

# Graduate Course Descriptions Effective Fall 2005

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## **Business**

### **BA 5200 - Information Systems**

Focuses on management of IS/IT within the business environment. Topics include IT infrastructure and architecture, organizational impact of innovation, change management, and human-machine interaction. Class format includes lecture, discussion, and integrative case studies.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BA 1200

### **BA 5290 - Special Topics in IS/IT**

IS/IT topics of interest to students and faculty.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **BA 5300 - Accounting**

This class covers the collection, reporting and analysis of financial information with emphasis on the use of that information to support decision making.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BA 2300

### **BA 5390 - Special Topics in Accounting**

Accounting topics of interest to students and faculty.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **BA 5400 - Finance**

Explores the theory and practice of finance and capital markets. Topics include role of the financial manager and goals of the firm, financial mathematics, valuation of assets, cost of capital, project evaluation, capital structure, forecasting, financing vehicles, special topics in finance.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BA 3400 or EC 3400

### **BA 5490 - Special Topics in Finance**

Finance topics of interest to students and faculty.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **BA 5610 - Operations and Quality Management**

Applications and case studies focusing on contemporary issues in operations and quality management to include lean manufacturing practices, ERP, quality and environmental management systems/standards, Six Sigma, statistical process control, and other current topics.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BA 2110

### **BA 5690 - Special Topics in Operations & Systems Management**

Operations and systems management topics of interest to students and faculty.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **BA 5700 - Management & Organizational Behavior**

Discusses managing effectively within the environmental context of the organization. Topics include corporate culture, managing in a global environment, planning and strategy, organizational structure, human resources management, managing change, leadership, motivation, communication, conflict management, and teamwork.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** BA 3700

### **BA 5710 - Business Strategy**

Introduces students to a repertoire of strategies that have been found useful in the creation of competitive advantage: cost leadership, business model differentiation, vertical integration, diversification, globalization, mergers and acquisitions, tacit collusion, alliance, and flexibility-agility-adaptability strategies.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BA 3700

### **BA 5720 - Entrepreneurship I - Launching Entrepreneurial Ventures**

Focuses on the development of new technology-based businesses. Topics include creativity, screening technological opportunities, analyzing markets, testing business concepts, protecting intellectual property, strategy development, entrepreneurial team selection, securing financing, and developing a business plan.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **BA 5730 - Entrepreneurship II - Growing and Managing New Ventures**

Focuses on growing new technology-based businesses. Topics include building an effective entrepreneurial team, ethics and social responsibility, financial planning/reporting, working capital management, growth marketing, product/process development, raising capital, managing change and development, and planning for succession.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **BA 5750 - Strategic Managerial Processes**

Introduces students to advanced topics in strategic change, strategy formation, and strategy implementation through a review of organization theories and processes. Course materials are applied to specific projects through individual specialized strategic management research projects.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BA 3700

### **BA 5790 - Special Topics in Management**

Management topics of interest to students and faculty.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**BA 5800 - Marketing**

The course will provide an integrated approach to marketing management. Uses a modeling and case analysis approach to develop strategic marketing thinking.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BA 3800

**BA 5890 - Special Topics in Marketing**

Marketing topics of interest to students and faculty.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**BA 5990 - Special Topics**

Business topics of interest to students. Study is under the guidance of a faculty member.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

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**Biomedical Engineering**

**BE 5000 - Graduate Research**

Includes the study of an acceptable biomedical engineering problem and the preparation of a report or thesis.

**Credits:** variable to 12.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BE 5100 - Cell and Tissue Mechanics**

Focuses on mechanical behavior and adaptation of musculoskeletal tissues including material properties, viscoelasticity, fatigue and failure. Includes the role of mechanical forces in the development, growth and adaptation of musculoskeletal tissues; cell biology and cellular mechanotransduction.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate  
**Pre-Requisite(s):** BE 3750

**BE 5300 - Advanced Polymeric Biomaterials**

A specialized study of polymers used in biomedical engineering. Topics include: Processing-structure-properties relationships for polymer fibers and composites, degradation of polymers, and medical applications for composite biomaterials.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BE 5400 - Bio-Heat and Mass Transfer**

Explores principles of heat transfer and mass transfer as they relate to problems and applications in biology, medicine and related fields.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**BE 5440 - Genetic Engineering and Molecular Medicine**

Molecular medicine and its applications in genetic engineering will be discussed following a quick review of genetics and cell biology as well as the human disease mechanisms. In vivo, in vitro and ex vivo treatments utilizing genetically engineered products, allogeneic and autologous cell transplantation experiments will be discussed.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BE 5500 - Biomedical Materials**

An overview of biomaterials in three basic classes: metals, ceramics, and polymers. Topics include biomaterials used in special medical applications (such as tissue replacement, absorbable and non-absorbable sutures, and soft tissue replacements) as well as discussion of tissue, body, and blood response to implants (bio-compatibility).

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BL 2020 and BL 2021 and MY 2100

**BE 5660 - Advanced Active Implants**

Implantable devices which are actively delivering therapy and acting as monitoring tools will be covered. Emphasis will be on the component level design and system level integration. Each student will design an implantable device and demonstrate its feasibility with theoretical methods learned in the class. Students will also review existing designs and will reverse engineer them from patents and product brochures for presentation.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **BE 5700 - Advanced Biosensors**

This course introduces the student to biosensor development and applications. It provides an understanding of biological components, immobilization techniques, transducers, and fabrication methods. In particular, microfabrication and nanofabrication techniques will be discussed.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **BE 5750 - Bioapplications of Nanotechnologies**

The prospect of bioapplications of nanotechnologies, selected topics including nanodevices for biosensor and drug delivery, biocompatibility and toxicity of nanomaterials, nanostructured polymers for tissue engineering, design and operation of medical nanorobots, ethics and societal impacts of nanobiotechnology, etc.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **BE 5800 - Advanced Biomaterials Interfaces**

This course introduces the students to the effects of topography and texture on the performance of biomaterials. Special emphasis is placed on tissue engineering scaffolds and microfabrication and nanofabrication techniques. Some of the topics include: self-organization of biomembranes and supramolecular systems, bioactive materials, and the molecular basis for surface recognition and masking.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **BE 5900 - Biomedical Engineering Topics**

Biomedical engineering courses will be offered as professional electives dependent upon the interest of the faculty.

**Credits:** variable to 6.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BE 5940 - Introduction to Tissue Engineering**

Explore the application of engineering principles toward the construction/reconstruction of human tissue. Fundamental biological principles involved in tissue engineering are reviewed from an engineering perspective with examples of engineered tissues such as blood vessels, skin, liver, cartilage and bone.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**BE 6000 - Doctoral Research**

Includes the study of an acceptable biomedical engineering problem and the preparation of a report or thesis.

**Credits:** variable to 12.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BE 6900 - Biomedical Engineering Topics**

Biomedical engineering courses will be offered as professional electives dependent upon the interest of the faculty.

**Credits:** variable to 6.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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**Biological Sciences****BL 5030 - Molecular Biology**

Molecular biology of gene structure, expression and regulation. Molecular techniques and their application to biotechnology and genomes are covered.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5040 - Electron Optical Methods of Analysis I: Principles and Techniques for Biologists**

Hands-on course focusing on use of transmission electron microscopes. Topics include sample preparation for biology, transmission electron optics, specimen-beam interactions, operating parameter choices, image formation and processing. Successful completion of course is the prerequisite to becoming a certified operator, MTU Electron Optics Facility. (This is a half semester course.)

**Credits:** 2.0

**Lec-Rec-Lab:** (0-3-3)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5050 - Electron Optical Methods of Analysis II: Principles and Techniques for Biologists**

Hands-on focusing on the use of transmission electron microscopes. Topics: sample preparation for biology, transmission electron optics, specimen-beam interactions, operating parameter choices, image formation and processing. Successful completion of course is the prerequisite to becoming a certified operator in the MTU Electron Optics Facility. (This is a half semester course)

**Credits:** 2.0

**Lec-Rec-Lab:** (0-3-3)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5060 - Biological Ultrastructure**

Microscopical investigations of biological specimens with transmission and scanning electron, scanning tunneling, and atomic force. Basic laboratory techniques include fixation and embedding, ultrathin sectioning, critical point drying, sputter coating. Also includes advanced cytochemical, cryo- and high-resolution techniques.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-2-6)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BL 5040 or BL 5050

**BL 5150 - Advanced Plant Physiology**

Comprehensive study of metabolic activities and growth processes of plants. Emphasizes water relations and growth at the submicroscopic, microscopic, and macroscopic levels. Prerequisite: a course in plant physiology.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5160 - Plant Biochemistry and Molecular Biology**

Biochemical principles underlying central processes unique to plants, including photosynthesis and symbiotic nitrogen fixation. Also covers fundamentals of plant molecular biology including transformation of plants and regulation of gene expression. Background required: one year of biochemistry and a course in plant physiology.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5170 - Plant Cell & Development**



Cellular, molecular processes involved in plant development. In-depth study of the structure and function of the plant cell as related to plant development. Such topics as control of iterative growth, cellular basis of form, cell differentiation, competence, determination and coordination of development. Background required: course in biochemistry and in plant physiology.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **BL 5200 - Microbial Physiology**

Structure and function of microorganisms, with emphasis on mechanisms for responding to changing environmental and nutritional conditions.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BL 3210 or BL 3310

### **BL 5250 - Immunological Toxicology**

Covers current topics in immunology and toxicology, including lymphokines, lymphocyte interactions, immune network theory, acquired and genetic immune defects, immunization of animals, characteristics of antibodies, immunoassays, and production of monoclonal antibodies.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **BL 5340 - Special Topics in Biology**

A discussion of recent developments in the biological sciences. Recent offerings have included population genetics, taxonomy of aquatic insects, herpetology, bryology, fungi, and lichens.

**Credits:** variable to 10.0; Repeatable to a Max of 10

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **BL 5350 - Special Topics in Physiology**

A discussion of recent developments in physiology. Recent offerings have included respiratory physiology, renal physiology, clinical cardiology, and neurophysiology.

**Credits:** variable to 10.0; Repeatable to a Max of 10

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **BL 5360 - Special Topics in Biochemistry**

A discussion of recent developments in the field of biochemistry. Topics taught recently include steroid biochemistry, immunology, and metabolic control theory.

**Credits:** variable to 10.0; Repeatable to a Max of 10

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5370 - Special Topics in Microbiology**

A discussion of recent developments in the field of microbiology. Topics taught recently include bacterial genetics, industrial microbiology, and advanced microbial ecology.

**Credits:** variable to 10.0; Repeatable to a Max of 10

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5380 - Special Topics in Ecology**

A discussion of recent developments in the field of ecology. Topics taught recently include systems ecology, ecology of Great Lakes fisheries, ecology of algae, aquatic macrophytes, and world ecosystems.

**Credits:** variable to 10.0; Repeatable to a Max of 10

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5390 - Special Topics in Clinical Laboratory Science**

A discussion of recent developments in clinical laboratory science.

**Credits:** variable to 10.0; Repeatable to a Max of 10

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5400 - Special Topics in Plant Sciences**

A discussion of recent developments in plant science. Topics may include biotechnology, physiology, systematics, phylogenetics, biochemistry, and molecular genetics.

