and model fitting.
- STAT 5531: MULTIVARIATE STATISTICAL ANALYSIS**
Prerequisite: MATH 4435 or equivalent. The study of multivariate normal distribution, estimation of mean and covariance matrix. T2-statistic, Wishart analysis, principal components and factor analysis and other techniques as applied to industrial and decision processes.
- STAT 5532: LINEAR MODELS AND REGRESSION ANALYSIS**
Prerequisite: MATH 4435 or equivalent. Distributions of quadratic forms, general linear models, least squares estimation, hypothesis testing, confidence intervals, multiple regression, variable selection, residual analysis and regression diagnostics.
- STAT 5533: STATISTICAL COMPUTING WITH SAS AND S-PLUS**
Prerequisite: MATH 4435 or equivalent. Data management, reporting, graphical displays, macros, statistical analysis and interpretation and related topics.
- STAT 5534: SAMPLING METHODS**
Prerequisite: MATH 4435 or equivalent. Sampling from finite populations, sampling strategies, estimation procedures including ratio and regression estimation, large scale sample survey methods for quality control and applied research in agriculture, business, social sciences and other fields.
- STAT 5535: EXPERIMENTAL DESIGNS AND ANALYSIS**
Prerequisite: MATH 4435 or equivalent. Completely randomized design, randomized blocks, Latin squares, factorial experiments, confounding and fractional factorial designs for industrial experiments and applications.
- STAT 5537: STATISTICAL MODELING AND METHODS**
Prerequisite: MATH 4435 or equivalent. Univariate statistical modeling, model-fit tests, model comparisons, logistic models, time series and spectral analysis, non-linear models, bootstrap methods and simulations.
- STAT 5631: RELIABILITY AND SURVIVAL ANALYSIS**
Prerequisite: MATH 4435 or equivalent. Measures of failure, reliability function, failure models, life testing and censoring, system reliability, parameter estimation and testing regression models, Cox proportional hazard models and software reliability.
- STAT 5931: RESEARCH TOPICS IN STATISTICS**
Identified by specific title each time course is offered.
- STAT 5939: INDEPENDENT STUDY IN STATISTICS**
Prerequisites: Approval of instructor, chair and associate dean.
- STAT 6837: STATISTICS RESEARCH AND CONSULTING I**
Prerequisite: STAT 5531 or STAT 5532. Each student will develop a research proposal which allows integrating statistics knowledge and data analysis procedures. A written proposal will be required.
- STAT 6838: STATISTICS RESEARCH AND CONSULTING II**
Prerequisite: STAT 6837. Each student will carry out analyses of data and develop inferences. A written paper and a presentation will be required.
- STAT 6939: MASTER'S THESIS RESEARCH**
Prerequisites: Approval of faculty advisor, master's committee and dean.

SOFTWARE ENGINEERING

*Pending Coordinating Board approval

SWEN 5130: REQUIREMENTS ENGINEERING

Prerequisite: SWEN 4432 or SWEN 5432. Current techniques, methods, tools and processes used in requirements analysis, definition and specification, including system modeling.

SWEN 5131: SOFTWARE ENGINEERING TOOLS

Prerequisite: SWEN 4432 or SWEN 5432. Current tools used in industry to support various phases of software development are covered such as Rational Rose, Objectory Process, as well as coverage of object-oriented modeling using UML (Unified Modeling Language)

***SWEN 5132: SOFTWARE DESIGN PATTERNS**

Prerequisite: A course in programming in a high level language is required. This course provides an in-depth view of software design patterns; the recurring solutions to common problems in software design. It provides opportunities for learning the most advanced features of modern software development methodology. Topics include Design visualization, Creational, Structural and Behavioral Design Patterns, Anti-patterns, Service Oriented Architecture pattern, Secure usability and Pattern languages.