**Credits:** variable to 10.0; Repeatable to a Max of 10

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5431 - Population Ecology**

The distribution and abundance of organisms, including theoretical, laboratory, and field studies of factors limiting population growth. Examines biological limitations, including competition, predation, parasitism, and disease.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5451 - Aquatic Ecology**

Integrated coverage of flowing and standing fresh water environments, including biological, physical, and chemical factors and their interactions. Applied aspects include biological responses to stress, fisheries, and the management of aquatic systems. Emphasizes the fundamentals of aquatic systems and fieldwork on local environments.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-3)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5460 - Advanced Ecology: Ecosystems**

Comparison of ecosystem structure and processes with emphasis on lakes. Stresses critical reading of recent journal literature.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5500 - Graduate Seminar in Biological Sciences**

Analysis, evaluation, and synthesis of primary scientific literature on a specific topic in recitation/discussion format.

**Credits:** 1.0; Repeatable to a Max of 4

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5501 - Graduate Research Seminar Ecology/Environmental**

Seminar is designed to facilitate critical discussions of student research projects at various stages of their development. The presenter will provide an overview or seminar on their project and research goals, which will establish the foundation for the discussion thereafter.

**Credits:** 1.0; May be repeated

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**BL 5520 - Satellite Limnology**

Provides an overview of historical, current applications of satellite remote sensing in limnologic research, including remote sensing of lake surface temperatures and ice, application of satellite image analysis for evaluating water quality variables (e.g., suspended solids and chlorophyll), development of a new lake, ocean color algorithms, and review of satellite instrument capabilities.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-2)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5680 - Bryology**

Emphasizes the broad aspects of bryology, including physiology, ecology, development, taxonomy, and evolution with an ecological theme that is fortified with laboratory examination of structures and field identification of bryophyte species, communities, and adaptations.

**Credits:** 4.0

**Lec-Rec-Lab:** (3-0-3)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5681 - Field Bryology**

A field course in the identification of mosses, liverworts and hornworts. Field trips will include various sites in the Keweenaw Peninsula. This intensive course will be taught as one week of field trips in the Keweenaw Peninsula.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-0-3)

**Semesters Offered:** Summer

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**BL 5750 - Advanced Ecology: Communities**

Discussion of factors that determine plant and animal species distribution, abundance, and diversity. Emphasis on theoretical concepts involves critical reading of recent literature.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 5990 - Masters Research in Biological Sciences**

An original investigation in biology that culminates in a thesis.

**Credits:** variable to 15.0; Repeatable to a Max of 15; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**BL 6990 - Doctoral Research in Biological Sciences**

An original investigation in theoretical or experimental biology, or both, and submission of a dissertation in partial fulfillment of the requirements for the PhD degree.

**Credits:** variable to 45.0; Repeatable to a Max of 45; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

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**Civil & Environmental Engrg**

**CE 5101 - Advanced Bituminous Materials**

Applications and properties of asphalt binder, aggregates for bituminous mixtures, and analysis and design of asphalt concrete mixtures. Includes asphalt cement production, rheology, chemistry, and grading, aggregate grading and blending, and mixture design and characterization. Also discusses asphalt mixture production, construction, and recycling.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-2)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate  
**Pre-Requisite(s):** CE 3101

**CE 5102 - Advanced Concrete Materials**

Properties and applications of portland cement and portland cement concrete. Includes cement production, chemistry and hydration, concrete admixtures, and the properties of fresh and hardened concrete. Presents concrete microstructure and durability. Other topics include high-strength and high early-strength concrete, fiber-reinforced concrete, and advanced cement-based materials.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-2)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CE 3101

**CE 5190 - Special Topics in Civil Engineering Materials**

Advanced study of materials related topics, including discussions of recent research developments at an advanced level.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**CE 5201 - Advanced Structural Analysis**

Energy methods in structural analysis. Elastic buckling of beams, beam-columns, and frames, including numerical methods for buckling analysis. Introduction to finite element analysis, including one- and two-dimensional elements.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CE 4201

**CE 5202 - Finite Element Analysis**

Introduction to the use of finite element methods in structural analysis. Covers the finite element formulation, 1- and 2-D elements, including isoparametric elements, axisymmetric analysis, plate and shell elements, dynamics, buckling, and nonlinear analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 4201

**CE 5211 - Advanced Reinforced Concrete Design**

Advanced topics in behavior of reinforced-concrete structures and relationships with element

design. Code requirements, reasoning behind theoretical and experimental studies for understanding structural behavior, and applications to design. Other topics include deep beams, corbel design, and yield-line analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 4211

### **CE 5212 - Prestressed Concrete Design**

Theory of prestressed and post-tensioned members. Covers analysis and design of prestressed concrete beams, slabs, box girders, and bridge girders by elastic and ultimate strength methods. Precast and cast-in-place system construction techniques will be included.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 3201

### **CE 5221 - Advanced Structural Steel Design**

Critical analysis of behavior of steel and thin-walled metal structural elements. Introduction to basic concepts of structural stability. P-delta effect as used in structural design. Torsional behavior of prismatic beams, including St. Venant and warping torsion. Torsional buckling.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CE 4221

### **CE 5231 - Advanced Timber Design**

Design of glulam members, including tapered beams, tapered and curved beams, and arches. Covers use of timber connectors as well as design of wood shear walls and diaphragms.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CE 4201 and CE 4231

### **CE 5241 - Structural Dynamics I**

Free and forced vibration of undamped and damped single degree of freedom systems. Generalized coordinates and Rayleigh's method. Multiple degree-of-freedom systems, including shear buildings and frames. Frequency response analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CE 4201

**CE 5242 - Structural Dynamics II**

Earthquake engineering and advanced dynamic analysis. Includes time history response of multiple degree-of-freedom systems, seismicity, equivalent static force method, modal analysis, base isolation, soil-structure interaction, and an introduction to random vibrations.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 5241

**CE 5243 - Probabilistic Analysis and Reliability in Civil Engineering**

Basic probability and statistics, including random variables, moments, probability distributions, and regression analysis. Also examines time-to-failure analysis, capacity/demand reliability analysis, first-order reliability methods, Monte Carlo simulation, and system reliability in a civil and environmental engineering context.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** MA 3710

**CE 5250 - Special Topics in Structural Engineering**

Advanced study of structural engineering topics, including discussions of recent research developments at an advanced level. Topics might include loading analysis, advanced topics in steel design, composite materials for structures, and behavior of a variety of reinforcements for concrete applications.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CE 5332 - Productivity Planning and Improvement**

Analysis of current trends in productivity, factors that affect productivity, and techniques to identify and improve areas of low productivity.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** and BA 3700) or (BA 3610 CE 3332

**CE 5337 - Project Delivery Systems**

A study of project delivery, from feasibility through design and construction, focusing on the three contemporary systems: general contracting, design-build, and construction management.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Class(es): Graduate

**Pre-Requisite(s):** CE 3331

### **CE 5338 - Project Management and Administration**

Exploration of the essential elements of project management and construction administration for the design and construction industry. This includes project planning, organization, budgeting, monitoring, control, life cycle, organizational structure and characteristics, and responsibilities of project managers.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Class(es): Graduate

**Pre-Requisite(s):** CE 3331

### **CE 5390 - Special Topics in Construction Engineering**

Advanced study of construction engineering topics including discussion of recent research developments.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

### **CE 5401 - Advanced Pavement Design**

Advanced analysis, behavior, performance, and structural design of highway and airport pavements. Focuses on mechanistic characterization of pavement structures and approaches used to characterize existing structures for the purpose of rehabilitation. Subjects include advanced materials characterization, mechanistic modeling, nondestructive testing, and pavement rehabilitation. Also includes airport pavement design and rehabilitation.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 4401

### **CE 5402 - Highway Design**

Advanced highway design, including horizontal and vertical alignment, cross-section elements, super elevation, and other road design topics. Includes extensive use of highway design computer software with a complete roadway design project using software.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 3401



**CE 5403 - Pavement Management Systems**

Principles of pavement management, including inventory, condition assessment, needs determination, and budget analysis. Emphasis on field condition assessment techniques. Presents database design to illustrate data handling techniques and introduces several software packages.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**CE 5404 - Transportation Planning**

Introduction to urban transportation planning, travel characteristics, demand forecasting techniques, corridor studies, traffic impact studies, and public transit planning and operations.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**CE 5405 - Environmental Impacts of Transportation**

Introduction to environmental legislative and regulatory history. Understanding of the basic elements of environmental impact analysis for transportation facilities. Topics include noise, air quality, wetlands, cultural, historic, community, and socioeconomic aspects, and public participation techniques.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**CE 5406 - Airport Planning and Design**

Introduction to the air transportation system, airport planning studies, demand forecasting, aircraft characteristics, runway requirements, airport layout and design. Also includes environmental impacts, airport capacity and operations, terminal and ground access planning and analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**CE 5407 - Advanced Airport Planning and Design**

Airport capacity and delay analysis, terminal and ground access planning, security, environmental aspects, noise and land use planning, airport management and operations. Includes extensive use of airport computer simulation software packages.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; May not be enrolled in one of the following  
Class(es): Freshman, Sophomore, Junior  
**Pre-Requisite(s):** CE 5406

### **CE 5408 - Public Transit**

An introduction to public transit, user characteristics, management, transit modes, data collection and surveys, planning, operations, scheduling, transit finances, and future trends.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; May not be enrolled in one of the following  
Class(es): Freshman, Sophomore, Junior

### **CE 5410 - Intelligent Transportation Systems**

Introduction to ITS, concepts, technologies, activities, and deployment issues. Topics include advanced traffic management, traveler information systems, commercial vehicle operations, vehicle control systems, ITS applications in public transit, and rural ITS.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; May not be enrolled in one of the following  
Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** CE 4402

### **CE 5490 - Special Topics in Transportation Engineering**

Topics of special interest in transportation engineering.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required

### **CE 5501 - Environmental Process Engineering**

Review of mass transfer, kinetics, reactor design, and mathematical modeling principles.

Includes illustration by application to several important natural systems and environmental engineering unit processes. Mathematical models of selected environmental engineering systems are developed and solved using PCs.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **CE 5502 - Biological Treatment Processes**

Application of kinetics, reactor theory, and microbiology to modeling and design of aerobic and anaerobic wastewater treatment systems. Topics include activated sludge process models and application of these models to process design and operation.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-3)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CE 4502

### **CE 5503 - Physical-Chemical Treatment Processes**

Advanced theory, fundamentals, and application of physical and chemical processes employed in design and operation of drinking water treatment systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CE 5501

### **CE 5504 - Surface Water Quality Modeling**

Mathematical models are applied in the solution of water quality management problems. The spatial and temporal variation of conservative and reactive substances is simulated in lakes, rivers, and embayments. Kinetic representations of natural phenomena are developed, including mass transport, biogeochemical cycling of nutrients and toxics and food web dynamics.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 4505

### **CE 5505 - Atmospheric Chemistry**

Study of the fundamental processes that govern tropospheric and stratospheric composition, with applications to tropospheric ozone, atmospheric fate of organic compounds, atmospheric radiation and climate impacts, acidic deposition, and stratospheric ozone, and to atmospheric gas-phase measurements.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 4504 or CE 4501

### **CE 5506 - Air Quality Modeling**

Mathematical tools for the analysis of air quality issues at the indoor, local, and regional scales. Introduces statistical and deterministic methods. Provides hands-on experience with state-of-the-science air quality models from U.S. EPA and engineering consulting firms.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CE 4504

### **CE 5507 - Sorption and Biological Processes**

Fundamental principles and modeling of some important physical and biological fate processes that govern the transport, persistence, and/or degradation of organic and inorganic pollutants in natural or engineered systems. Topics include sorption to soils/sediments, biodegradation of organic chemicals, bioavailability, and engineered remediation.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **CE 5508 - Biogeochemical Processes**

To define what constitutes sustainable human activities, one must understand linkages among physical, chemical, and biological structures and processes that comprise our biosphere. Examine interactions between physical, chemical, and biological processes on earth; model these interactions; and identify areas where knowledge is insufficient for modeling.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 4501

### **CE 5509 - Environmental Organic Chemistry**

Investigation of factors controlling the environmental fate, distribution, and transformation of organic xenobiotic molecules. Thermodynamics and kinetics of chemical partitioning among air, water, sediment, and organic phases. Transformations examined include hydrolysis, oxidation-reduction, photochemistry, and "organism-assisted" reactions. Structure-activity relationships and estimation techniques are presented with a goal of modeling environmental impacts.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CE 4501 or CH 3510

### **CE 5510 - Practical Applications and Analytical Techniques for Environmental Measurements**

Develop methods and skills for laboratory work required for experimental research in environmental engineering. Topics include laboratory safety, quality control/quality assurance, purchasing, and use of analytical equipment. Students select one or more of the following topics for specialized study: GC, AA, carbon analysis, HPLC, UV/Vis spectroscopy, liquid scintillation counting.

**Credits:** variable to 3.0

**Semesters Offered:** Summer

**Restrictions:** Permission of instructor required

**CE 5511 - Air Quality and the Built Environment**

Investigates the complex interaction between the engineered environments in developed and developing nations and air quality. Major topics include: air pollutant health impacts and epidemiology, indoor air quality, urban design and air quality, infrastructure and air quality, and atmospheric sustainability.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-1)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**CE 5560 - Advanced Topics in Air Quality Engineering**

Advanced study of topics related to atmospheric chemistry and/or modeling the transformation and transport of atmospheric pollutants.

**Credits:** variable to 4.0; Repeatable to a Max of 8

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required

**CE 5561 - Advanced Topics in Biological Processes**

Advanced study of biological processes associated with natural and engineering systems.

**Credits:** variable to 4.0; Repeatable to a Max of 8

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required

**CE 5562 - Advanced Topics in Physical-Chemical Processes**

Advanced study of physical and chemical processes that occur in natural and engineered systems.

**Credits:** variable to 4.0; Repeatable to a Max of 8

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required

**CE 5563 - Advanced Topics in Surface Water Quality Engineering**

Advanced topics related to understanding the biogeochemistry of surface waters (lakes, rivers, wetlands) and the mathematical modeling of those systems.

**Credits:** variable to 4.0; Repeatable to a Max of 8

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required

**CE 5590 - Special Topics in Environmental Engineering**

Advanced study of environmental engineering topics including discussion of recent research developments.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**CE 5610 - Civil and Environmental Engineering Systems Analysis**

Operations research theory with application to civil and environmental engineering problems. Decision theory and optimization techniques, including linear programming, nonlinear programming, and dynamic programming. Computer based applications will be included.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** MA 2150 or MA 2160

### **CE 5660 - Hydrology II**

Advanced hydrology aimed at a more thorough understanding of the individual components of the hydrologic cycle. Includes physical hydrology, hydrometeorology, stochastic hydrology, and remote sensing applications.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CE 3620

### **CE 5661 - GIS Applications**

Application of a Geographical Information Systems (GIS) to hydrologic modeling. While the application centers on hydrologic modeling, the experiences gained are applicable to a wide variety of situations. Learn the processes of obtaining, manipulating, and generating data via ArcInfo and ArcView.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CE 3620

### **CE 5664 - Water Resources Modeling**

Application of fundamental principles to develop mathematical models of water resources systems. Includes application of numerical methods, programming to develop simple water resources models, and application of state-of-the-art models for hydrology and river analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CE 3620

### **CE 5665 - Sediment Transport**

Basin mechanics of the transport of sediments in natural systems, including tractive forces and geomorphic functions.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CE 3620

**CE 5666 - Water Resources Planning and Management**

Economic and environmental aspects of water use. Topics include flood damage reduction, water demand and hydrologic forecasting, water supply planning, and water resource systems operation.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CE 3620 and (EC 3402 or ENG 3402 or EC 3400)

**CE 5668 - Cold Regions Hydrology**

Analysis of the effects of fresh water ice and snow engineering projects. Topics include snow hydrology, formation, melt, transport distribution, and loading; ice formation, mechanics, bearing capacity, hydraulic effects on rivers, ice jams, and ice control.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** CE 3620

**CE 5690 - Special Topics in Water Resources**

Advanced study of water resources topics including discussion of recent research developments.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**CE 5810 - Advanced Soil Mechanics**

Provides advanced studies in the topics of soil compressibility and soil strength. Develop advanced procedures for determining stress distribution and stress changes from a fundamental basis. Students are strongly advised to take CE5820 concurrently.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CE 3810

**CE 5820 - Geotechnical Engineering Laboratory**

Hands-on experimental lab course intended to develop understanding of soil behavior and the subtle variables that influence testing results. Tests studied include cyclic and monotonic triaxial drained and undrained strength, triaxial and one-dimensional compression, and as-compacted vs. long-term behavior of fill materials.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-1-4)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CE 3810

### **CE 5830 - Advanced Geotechnical Engineering**

Applies soil mechanics to the design of foundations and earth-retaining structures. Proper input parameters are stressed, and elements include the design of conventional retaining walls, reinforced earth walls, caissons, piles, shallow foundations, de-watering systems, and the support of temporary excavations.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 5810 and CE 5820

### **CE 5840 - Frozen Ground Engineering**

Stresses the problems and their solutions in seasonally frozen ground. Topics include definition of detrimental frost action, frost susceptibility criteria, mechanism of frost action, frost-resistant design, and the use of insulation. Studies both pavements and light building foundations. Take field trips during the spring thaw period.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 3810

### **CE 5850 - Stability of Earth Structures**

Studies the analysis and design of earth cuts, earth embankments, and gravity dams. Topics include field compaction of soil, compacted properties, fluid flow through the soil, and slope stability procedures. Requires a field trip to an RCC dam and an analysis of its water pressure and movement records.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CE 3810

### **CE 5860 - Fundamentals of Soil Behavior**

Develop an understanding of the factors determining and controlling the engineering properties of a soil. Topics include crystal structure and surface characteristics, soil mineralogy, soil formation, rock weathering, soil composition, soil water, clay-water electrolyte systems, soil structure and stability, volume change behavior, and strength and deformation behavior.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)



**Semesters Offered:** Fall  
**Pre-Requisite(s):** CE 3810

**CE 5890 - Special Topics in Geotechnical Engineering**

Advanced study of geotechnical engineering topics including discussion of recent research developments.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CE 5920 - Civil Engineering Independent Study**

Approved research or design project in civil engineering, originating with an individual student or assigned by the instructor.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CE 5930 - Environmental Engineering Independent Study**

Approved research or design project in environmental engineering, originating with an individual student or assigned by the instructor.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CE 5990 - Civil Engineering Graduate Seminar**

Detailed study and group discussions of current literature and graduate research projects related to the broad field of civil engineering. Topics will be combined to address the student's area of interest, including construction, environmental, geotechnical, structures, transportation, and water resources. External speakers discuss current related issues.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CE 5991 - Environmental Engineering Graduate Seminar I**

Presentations and discussion of current literature and research related to the broad field of environmental engineering.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall

**CE 5992 - Environmental Engineering Graduate Seminar II**

Presentations and discussion of current literature and research related to the broad field of environmental engineering.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Spring

**CE 5993 - Field Engineering in the Developing World**

Study of applying appropriate and sustainable engineering solutions and technology in the developing world. Concepts of sustainable development are covered. Topics are drawn from several areas of engineering, including water supply/treatment, wastewater treatment, materials, solid waste, construction, and watersheds.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-1-2)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CE 5994 - International Civil & Environmental Engineering Field Experience**

Field work and reporting from students in the Peace Corps Master's International Program in Civil & Environmental Engineering.

**Credits:** 1.0; May be repeated

**Lec-Rec-Lab:** (0-0-2)

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**CE 5995 - International Engineering Master's Research**

An original investigation in theoretical or experimental engineering and submission of a thesis or report in partial fulfillment of the requirements of the Master of Science degree conducted while in the Peace Corps Master's International Civil & Environmental Engineering program.

**Credits:** variable to 9.0

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering; Must be enrolled in one of the following Major(s): Civil Engineering, Environmental Engineering

**CE 5998 - Engineering Design Practicum**

Advanced independent study for students in the Master of Engineering program. In consultation with student's advisor, develop and execute a project demonstrating capabilities in problem solving, communications, and decision making. The practicum can be done on campus or at the site of a Michigan Tech corporate partner.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CE 5999 - Master's Research**

Study of an acceptable civil or environmental engineering problem and preparation of a report or

thesis.

**Credits:** variable to 10.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **CE 6999 - Doctoral Research**

Original research leading to the preparation of a dissertation in partial fulfillment of the requirements for the PhD degree.

**Credits:** variable to 10.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Civil Engineering, Environmental Engineering, Engineering - Environmental

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## **Chemistry**

### **CH 5210 - Analytical Separations**

Covers theory and applications of modern gas chromatography, high performance liquid chromatography, and ion chromatography as well as instrumentation for these techniques. Studies trace organic analysis and environmental problems.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **CH 5220 - Physical Methods of Analysis**

Electrochemical methods, including potentiometry, voltammetry, chronopotentiometry, and electrolysis; electrochemistry in nonaqueous media; mechanisms of electrode processes. Analytical applications of atomic spectroscopy, nuclear magnetic resonance, and mass spectrometry.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **CH 5310 - Advanced Inorganic Chemistry**

Covers the organometallic chemistry of the transition elements, beginning with a historical overview of the subject, as well as basic ideas in complex and transition metal chemistry.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CH 4320

**CH 5410 - Advanced Organic Chemistry I**

Advanced study of mechanistic organic and physical organic chemistry intended to bring the student to the level of current research activity. Topics may include methods for determining organic reaction mechanisms, chemical bonding as it applies to organic compounds, structure-reactivity relationships, molecular rearrangements, and molecular orbital theory.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CH 5420 - Advanced Organic Chemistry II**

Advanced study of organic reactions and synthetic organic chemistry intended to bring the student to the level of current research activity. Topics may include retrosynthetic analysis and synthesis design, synthons, protecting groups, and analysis of syntheses from recent literature.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CH 5509 - Environmental Organic Chemistry**

Investigation of factors controlling the environmental fate, distribution, and transformation of organic xenobiotic molecules. Covers thermodynamics and kinetics of chemical partitioning among air, water, sediment, and organic phases. Transformations examined include hydrolysis, oxidation reduction, photochemistry, and "organism-assisted" reactions. Structure-activity relationships and estimation techniques are presented with a goal of modeling environmental impacts.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CE 4501 or CH 3510

**CH 5510 - Classical and Statistical Thermodynamics**

Principles of classical chemical thermodynamics from the viewpoint of Gibbs and DeDonder; principles of applications of statistical mechanics to thermodynamics, including the properties of gases, liquids, electrolytic solutions, solutions of high polymers, and other systems of chemical interest.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CH 3520

**CH 5520 - Chemical Kinetics**

An advanced study of chemical reaction rates, including methods of analysis of reaction rate data and the theory of rate processes.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CH 3520

### **CH 5530 - Molecular Spectroscopy**

An introduction to molecular spectroscopy and molecular structure. Topics include infrared and Raman spectroscopy, electronic spectroscopy, fluorescence, phosphorescence, and resonance techniques.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CH 3520

### **CH 5540 - Applications of Group Theory in Chemistry**

The predictive power of group theory in chemistry is developed through theory and detailed applications. Emphasizes group theoretical applications to molecular orbital theory, orbital symmetry, ligand field theory, and vibrational spectroscopy.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CH 3520

### **CH 5550 - Solid State Chemistry**

Introduces principles of solid state chemistry and the application to produce compounds with the desired physical and chemical properties. Discusses reactivity, preparation techniques, structure, impurity or dopant effects, phase transformations, electric and magnetic properties, and point defect chemistry.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CH 3520

### **CH 5560 - Computational Chemistry**

Focuses on the theory and method of modern computational techniques applied to the study of molecular properties and reactivity through lecture and computer projects. Covers classical mechanical as well as quantum mechanical approaches.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CH 3520

**CH 5570 - Biophysical Chemistry**

A discussion of experimental techniques and applications of physical chemistry principles to the study of the structure, dynamics, and chemical reactions of proteins, nucleic acids, and other biopolymers.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CH 3520

**CH 5810 - Magnetic Resonance Spectroscopy**

Considers the physical interactions of importance to magnetic resonance spectroscopy. Illustrates these principles by selected, modern experimental techniques. Emphasizes on spin 1/2 particles.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CH 3521

**CH 5900 - Chemistry Seminar**

Graduate seminar in chemistry.