***SWEN 5133: ASPECT-ORIENTED DEVELOPMENT**

Prerequisite: A course in programming in a high level language is required. Aspect-Oriented Development (AOD) is a new programming paradigm that increases modularity with a separation of cross-cutting concerns. This course will provide a broad perspective of AOD and will cover the relationship of aspect-oriented development and software product lines. The topics include Separation of concern, Aspect-Oriented program, Patterns and frameworks of AOD, Aspects in enterprise software.

***SWEN 5134: SERVICE ORIENTED ARCHITECTURE**

Prerequisite: A course in computing or software development or networking is required. Service Oriented Architecture (SOA) is an emerging paradigm that fosters distributed capabilities. It becomes more important for the latest information technology architectures and applications. This course provides an in depth view of SOA concepts, design principles, architecture patterns, interoperability standards, security considerations, runtime infrastructure, web services, e-governance, interoperability standards and technology infrastructure.

SWEN 5230: SOFTWARE PROJECT MANAGEMENT

Prerequisite: CSCI 3133. Issues faced in management of large software development projects; estimation, planning execution, monitoring, evaluation and refinement.

SWEN 5232: SOFTWARE CONSTRUCTION

Prerequisite: SWEN 4432 or SWEN 5432. Modern development methods, analysis and design, implementation. Emphasis placed on rigor and quality. Case study. Laboratory instruction.

SWEN 5233: SOFTWARE ARCHITECTURE

Prerequisites: SWEN 5232. Knowledge of complex programs recommended. Domain models, generic architectures and frameworks as well the context, scope, current and future state of software architecture.

SWEN 5234: SOFTWARE ENGINEERING PROCESSES

Prerequisite: CSCI 3333. Theory and application of the Capability Maturity Model: process assessments, modeling and improvement techniques. Interrelated life cycle issues of development and maintenance, quality and safety assurance, project management and automated support environments.

SWEN 5430: SOFTWARE METRICS

Prerequisite: SWEN 4432. MATH 3334 recommended. Theory, application and techniques of measurement and analysis. Process and product metrics.

SWEN 5431: TESTING, VALIDATION AND VERIFICATION

Prerequisite: SWEN 4432 or SWEN 5432. Role of software testing, verification and validation (V&V) in the system life cycle. Current techniques, tools and methods are addressed as well as current testing and V&V standards. Laboratory instruction.

SWEN 5432: SOFTWARE ENGINEERING LIFE CYCLE

Prerequisite: A course on data structures or software development work experience. In-depth study of the front end of the software life cycle. Feasibility, Concept, Requirements, Specification, Architecture and detailed design methods are explored and exercised.

SWEN 5435: PERSONAL SOFTWARE PROCESS

Prerequisite: A course on data structures or software development experience. Examination, study and improvement of the students' personal software development practice and study of the process used to effect such improvement.

SWEN 5532: SOFTWARE SAFETY

Prerequisites: SWEN 5233 and SWEN 5234. Analysis, design, verification and validation of mission and safety critical systems. Risk and hazard assessment, certification techniques and standards.

SWEN 5534: REUSE AND REENGINEERING

Prerequisite: SWEN 4432 or SWEN 5432. Engineering for and with reuse. Domain and application engineering and reverse and forward engineering.

SWEN 5931: RESEARCH TOPICS IN SOFTWARE ENGINEERING

Identified by specific title each time course is offered.

SWEN 5939: INDEPENDENT STUDY IN SOFTWARE ENGINEERING

Prerequisites: Approval of instructor, chair and associate dean.

SWEN 6837, 6838: SOFTWARE ENGINEERING CAPSTONE PROJECT

Prerequisites: At least 18 hours of graduate work including SWEN 5233 and SWEN 5234. Students will be grouped into teams to undertake a software project utilizing the tools, techniques and skills acquired during their previous course work. Each team will be assigned to a client and will interact with that client to establish

requirements, agree upon a design and achieve a successful acceptance test of the resulting software system. Teams will meet on a weekly basis with their faculty mentor to discuss progress.

SWEN 6939: MASTER'S THESIS RESEARCH

Prerequisites: Approval of faculty advisor, master's committee and dean.