**Credits:** 1.0; Repeatable to a Max of 2

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CH 5990 - Graduate Research in Chemistry**

An original investigation in chemistry for students seeking an MS degree.

**Credits:** variable to 12.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CH 6290 - Special Topics in Analytical Chemistry**

Discussion of current research developments at an advanced level. A list of possible topics might include chromatography, magnetic resonance, surface analysis, mass spectrometry, or environmental analysis.

**Credits:** variable to 3.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CH 6390 - Special Topics in Inorganic Chemistry**

Discussion of recent developments in inorganic chemistry.

**Credits:** variable to 3.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CH 4320

**CH 6490 - Special Topics in Organic Chemistry**

Advanced study in special areas of organic chemistry. Topics could include organic synthetic methods, production and reactions of enolate ions, heterocyclic, carbohydrate, bioorganic, or free-radical chemistry.

**Credits:** variable to 3.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CH 6510 - Current Topics Seminar - Physical Chemistry**

A weekly discussion between graduate students and faculty of current research and literature topics in physical chemistry. Required for all graduate students in physical chemistry.

**Credits:** 1.0; May be repeated

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CH 6590 - Special Topics in Physical Chemistry**

A discussion of recent research developments at an advanced level. Topics could include atomic and molecular structure, kinetic theory of gases, solid-state chemistry, thermodynamics, electrochemistry, and molecular spectroscopy.

**Credits:** variable to 3.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CH 6690 - Special Topics in Polymer Science**

Advanced study in special areas of polymer science. Topics could include thermal analysis, polymer surface science, advanced polymerization processes, scaling laws, etc. Some topics may include a laboratory component.

**Credits:** variable to 3.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CH 6790 - Special Topics in Biochemistry**

Advanced study in special areas of biochemistry and molecular biology. Topics could include bioorganic chemistry, signal transduction or transcriptional control.

**Credits:** variable to 3.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**CH 6800 - Current Topics in Graduate Chemistry**

Discussion of recent topics in chemistry at a graduate level.

**Credits:** variable to 3.0; Repeatable to a Max of 12

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **CH 6990 - Chemistry Doctoral Research**

Laboratory research in preparation of the PhD thesis. Requires permission of the student's advisory committee and the graduate faculty.

**Credits:** variable to 12.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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## **Chemical Engineering**

### **CM 5100 - Appl Mathematics for CM**

The solution to basic equations for momentum, mass, and heat transfer by use of separation of variables, numerical methods, and other mathematical techniques.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **CM 5200 - Advanced CM Thermodynamics**

Emphasis in phase equilibria and related concepts, such as molecular or statistical thermodynamics, nonideal fluids and solids.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **CM 5300 - Advanced Transport Phenomena**

Single- and multi-component mass, energy, and momentum transport. Derivation and use of the general transport equations for Newtonian and non-Newtonian flows, convective flows, and mass transport in flowing systems. Applications to complex systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CM 5100

### **CM 5310 - Laboratory Safety**

Provides the technical and cultural background necessary to operate and manage a safe Laboratory.

**Credits:** 1.0

**Lec-Rec-Lab:** (1-0-0)



**Semesters Offered:** Fall

**CM 5400 - Adv Reactive Systems Analysis**

An analytical study of various aspects of chemical reactor behavior, such as multiple steady-states, dynamics, stability, and control. Also covers transport phenomena in packed beds of solids and mathematical modeling of packed-bed reactors.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CM 5500 - Theory and Methods of Research**

Discusses modern methods of research. Topics could include statistical analysis, presentation of data, modern experimental methods, or oral presentation skills.

**Credits:** 2.0

**Lec-Rec-Lab:** (1-0-2)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CM 5650 - Heterogeneous Catalysis**

A survey of theories of catalytic activity of solids with examples drawn from reactions of industrial importance.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CM 5670 - Advanced Process Design**

Problems and lectures in plant design. Course content will vary according to particular needs of the students involved.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CM 5680 - Adv Chemical Process Control**

Analysis and design of digital and sampled control systems; use of z-transform and time-domain methods. Study of nonlinear feedback systems, stability criteria, and state-space methods. Design using optimal control. Multivariable and adaptive control system concepts as applied to chemical processes.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CM 5700 - Advanced Polymer Rheology**

Exploration of advanced non-Newtonian constitutive equations and nonlinear polymer behavior. In-depth analysis of rheological constitutive equations and their applications. Models studied include the convected-Maxwell, Rouse, and Doi-Edwards models as well as more recent models.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CM 4650

**CM 5710 - Coal Preparation**

Geology, petrography, mining, and preparation of coal. Covers topics such as coal-water-fuels, transportation, economics, and environmental considerations.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** On Demand

**CM 5730 - Control of Process Streams**

Sampling statistics, on-line sensors, serial and parallel interfacing, artificial intelligence, and fuzzy logic applied to minerals and materials processing operation.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** On Demand

**CM 5900 - Special Topics in CM**

A discussion of chemical engineering topics of current interest not included in regular graduate courses.

**Credits:** variable to 3.0

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**CM 5950 - Advanced Special Projects**

This is a course for graduate students who wish to do extensive work on projects or topics not directly related to their thesis topic and not covered in one of the graduate courses.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**CM 5990 - MS Research**

An original investigation of a chemical engineering problem.  
**Credits:** variable to 15.0; May be repeated; Graded Pass/Fail Only  
**Semesters Offered:** Fall, Spring, Summer

### **CM 6990 - Doctoral Research**

An original investigation in theoretical or applied chemical engineering or both, and submission of a dissertation in partial fulfillment of the requirements for the PhD degree.  
**Credits:** variable to 12.0; May be repeated; Graded Pass/Fail Only  
**Semesters Offered:** Fall, Spring, Summer

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## **Computer Science**

### **CS 5090 - Special Topics in Computer Science**

Special topics in computer science offered on occasion based on student and faculty demand and interest.

**Credits:** variable to 4.0; May be repeated  
**Semesters Offered:** Fall, Spring, Summer  
**Restrictions:** Permission of department required

### **CS 5091 - Master's Seminar in Computer Science**

From time to time, depending on student demand, a seminar will be offered on advanced topics in current computer science research.

**Credits:** variable to 3.0; May be repeated; Graded Pass/Fail Only  
**Semesters Offered:** On Demand  
**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

### **CS 5131 - Compiler Optimization**

This course emphasizes the design and implementation of low- and high-level compiler optimizations. Topics include control- and data-flow analysis, traditional compiler optimization, global register allocation, instruction scheduling, dependence analysis, memory-reuse analysis and loop transformations.

**Credits:** 3.0  
**Lec-Rec-Lab:** (0-3-0)  
**Semesters Offered:** Fall, Spring  
**Pre-Requisite(s):** CS 4131

### **CS 5311 - Computation Theory**

Turing machines, recursive functions, register machines, parallel computational models, bounds of complexity, NP-completeness, and P-Space completeness.

**Credits:** 3.0  
**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring  
**Pre-Requisite(s):** CS 4311

### **CS 5321 - Advanced Algorithms**

Topics include algorithms for complex data structures, amortized analysis, and NP-completeness. Application areas include approximation algorithms, network flow, combinatorics, string matching, and parallel algorithms. Additional topics as time permits.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CS 4321

### **CS 5331 - Parallel Algorithms**

Emphasizes the principles used in the development of algorithms for parallel computers, including programming paradigms, implementation, analysis, and performance evaluation. Considers algorithms in the areas of scientific computation and nonnumeric processing as well as software tools for performance visualization and debugging.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 4431 and CS 4321

### **CS 5411 - Advanced Operating Systems**

Advanced concepts in operating systems. Topics include real-time and multiprocessor scheduling, I/O, modern file systems, and performance analysis. Also requires a substantial implementation project.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 4411

### **CS 5431 - Advanced Computer Architecture**

An in-depth study of various aspects of parallel processing, with an emphasis on parallel architectures. The course has an analytical focus and investigates models of various aspects of the design and analysis of parallel systems. Topics include simple uniprocessor/multiprocessor performance models, pipelining, instruction-level parallelism, and multiprocessor design issues.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 4431 or (EE 3173 and EE 3175)

**CS 5441 - Distributed Systems**

Covers time and order in distributed systems; mutual exclusion, agreement, elections, and atomic transactions; Distributed File Systems, Distributed Shared Memory, Distributed System Security; and issues in programming distributed systems. Uses selected case studies.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 4411

**CS 5461 - Mobile Networks**

Mobile network issues including routing and mobility management strategies in ad hoc networks, sensor networks, and personal area networks such as Bluetooth.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 4461

**CS 5611 - Computer Graphics: Advanced Rendering and Animation**

Topics include polygonal objects, parametric curves and surfaces, lighting models, shadows and textures, ray-tracing techniques, radiosity methods, volume rendering, and animation.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 4611

**CS 5621 - Computer Graphics: Geometric Modeling and Processing**

Design concepts in geometric modeling. Topics include representation of shapes for solids and surfaces; shape modeling, including parametric curves and surfaces such as Bezier, B-spline, and NURBS curves and surfaces; implicit curves and surfaces; surface intersection, blending, and offsetting; applied computational geometry; and the design of robust geometric algorithms.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CS 5611 and MA 2330

**CS 5632 - Computer Graphics: Scientific and Data Visualization**

Covers the fundamental concepts in the field of scientific, engineering, biomedical, and information visualization. Emphasizes the representation of scalar, vector, and tensor fields; data sampling and resampling; reconstruction using multivariate, multivalued finite elements, surfaces, volumes and functions on surfaces; and volumetric rendering techniques.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** (MA 2320 or MA 2321 or MA 2330) and CS 5611

### **CS 5711 - Advanced Software Engineering**

This course surveys current research in software engineering. Topics include both the technical aspects of software development (e.g. requirements modeling/analysis, design, verification) and issues pertaining to software process and project management (e.g. measurement, risk analysis, team organization).

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CS 4711 and CS 4712

### **CS 5811 - Advanced Artificial Intelligence**

Course topics include current topics in artificial intelligence including agent-based systems, learning, planning, use of uncertainty in problem solving, reasoning, and belief systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CS 4811

### **CS 5911 - Advanced Numerical Analysis**

Topics include linear and nonlinear systems, interpolation, function approximation, numerical integration and differentiation, fast fourier transform, ODEs and PDEs, eigenvalue calculation, and unconstrained optimization.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

### **CS 5990 - Master's Research in Computer Science**

The study of an acceptable computer science problem and the preparation of a thesis

**Credits:** variable to 9.0; Repeatable to a Max of 99; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **CS 5999 - Master's Reading and Research in Computer Science**

Individual reading and research on current topics in computer science.

**Credits:** variable to 9.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**CS 6090 - Special Topics in Computer Science**

Special topics in Computer Science offered on occasion based on student and faculty demand and interest.

**Credits:** variable to 4.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of department required

**CS 6091 - Doctoral Seminar in Computer Science**

Seminar covers advanced topics in current Computer Science research for doctoral degree candidates. Offered according to student demand.

**Credits:** variable to 3.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

**CS 6461 - Advanced Computer Networks**

Most advanced research issues in computer networks will be discussed. Topics include overlay networks, anonymity, distributed denial of service, and security in a sensorized universe. With term project students will experience a full cycle of typical research activities in networking.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CS 4461

**CS 6621 - Computer Graphics: Contemporary Modeling and Design Research Topics**

An in-depth study of recent developments in computer graphics, geometric modeling and visualization, with an emphasis on polyhedron simplification, refinement, surgery, multiresolution representations and geometric compression. In addition, this course will also cover the blossoming principle, scatter data interpolation and approximation d surface subdivision schemes.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

**Pre-Requisite(s):** CS 5611

**CS 6990 - Doctoral Research in Computer Science**

The study of an acceptable computer science problem and the preparation of a dissertation.

**Credits:** variable to 9.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **CS 6999 - Doctoral Reading and Research in Computer Science**

Individual reading and research on current topics in Computer Science for doctoral degree candidates.

**Credits:** variable to 9.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

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### **Computational Science & Engr**

#### **CSE 5091 - Computational Science and Engineering Seminar**

From time to time, depending on student demand, a seminar will be offered on current topics in computational science and engineering.

**Credits:** variable to 3.0; May be repeated

**Semesters Offered:** Fall, Spring

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

#### **CSE 5200 - Computational Genomics**

Topics include introduction to molecular biology, DNA sequence assembly, fast database searching, sequence alignment, and gene recognition.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

#### **CSE 5311 - Computation Theory**

Turing machines, recursive functions, register machines, parallel computational models, bounds of complexity, NP-completeness, and P-Space completeness.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CS 4311

#### **CSE 5321 - Advanced Algorithms**

Topics include algorithms for complex data structures, amortized analysis, and NP-completeness. Application areas include approximation algorithms, network flow, combinatorics, string matching, and parallel algorithms. Additional topics as time permits.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CS 4321



**CSE 5331 - Parallel Algorithms**

Emphasizes the principles used in the development of algorithms for parallel computers, including programming paradigms, implementation, analysis, and performance evaluation. Considers algorithms in the areas of scientific computation and nonnumeric processing as well as software tools for performance visualization and debugging.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CS 4321 and CS 4431

**CSE 5711 - Advanced Software Engineering**

Surveys current research in software engineering. Topics include both the technical aspects of software development (e.g. requirements modeling/analysis, design, verification) and issues pertaining to software process and project management (e.g. measurement, risk analysis, team organization).

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CS 4711 and CS 4712

**CSE 5811 - Advanced Artificial Intelligence**

Current topics in artificial intelligence including agent-based systems, learning, planning, use of uncertainty in problem solving, reasoning, and belief systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CS 4811

**CSE 5900 - Computational Linear Algebra**

Computational methods for solving systems of linear equations. Presents background in linear algebra theory and computational techniques. Typical topics include finite element methods, conjugate gradient methods, other iterative methods, and direct methods. Emphasizes modern computational approaches.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**CSE 5911 - Advanced Numerical Analysis**

Topics include linear and nonlinear systems, interpolation, function approximation, numerical integration and differentiation, fast fourier transform, ODEs and PDEs, eigenvalue calculation, and constrained optimization.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **CSE 6090 - Special Topics in Computational Science and Engineering**

Special topics in Computational Science and Engineering offered on occasion based on student and faculty demand and interest.

**Credits:** variable to 4.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of department required

### **CSE 6091 - Computational Science and Engineering Seminar**

From time to time, depending on student demand, a seminar will be offered on current topics in computational science and engineering.

**Credits:** variable to 3.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

### **CSE 6131 - High-Level Program Analysis and Optimization**

Covers the use of high-level program analysis to transform code with deep memory hierarchies and vector and parallel features. Topics include dependence analysis, memory-hierarchy analysis, loop transformations and code generation strategies for high-performance computer architectures.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** CS 4131

### **CSE 6990 - Doctoral Research**

By arrangement with the instructor directing the PhD dissertation.

**Credits:** variable to 9.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **CSE 6999 - Doctoral Reading and Research**

Individual reading and research on current topics in computational science and engineering.

**Credits:** variable to 9.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following

Level(s): Graduate

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## **Economics**

### **EC 5000 - Microeconomics**

The study of consumer demand theory of the firm, market structure, and industrial performance. Emphasizes establishment of an analytic framework for evaluating public policy.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-4-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** EC 3002

### **EC 5010 - Macroeconomics**

The study of the determinants of the level of income, employment, the rate of inflation, economic growth, and cyclical variations in the economy, including considerations of the rationale for monetary and fiscal policy and their impact on the business community.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-4-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** EC 3003

### **EC 5300 - Managerial Economics**

Economic analysis of the operation of a business. Topics include optimization, demand theory and forecasting, production/cost analysis, market structure and strategic behavior, risk analysis, antitrust policy and regulation of safety and the environment, and international management.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** EC 3001 or (EC 2002 and EC 2003)

### **EC 5400 - Advanced Engineering Economics**

Presents and demonstrates procedures and quantitative techniques used in capital budgeting and project evaluation and selection for industry. Topics include cash flow analysis, decision methods, risk and uncertainty, cost of capital, taxes and depreciation, and forecasting market variables. Topics presented with study problems, applying spreadsheet programs.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** BA 3400 or EC 3400

**EC 5600 - Natural Resource and Environmental Economics**

Supply and use of renewable and depletable natural resources, including minerals, energy, agriculture, forests, fisheries, wildlife, and water. Efficient management of private and common property resources and environmental issues and concerns. Efficiency, market failures, benefit-cost analysis, and policy analysis. No credit if a student has previous credit for EC4610.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-4-0)

**Semesters Offered:** Spring

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**EC 5610 - Economics of Nonfuel Minerals**

Economics of the nonfuel minerals industries: market analysis, market structure, international trade issues, policy analysis, role of minerals in society, supply, demand, markets, and foreign trade for important minerals, effects of government policies on the minerals industries. No credit if a student has previous credit for EC4600.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-4-0)

**Semesters Offered:** Fall

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**EC 5620 - Energy Economics**

Examines social and private problems in the supply, distribution, and use of energy resources and the energy industries. Studies production, allocation, and environmental and social problems of petroleum, natural gas, coal, nuclear, electricity, and various alternative energy sources. No credit if a student has previous credit for EC4620.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-4-0)

**Semesters Offered:** Spring

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**EC 5900 - Special Topics**

Economic topics of interest to students or independent study in economics under the guidance of a faculty member.

**Credits:** variable to 4.0; Repeatable to a Max of 8

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**EC 5999 - Graduate Research**

Under the guidance of a faculty member, students will read, conduct research, and prepare a

report, paper, or thesis.

**Credits:** variable to 15.0; Repeatable to a Max of 15; Graded Pass/Fail Only

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **EC 5999D - Graduate Research**

Under the guidance of a faculty member, students will read, conduct research and prepare a report, paper or thesis.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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## **Education**

### **ED 5100 - College Teaching**

Covers course preparation, educational testing and evaluation, understanding theories and processes of student learning, developing assignments, instructional strategies (discussions, lecturing, collaborative learning, cases/simulations, etc.), using instructional technologies, motivating students, the roles of the teaching assistant, and using institutional resources for student development.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-2-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **ED 5110 - Educational Psychology**

Review of psychological principles as they relate to human learning. Covers factors in school that contribute to the emotional, psychological stability of the developing child: assessing students' capabilities, setting educational objectives for the child, classroom practices, procedures, teachers' behavior and their relationship to different types of students. All four components of the Early Block must be taken concurrently.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-2-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Co-Requisite(s):** ED 5210, ED 5310

### **ED 5210 - Principles of Education**

Contemporary issues in education from historical, philosophical, sociological, and legal perspectives. Emphasizes the structure/function of U.S. education as well as exceptional children, especially the handicapped and culturally different. This course is one component of the Teacher Education Early Block. Requires admission to teacher education program. All four components of the Early Block must be taken concurrently.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-2-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Co-Requisite(s):** ED 5110, ED 5310

### **ED 5310 - Graduate Seminar in Education**

Introduction to contemporary issues in teacher education. Synthesis of clinical experiences with the psychological foundations of learning and foundations of education courses. Requires a term project. This course is one component of the Teacher Education Early Block. Requires admission to teacher education program. All four components of the Early Block must be taken concurrently.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Co-Requisite(s):** ED 5110, ED 5210

### **ED 5410 - Educational Field Experience**

Observation, tutoring and classroom teaching in an area elementary school classroom. This course is one component of the Teacher Education Early Block. Requires admission to teacher education program. All four components of the Early Block need to be taken concurrently.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-0-3)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Co-Requisite(s):** ED 5110, ED 5210

### **ED 5420 - Mentoring Student Teachers**

Classroom mentoring, support and supervision of student teachers. Emphasis on helping student teachers improve skills in assessment, planning, classroom management.

**Credits:** 1.0; Repeatable to a Max of 6

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Permission of department required

### **ED 5500 - Special Studies in Educational Psychology**

Individual or group studies of specially selected issues or problems in educational psychology. Credit may be granted for scholarly work under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product research reports, curricula, computer program, or other.

**Credits:** variable to 6.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**ED 5510 - Special Studies in Educational Technology**

Individual or group studies of specially selected issues or problems in educational technology. Credit may be granted for scholarly work under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

**Credits:** variable to 6.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

**ED 5520 - Special Studies in Middle and Secondary Methods**

Individual or group studies of specially selected issues or problems in middle and secondary school methods. Credit may be granted for scholarly work under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

**Credits:** variable to 6.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

**ED 5530 - Special Studies in Elementary and Middle Methods**

Individual or group studies of specially selected issues or problems in elementary and middle schools methods. Credit may be granted for scholarly work under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

**Credits:** variable to 6.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

**ED 5540 - Special Studies in Education I**

Individual or group studies of specially selected issues or problems in education. Credit may be granted for scholarly work under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

**Credits:** variable to 6.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

**ED 5550 - Special Studies in Education II**

Individual or group studies of specially selected issues or problems in education. Credit may be granted for scholarly work, under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

**Credits:** variable to 6.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

**ED 5560 - Ecology of Isle Royale for Educators**

K-12 teachers participate in a field-based camping experience on Isle Royale National Park, exploring basic ecological concepts regarding the interrelatedness of plants, animals, geology, climate, and human influences on Isle Royale. Prepares teachers to help students understand interrelationships, energy distribution in ecosystems and change over time.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-1-6)

**Semesters Offered:** Summer

**Restrictions:** Permission of department required

**Pre-Requisite(s):** ED 5561(C)

**ED 5561 - Ecology of Isle Royale Practicum for Educators**

Teachers will implement a one-two week teaching unit based on their experiences in ED5560 and assess its impact on learning in their classroom.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** On Demand

**Restrictions:** Permission of department required

**Pre-Requisite(s):** ED 5560(C)

**ED 5600 - Independent Study in Education**

Through an independent study, gain additional insights to relevant topics in education and research. Students must work directly with select faculty to develop a structured line of study on select educational topics.

**Credits:** variable to 6.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

**ED 5601 - Special Content Studies in Education**

Educators' Science and Mathematics Institute Series Courses. Intensive institutes designed to help elementary, middle and high school educators integrate important concepts in math and science into classroom teaching units. New content areas are designed each year to address the needs of participating teachers.

**Credits:** variable to 9.0; Repeatable to a Max of 9

**Semesters Offered:** Fall, Spring, Summer

**ED 5602 - Special Applications in Education**

Educators' Science and Mathematics Institute Series Practicums. Practical application following special content studies during which elementary, middle and high school teachers implement and evaluate a teaching unit that they designed for their own classroom inspired by the previous content course. A mandatory teachers' forum provides opportunity to share ideas with other



participating teachers

**Credits:** variable to 9.0; Repeatable to a Max of 9

**Semesters Offered:** Fall, Spring

### **ED 5603 - Special Topics in Education**

Teachers' Earth Science Institute Courses. Utilizes mineral science and mineral processing to enhance the teaching of science in middle and high school. Teachers will be involved in hands-on, discovery-based activities that integrate concepts in math, physics, and chemistry with elements of social sciences.

**Credits:** variable to 9.0; Repeatable to a Max of 9

**Semesters Offered:** Spring, Summer

### **ED 5620 - Professional Development for Educators: Teaching Earth Science**

A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of earth science. Up to 4 credits in ED5620-5695 may be applied to the M.S. in Applied Science Education.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **ED 5630 - Professional Development for Educators: Teaching Life Sciences**

A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of teaching life science. Up to 4 credits in ED5620-5695 may be applied to the M.S. in Applied Science Education.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **ED 5640 - Professional Development for Educators: Teaching Environmental Science**

A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of environmental science. Up to 4 credits in ED5620-5695 may be applied to the M.S. in Applied Science Education.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **ED 5641 - Global Change Institute for Teachers**

This course will provide teachers with the skills necessary to engage middle/high school students in real-world study of global climate change and its effects on ecosystems. National Content Standards for mathematics, and life, earth, and physical sciences will be addressed.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** Summer

**ED 5650 - Professional Development for Educators: Teaching Physical Science**

A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of physical science. Up to 4 credits in ED5620-5695 may be applied to the M.S. in Applied Science Education.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**ED 5660 - Professional Development for Educators: Teaching Mathematics**

A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of mathematics. Up to 4 credits in ED5620-5695 may be applied to the M.S. in Applied Science Education.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**ED 5665 - Professional Development for Educators: Teaching Computer Science**

A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of computer science. Up to 4 credits in ED5620-ED5695 may be applied to the M.S. in Applied Science Education.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** On Demand

**ED 5670 - Professional Development for Educators: Teaching Technology**

A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of technology. Up to 4 credits in ED5620-5695 may be applied to the M.S. in Applied Science Education.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**ED 5680 - Professional Development for Educators: Teaching Social Studies**

A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of social studies. Up to 4 credits in ED5620-5695 may be applied to the M.S. in Applied Science Education.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**ED 5690 - Professional Development for Educators: Teaching Language Arts**

A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of language arts. Up to 4 credits in ED5620-5695 may be applied to the M.S. in Applied Science Education.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**ED 5695 - Professional Development for Educators: Teaching Business**

A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of business. Up to 4 credits in ED5620-5695 may be applied to the M. S. in Applied Science Education.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**ED 5700 - Science Education Research**

In-depth study of education research methods pertaining to classroom practice, curriculum standards, and program evaluation. Course will include an opportunity to design research to answer questions relevant to classroom teaching and learning. Equivalent to ED 5701 plus ED 5702.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-2-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** ENG 5100

**ED 5701D - Science Education Research Methods**

Study of research methods in science education. Issues of research design, program evaluation, and data presentation will be addressed.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Class(es): Graduate

**ED 5702D - Action Learning and Action Research**

A form of systematic inquiry conducted by teacher researchers to gain insight into how students learn. Use of scientific research projects to teach science in secondary schools. Developing students as communities of science learners.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Class(es): Graduate

**ED 5710 - Measurement and Evaluation in Education**

Survey of measurement and evaluation techniques as they apply to K-12 curriculum. Reviews teacher-made tests and standardized tests. Emphasizes designing and use of quality measurement tools in the classroom.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**ED 5730 - Science Learning Materials, Inquiry and Assessment**

Examination of learning materials that enable inquiry-based learning as prescribed by National Science Education Standards. Assessment techniques to measure this type of learning will be considered. Equivalent to ED 5731 plus ED 5732.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-2-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** ED 5700

**ED 5731D - Science Learning Materials and Inquiry**

Inquiry, as described by the National Science Education standards, will serve as the focus of a survey of learning materials, particularly those that are internet-based. Identification, selection, and evaluation of source materials for teaching science.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Class(es): Graduate

**ED 5732D - Assessing Science Learning**

A survey of alternative and authentic assessment techniques for ensuring consistency, reliability, and fairness in evaluating science learning. Assessment planning techniques reviewed will use both national and state standards as guides to measure outcomes.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Class(es): Graduate

**ED 5740 - Connecting Michigan Science Benchmarks and Research**

Current research and classroom practice will be examined using the Michigan Mathematics and Science Benchmarks. Objective is to further understanding of how goals can promote higher levels of learning. Equivalent to ED 5741 plus ED 5742

**Credits:** 2.0

**Lec-Rec-Lab:** (0-2-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** ED 5700 and (ENG 5200 or ENG 5300)

**ED 5741D - Michigan Benchmarks**

An examination of the Michigan Mathematics and Science Benchmarks from the standpoint of national goals, standardized assessment, and classroom practice.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Class(es): Graduate

**ED 5742D - Research Trends and Classroom Practice**

An exploration of the major issues and applicable research results that apply to the teaching and learning of secondary science and mathematics.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Class(es): Graduate

**ED 5810 - Advance Methods of Teaching Science, Math, and Computer Science**

Application of learning and instructional theories to the teaching of science, mathematics, and computer science. Emphasizes methods of materials used to teach early adolescents. Taught from the perspective of science/math/computer science teachers. Lab offers opportunities to refine instructional techniques. Admission to teacher education required.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-3)

**Semesters Offered:** On Demand

**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

**Co-Requisite(s):** ED 5910

**Pre-Requisite(s):** ED 5110 and ED 5210 and ED 5310 and ED 5410

**ED 5900 - Graduate Research in Education**

Students will conduct a research project/report as a capstone to an approved plan of study. The student should present a project plan to their education advisor for approval, conduct whatever work is necessary for the project, prepare a final report at the conclusion of the project, and defend the project/report in an oral presentation.

**Credits:** variable to 6.0; Repeatable to a Max of 6

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** ED 5700

**ED 5910 - Teaching Internship**

Knowledge of human growth and learning theories, methods and materials, and individual differences applied to classroom settings, conducted under the supervision of an experienced

middle or secondary school teacher. Completion of MTTC Basic Skills Test. See department for application deadlines.

**Credits:** 12.0

**Lec-Rec-Lab:** (0-0-36)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Co-Requisite(s):** ED 5810

**Pre-Requisite(s):** ED 5110 and ED 5210 and ED 5310 and ED 5410

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## **Electrical Engineering**

### **EE 5200 - Advanced Methods in Power Systems**

Advanced analysis and simulation methods for load flow, symmetrical components, short circuit studies, optimal system operation, stability, and transient analysis. Application of commonly used software reinforces concepts and provides practical insights.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 4222

### **EE 5220 - Transient Analysis Methods**

A study of transient behaviors and their analysis and prediction. Addresses analytical methods and their numerical implementation, switching and lightning surges, short circuits, and non-linear effects. Includes computer simulations.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 4222

### **EE 5223 - Power System Protection**

Real-time monitoring and protection of modern power systems. Secure and reliable operation of radial and grid systems. Protection of transmission lines, buses, generators, motors, transformers, and other equipment against disturbances.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**EE 5224 - Power System Protection Lab**

Theory-based application of software and hardware used for power system protection. Fault simulations, protective relay settings and coordination, and test operation of relays under static, dynamic, and transient conditions.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-0-2)

**Semesters Offered:** Spring

**Pre-Requisite(s):** EE 5223(C)

**EE 5230 - Power System Operations**

Study of advanced engineering and economic algorithms and analysis techniques for the planning, operation, and control of the electric power system from generation through transmission to distribution.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**EE 5240 - Computer Modeling of Power Systems**

Topics include modeling and computer methods applied to electrical power systems, matrix formulations, network topology and sparse matrix data structures, loadflow, short-circuit and stability formulations, constrained optimization methods for loadflow and state estimation, and time-domain simulation methods for transient analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Computer Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 5200

**EE 5250 - Distribution Engineering**

Modeling and analysis of electrical distribution systems; load characteristics, load modeling, unbalanced three-phase overhead and underground line models, and distribution transformers. Analysis of over current protection, voltage drop, and power quality.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Computer Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 4221

**EE 5290 - Selected Topics in Power Systems 1**

Selected topics of current interest.

**Credits:** variable to 4.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 5410 - Engineering Electromagnetics**

A mathematically rigorous study of dynamic electromagnetic fields, beginning with Maxwell's equations. Topics include scalar and vector potentials, waves, and radiation.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 3140

### **EE 5420 - Electromagnetic Systems Engineering**

Theory and application of microwave circuits such as filters, couplers, and transmission lines. Includes use of numerical modeling and applications to radar systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 5410

### **EE 5430 - Electronic Materials**

A study of the physical principles, operational characteristics, models, and basic applications of selected solid-state devices.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **EE 5440 - Laser Types, Laser Design, Modeling Techniques, and Nonlinear Optics**

Survey of laser types and analysis of the common physical and engineering principles, including energy states, inversion, gain, and broadening mechanisms. Design issues include resonators, packaging, cooling, pulsed power, and safety. Students will construct computational model that predicts laser performance. Nonlinear optics and selected applications also covered.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering



**Pre-Requisite(s):** EE 3140

**EE 5450 - Modeling of IC Interconnects**

Techniques of modeling phenomena associated with metallic integrated circuit interconnections will be presented. These include parasite elements, propagation delays, crosstalk and electromigration induced failure. Optical and superconducting interconnections will also be reviewed.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**EE 5460 - Solid State Devices**

A study of the physical principles, operational characteristics and models and basic applications of solid state devices such as p-n junctions, metal- semiconductor junctions and transistors.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**EE 5470 - Semiconductor Fabrication**

Graduate level introduction to the science and engineering of semiconductor device fabrication.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**EE 5480 - Advanced MEMS**

This course will cover advanced topics dealing with MEIXIS technologies, transduction mechanisms, and microfabricated sensors and actuators and is a continuation of EE4240/MY4240

**Credits:** 4.0

**Lec-Rec-Lab:** (3-1-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** EE 4240 or MY 4240

**EE 5500 - Statistical Signal Processing**

Focuses on the application of statistical techniques to the study of random signals and noise. Includes random processes in continuous and discrete time and space, second-order properties of random processes, the interaction of random processes with linear systems, parameter estimation,

and the design and implementation of statistical signal-processing algorithms.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 5510 - Information Theory and Coding**

Definition of information and a study of its properties. Channel capacity and error-free communication over noisy channels. Covers encoding, decoding, and encrypting systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 5520 - Fourier Optics**

Analysis and modeling of diffraction effects on optical systems, emphasizing frequency-domain analytic and computational approaches. Presents wave propagation, imaging, and optical information processing applications.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 3190

### **EE 5521 - Detection & Estimation Theory**

Detecting and estimating signals in the presence of noise. Optimal receiver design. Applications in communications, signal processing, and radar.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Computer Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 5520

### **EE 5522 - Digital Image Processing**

Image formation, enhancement, and reconstruction. Applications in medical imaging, computer vision, and pattern recognition.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in

one of the following Major(s): Computer Engineering, Electrical Engineering  
**Pre-Requisite(s):** EE 3190

### **EE 5530 - Wireless Digital Communication**

Detailed study of modulation, transmission, detection and demodulation in wireless digital networks. Emphasizes doppler shift, multipath, beamsteering and current topics.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 5540 - Statistical Optics**

Study of the effects of randomness in optical systems. Covers coherence theory, photon statistics, wave propagation, and imaging through random media. Presents analytic and computational approaches.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 5550 - Optical Information Processing**

Geometric and wave optics. Optical devices with applications in imaging, beamforming, and optical communication systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Computer Engineering, Electrical Engineering, Physics

### **EE 5560 - Multi-user Detection**

Demodulation of mutually interfering digital streams of information that occur in areas such as wireless communications and high-speed data transmission. Design and analysis of receivers for multi-access channels, with focus on fundamental models and algorithms. Topics include optimal multiuser detection and the optimal attainable performance in Gaussian multiuser channels, suboptimal linear multiuser detection, blind and adaptive methods, multiuser receiver for multiple-antenna reception, and the performance measure of asymptomatic multiuser efficiency.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Major(s): Computer Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 5520

**EE 5570 - Communication Networks**

System architectures. Data link control, error correction, and protocol analysis. Message delay, Markov processes, queuing, delays in statistical multiplexing, multiple users with reservations, limited service, priorities. Network delay, traffic flows, throughput analysis. Multiple access networks.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Computer Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 5500(C)

**EE 5580 - Wavelet and Spectral Analysis**

Fourier analysis, wavelet transforms and time-frequency analysis. Applications in signal and image processing.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Computer Engineering, Electrical Engineering

**EE 5610 - Linear Optimal Control I**

Performance analysis in multi-input, multi-output (MIMO) linear feedback systems including internal stability, principle gains and cost functions. Analysis of MIMO systems with random inputs. Stability and performance robustness analysis using singular values and structured singular values. Introduction to the calculus of variations and optimal control. The linear quadratic regulator, the stochastic regulator and their properties.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 5310(C)

**EE 5620 - Linear Optimal Control II**

Linear, mean-square estimation and Kalman filtering. Optimal estimation for colored plant and measurement noise. Linear quadratic Gaussian optimal control, loop transfer recovery and tracking system design. H-infinity optimal control mu-synthesis. Controller order reduction via pole-zero truncation and balanced truncation.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering  
**Pre-Requisite(s):** EE 5610

### **EE 5710 - Current Topics in Computer Engineering I**

Current topics in computer engineering suitable for both computer specialists and non-specialists.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 5711 - Mathematical Techniques for Computer Engineering**

Mathematical theory and methods frequently used in computer engineering research and development. Picks up where undergraduate courses usually stop. Includes selected topics from formal logic, theorem proving, probability, statistics, modeling and simulation. Contains a significant programming component.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** MA 2320 and MA 3520 and (MA 3710 or MA 3720) and CS 2141

### **EE 5715 - Linear Systems Theory and Design**

Overview of linear algebra, Modern Control: state-space based design of linear systems, observability, controllability, pole placement, observer design, stability theory of linear time-varying systems, Lyapunov stability, optimal control, Linear Quadratic regulator, Kalman filter, Introduction to robust control.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** EE 4261 or MEEM 4700 or MA 4330

### **EE 5720 - Current Topics in Computer Engineering II**

Current topics in computer engineering suitable for both computer specialists and non-specialists.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 5722 - Computer Networks**

Focuses on the fundamental network architecture concepts and the core design principles and

issues in the emerging communication/data networks. The course systematically gives students the complete picture of data and computer networks.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore

**Pre-Requisite(s):** (MA 3710 or MA 3720) and EE 2150

### **EE 5723 - Computer and Network Security**

Learn fundamental of cryptography and its application to network security. Understand network security threats, security services, and countermeasures. Acquire background knowledge on well known network security protocols. Address open research issues in network security.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** EE 2150 and (MA 3710 or MA 3720)

### **EE 5725 - Mobile Robotics & Multi-Robot Systems**

Introduction to mobile robotics and multi-robot systems. Introduce spatial description, mobile robot locomotion, kinematics, localization and mapping, motion planning and navigation. Topics in multirobot systems include biological inspirations, control structure, inter-robot communication, learning in multi-robot systems, and modeling and analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** (EE 3160 or EE 4261) and (MA 3710 or MA 3720) and (CS 1129 or CS 2141)

### **EE 5726 - Embedded Sensor Networks**

Introduces the concepts of wireless sensor networks. Topics include sensor network coverage and sensor deployment, time synchronization and sensor node localization, network protocols, data storage and very, collaborative signal processing. Introduce sensor network programming network reliability and tolerance.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** (CS 4461 or EE 4272 or EE 5722) and (EE 3170 or EE 3173) and (CS 1129 or CS 2141)

### **EE 5731 - Real-Time and Embedded Systems**

Theory and practice of building real-time embedded systems with sensors and actuators with real-time operating systems (RTOS) to obtain hard-real-time behavior. The lab class puts theory

into practice.

**Credits:** 4.0

**Lec-Rec-Lab:** (3-0-2)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** EE 3173 and EE 4261

### **EE 5751 - Verilog HDL Design**

Use of Verilog Hardware Description Language (HDL) to model, simulate, and synthesize combinational and sequential digital hardware systems. Emphasis is on developing Verilog models of encryption and authentication cryptographic algorithms.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-2)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** EE 2171

### **EE 5752 - Digital Storage Technologies**

Digital Storage Technologies including solid state memory devices, magnetic and optical disks will be covered. The usage of the available technologies in a microprocessor system memory hierarchy will be explored using architectural simulation tools.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** EE 3173 and EE 3175

### **EE 5755 - Fault-Tolerant Systems**

Covers both the theory and the practice of how to design, model, evaluate, and implement reliable systems out of unreliable components. Includes: Fault Models, Redundancy Management, Agreement, Consensus, Voting, Clock synchronization and reliable broadcast. Material is reinforced with real-world case studies.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CS 3421 and CS 4411 and (EE 3175 or EE 5910)

### **EE 5772 - Parallel Computer Organizations**

The range of multiprocessor computer architecture (CMP & SMP to Deep Blue to Beowulf Clusters) will be examined in conjunction with the communication protocols necessary to enable operation of these machines. Focus of this course will be on the hardware implementation rather

than programming techniques or algorithms.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Class(es): Senior

**Pre-Requisite(s):** EE 3173 and EE 3175

### **EE 5778 - Digital Arithmetic Algorithms and Architecture**

High speed implementations for common digital arithmetic and number crunching functional units will be examined and explained. A variety of SIMD ISA extensions (MMX, 3dNOW, SSE) will be covered together with their compatibility with standard floating point functional units and area impact.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Class(es): Senior

**Pre-Requisite(s):** EE 3173 and EE 3175

### **EE 5805 - Directed Study in Electrical & Computer Engineering**

Directed study on a topic mutually agreed upon by the student and the instructor.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 5900 - Special Topics in Electrical Engineering**

Special topics in electrical engineering selected by the student and approved by his/her advisor and the faculty member who will approve the study.

**Credits:** variable to 5.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 5920 - Power Systems Seminar**

An analytical study of any current high-level problem or series of problems associated with the advance of knowledge in power systems.

**Credits:** 1.0; May be repeated

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering



**EE 5940 - Electrophysics Seminar**

An analytical study of any current high-level problem or series of problems associated with the advance of knowledge in electrophysics.

**Credits:** 1.0; May be repeated

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**EE 5950 - Signals and Systems Seminar**

An analytical study of any current high-level problem or series of problems associated with the advance of knowledge in signals and systems.

**Credits:** 1.0; May be repeated

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**EE 5970 - Computer Engineering Seminar**

An analytical study of any current high-level problem or series of problems associated with the advance of knowledge into computer engineering.

**Credits:** 1.0; Repeatable to a Max of 2

**Lec-Rec-Lab:** (1-0-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Computer Engineering, Electrical Engineering

**EE 5990 - Thesis Research in Electrical Engineering**

Study of some acceptable electrical engineering problem and preparation of a thesis.

**Credits:** variable to 10.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required

**EE 5991 - Project Research in Electrical Engineering**

Study of some acceptable electrical engineering problem and preparation of a report.

**Credits:** variable to 6.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required

**EE 5992 - Practical Experience in Electrical Engineering**

A collaboration with industry on some acceptable electrical engineering task and preparation of a report.

**Credits:** variable to 4.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of department required

**EE 6210 - Power System Dynamics and Stability**

A study of the dynamic behavior of power systems. A review of synchronous machine modeling, system dynamic equations, and method of analysis. Examines overall system behavior via small signal and transient stability and energy functions. Also studies voltage stability and non-linear effects.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**Pre-Requisite(s):** EE 5200

**EE 6290 - Selected Topics in Power Systems 2**

Selected topics of current interest.

**Credits:** variable to 4.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**EE 6460 - CMOS Devices**

An in-depth treatment of field-effect devices.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** EE 5460

**EE 6480 - Thin Films**

Material science of thin films

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**EE 6900 - Advanced Topics in Electrical Engineering**

Advanced topics in electrical engineering selected by the student and approved by his/her advisor and the faculty member who will approve the study.

**Credits:** variable to 5.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

**EE 6920 - Advanced Seminar in Power Systems**

An in-depth study of any problem or series of problems of current importance associated with the advancement of knowledge in power systems.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 6940 - Advanced Seminar in Electrophysics**

An in-depth study of any problem or series of problems of current importance associated with the advancement of knowledge in electrophysics.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 6950 - Advanced Seminar in Signals and Systems**

An in-depth study of any problem or series of problems of current importance associated with the advancement of knowledge in signals and systems.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering

### **EE 6990 - Doctoral Research**

Original research leading to the preparation of a dissertation in partial fulfillment of the requirements for the PhD degree.

**Credits:** variable to 15.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required

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## **Engineering Fundamentals**

### **ENG 5100 - The Engineering Process**

This course introduces the engineering problem solving and design processes. Students will learn about the engineering profession and will complete a design/build/test project.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-2)

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **ENG 5101 - Introduction to Engineering for Educators I**

Course is aimed at inservice teachers to provide them with an introduction to the engineering

profession.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-0-6)

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **ENG 5102 - Introduction to Engineering for Educators II**

Course aimed at inservice teachers to provide them with further exposure to engineering applications in math and science.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-0-6)

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** ENG 5101

### **ENG 5200 - Engineering Applications in the Physical Sciences**

This class will show how engineers use principles from the physical sciences to solve problems and design systems. Key concepts will be linked to the Michigan Curriculum Frameworks for precollege education.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-2)

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** ENG 5100

### **ENG 5201 - Introduction to Engineering in the Physical Science I**

Course aimed at inservice teachers to provide them with exposure to engineering applications in the Physical Sciences.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-0-6)

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **ENG 5202 - Introduction to Engineering in the Physical Sciences II**

Course aimed at inservice teachers to provide them with further exposure to engineering applications in the Physical Sciences.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-0-6)

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** ENG 5201

### **ENG 5300 - Engineering Applications in the Earth Sciences**

This course will show how engineers use principles from the earth sciences to solve problems and design systems. Key concepts will be linked to the Michigan Curriculum Frameworks for precollege education.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-2)

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** ENG 5100

### **ENG 5301 - Introduction to Engineering in the Earth Sciences I**

Course aimed at inservice teachers to provide them with exposure to engineering applications in the Earth Sciences.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-0-6)

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **ENG 5302 - Introduction to Engineering in the Earth Sciences II**

Course aimed at inservice teachers to provide them with further exposure to engineering applications in the Earth Sciences.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-0-6)

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** ENG 5301

### **ENG 5510 - Sustainable Futures I**

Covers introductory and intermediate concepts of Sustainable Development. Explores methods/tools for assessing sustainability (economic, environmental, societal impacts) of current and emerging industrial technologies. Explores relationships between government policies and markets for introducing sustainable technologies into national economies and corporations.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore

**Pre-Requisite(s):** UN 2002

### **ENG 5520 - Sustainable Futures II**

Covers sustainability in developed and developing countries. Topics include policy analysis, regulatory impact & cost benefit analyses, trade & markets, laws & regulations, international disasters, GIS applications, green manufacturing, and evolution of environmental policy in U.S. and other countries.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**ENG 5530 - Graduate Colloquium in Sustainability**

Introduces students to general and specific issues related to sustainability. Topics include review and discussion of historical readings that define the movement towards sustainability, international issues related to sustainable development, corporate leadership, consumption, and societal issues.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**ENG 5900 - Engineering Internship for Educators**

Students will work in an industry or research internship during summer months with an engineer. At the conclusion of the internship, students will write a paper regarding how they will apply what they have learned in their pre-college classroom.

**Credits:** variable to 6.0

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** ENG 5100

**ENG 5998 - Engineering Design Practicum**

An advanced independent study for students in the Master of Engineering program. In consultation with his/her advisor, the student develops and executes a project demonstrating capabilities in problem solving, communications, and decision making. The practicum can be completed on or off campus.

**Credits:** variable to 4.0; Repeatable to a Max of 4

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering

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**Forest Resources & Env Science**

**FW 5020 - Identification & Biology of Forest Vegetation**

Emphasis will be placed on survival and regeneration strategies of forest vegetation. Includes systematic study of the major forest vegetation types of North America. An independent project component may be required.

**Credits:** 2.0

**Lec-Rec-Lab:** (1-0-3)

**Semesters Offered:** Fall

**FW 5024 - Advanced Wood Preservation**

Covers mechanisms of fungal degradation of wood; chemistry and formulation of modern wood preservatives used worldwide; and environmental aspects of wood preservation.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** FW 4024

**FW 5030 - Forest Measurement & Assessment**

Techniques used to measure a wide range of forest ecosystem attributes. Includes overstory and understory vegetation measurement and land measurement. Emphasis will be placed on statistically based sampling designs. An independent project component may be required.

**Credits:** 2.0

**Lec-Rec-Lab:** (1-0-3)

**Semesters Offered:** Fall

**FW 5050 - Current Topics in Forest Biotechnology**

Current topics in forest biotechnology. Could include micropropagation of young and old trees, anther culture, genetic engineering via agrobacterium and biolistics, and environmental concerns about the commercial use of forest biotechnology. Aspen and larch are used for labs, focusing on sterile technique, micropropagation, and genetic engineering.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-3)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5068 - Advanced Wood Composites**

In-depth analysis of the influence of material and processing parameters on the physical and mechanical properties of wood composite products. Applied surface sciences. New developments and special topics.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5070 - Developmental and Ecological Genetics**

Course will provide current knowledge on signal perception, transduction and response pathways in higher eukaryotes with most examples primarily from but not limited to plants in a lecture and colloquium format. Topics will cover major developmental pathways, and molecular bases of adaptation to biotic and abiotic factors.

**Credits:** 3.0

**Lec-Rec-Lab:** (1-2-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** BL 5030

**FW 5080 - Gene Profiling Analysis**

Advanced training in modern molecular techniques with an emphasis on gene expression analysis. Discussion of various gene profiling methods and their applications. Hands-on laboratory exercises and data analysis.

**Credits:** 2.0; Graded Pass/Fail Only

**Lec-Rec-Lab:** (0-1-3)

**Semesters Offered:** Spring

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**FW 5085 - Functional Genomics and Biotechnology**

Fundamentals and practical applications of functional genomics tools in biological research. Topics include transcript profiling, regulation of gene expression, mechanisms of gene silencing, genetic transformation, and high throughput DNA microarray and metabolic profiling technologies.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**FW 5088 - Forest Finance & Economics**

Financial analysis and economic theory applied to forestry project analysis and selection, focusing on prices. Covers risk, regional economics, taxation, auctions, and non-market valuation. Applies operations research and statistical concepts to solve resource use problems. Includes critical evaluation of published literature.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-2)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5089 - Tools of Bioinformatics**

Computer applications in molecular biology. Hands-on experience with using popular computer programs for DNA, RNA and protein sequence analysis, database management, data editing, assembly, and organization, multiple sequence comparisons, protein structural analysis, evolutionary relationships of genes, use of Internet for data retrieval, comparison and analysis.

**Credits:** 4.0

**Lec-Rec-Lab:** (2-1-2)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5100 - Advanced Terrestrial Ecology**

Structure and function of terrestrial ecosystems. Roles of ecotypic variation, animals, natural



disturbance, biological diversity, management, and global change on plant community dynamics and ecosystem processes.

**Credits:** 4.0

**Lec-Rec-Lab:** (3-0-2)

**Semesters Offered:** Spring

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **FW 5110 - Advanced Natural Resource Policy**

Covers advanced concepts related to policy and natural resources. Offers a survey of natural resource policies and organizations special attention to natural forest policies. State and federal levels of policy making will be linked to the human values, attitudes, and beliefs that set the context for natural resource policy processes.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-1-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **FW 5115 - Restoration Ecology**

Study the tools, challenges, and philosophical underpinnings associated with ecological restoration. Restoration of forest grassland communities (plant and animal) will be discussed.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **FW 5120 - Ecophysiology of Forest Productivity**

Examines how changes in resource availability and environment affect forest productivity through ecological and physiological responses expressed at molecular, whole plant, and ecosystem scales. Topics include carbon acquisition, carbon loss, nutrient acquisition, growth and allocation, forest hydrology and net ecosystem productivity.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **FW 5130 - Forest Vegetation Dynamics**

Investigation of how trees grow and interact in a variety of stand structures from a functional standpoint at both the tree- and stand-level. These principles will be used to test the use of silvicultural management tools for meeting a variety of objectives. Linkages will be made between stand development patterns and management options, with an emphasis on disturbance ecology.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-1-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore  
**Pre-Requisite(s):** FW 3020 or FW 3010 or BL 3400 or FW 3012

**FW 5150 - Advanced Natural Resource Policy Analysis**

This course focuses on student performance and understanding of advanced natural resource policy analysis related to federal land management decision making.

**Credits:** variable to 3.0; Repeatable to a Max of 3

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): Sch of Forest Res & Envir Sci

**FW 5160 - Operations Research in Natural Resource Management**

Forestry applications of operations research methods. Includes linear, mixed integer, separable, and dynamic programming and their application to renewable resource management and wood products manufacturing situations. Emphasizes problem formulation and case studies.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** FW 4150

**FW 5221 - Advanced Wetland Science**

Advanced study in wetland ecology concentrating on theoretical and technological advances. Readings will pertain to major topics in wetland ecology: hydrology, soils, vegetation, biogeochemistry, and ecological characteristics of different wetland types.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5350 - Soil Biology**

Ecology of soil microorganisms and fauna and their roles in soil organic matter decomposition and nutrient cycling.

**Credits:** 4.0

**Lec-Rec-Lab:** (3-1-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** FW 3330 or BL 3210

**FW 5376 - Advanced Forest and Environmental Resource Management**

Application of forest and environmental management practices and topical investigations by teams of students with the assistance of faculty, staff and representatives of state, federal and corporate land management groups as well as non-governmental organizations.

**Credits:** variable to 4.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor and department required; Must be enrolled in one of the following Level(s): Graduate

**FW 5400 - Advanced Conservation Biology**

This course examines the biology that underlies our attempts to conserve genetic, species, and community diversity. Discussion will include current issues from the primary literature and applications to student research projects.

**Credits:** 4.0

**Lec-Rec-Lab:** (4-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5410 - Analysis of Natural Resource Data**

Theory, application, and interpretation of quantitative methods for the analysis of ecological data, including techniques used in developing and using quantitative management tools.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MA 5701

**FW 5411 - Applied Regression Analysis**

Regression as a tool for the analysis of forest and environmental science data. Topics include multiple linear, curvilinear and non-linear regression, hierarchical and grouped data and mixed-effects models. Emphasis is placed on application of tools to real-world data.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5510 - Special Topics in Natural Resources**

Independent study of a specific area of natural resources.

**Credits:** variable to 9.0; Repeatable to a Max of 9

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5550 - Geographic Information Systems for Resource Management**

Use of geographic information systems (GIS) in resource management. Studies various components of GIS in detail, as well as costs and benefits. Laboratory exercises use ArcMap, ArcView, and ArcInfo software packages to solve resource management problems.

**Credits:** 4.0

**Lec-Rec-Lab:** (3-0-3)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore,

Junior

**Pre-Requisite(s):** MA 2720 or MA 2710 or MA 3710

**FW 5560 - Digital Image Processing: A Remote Sensing Perspective**

Presents the theory and quantitative procedures of digital image processing using remotely sensed data. Emphasizes image acquisition, preprocessing, enhancement, transformation classification techniques, accuracy assessment, and out-products. Discusses linkages to GIS. Also covers evaluating applications of the technology to current resource management problems via peer-reviewed literature.

**Credits:** 4.0

**Lec-Rec-Lab:** (3-0-3)

**Semesters Offered:** Spring

**Restrictions:** Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**FW 5600 - Advanced Insect Ecology**

An advanced examination of insects as a highly successful group of organisms which are involved in a myriad of interactions in terrestrial and aquatic ecosystems. This course will include study of some of the unique mechanisms that insects have evolved to overcome challenges facing them in different environments.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-1-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5641 - Global Change Institute for Teachers**

This course will provide teachers with the skills necessary to engage middle/high school students in real-world study of global climate change and its effects on ecosystems. National Content Standards for mathematics and life, earth and physical sciences will be addressed.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Summer

**FW 5700 - Graduate Field Forestry**

For graduate students without an undergraduate degree in forestry or a closely related field. Covers field skills in mapping/GPS work, forest diseases and insects, wildlife, timber harvesting, natural resource inventory, and silviculture.

**Credits:** 8.0

**Lec-Rec-Lab:** (3-0-15)

**Semesters Offered:** Fall

**FW 5701 - Graduate Field Applied Ecology**

Field skills in mapping/GPS work, forest diseases and insects, wildlife, vegetation

geomorphology, natural resource inventory and silviculture for graduate students without an undergraduate degree in environmental science or a closely related degree.

**Credits:** 8.0

**Lec-Rec-Lab:** (3-0-15)

**Semesters Offered:** Fall

### **FW 5710 - Trees in Agricultural Systems**

Farm systems analysis and the role of trees in tropical farming systems. Also covers specific material on soil conservation and tropical crops.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **FW 5720 - International Forestry Seminar**

Seminar for students who have completed FW5730. Synthesizes field work in a theoretical framework. Covers macro aspects of development theory.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** FW 5730

### **FW 5730 - Field Work in International Forestry**

Field work and reporting from students in the Peace Corps Loret Miller Ruppe Masters International Program in Forestry.

**Credits:** 1.0; May be repeated

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **FW 5740 - Overseas Research**

An introduction to conducting research overseas. Covers scientific methods, ethics, and responsibilities in other cultures, social research, and research development.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **FW 5760 - Graduate Tropical Forestry**

Fundamental ecological processes in tropical forests, traditional use including tenure, current

problems and solutions to those problems.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-2-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5770 - Rural Community Development Planning and Analysis**

Context, analysis, and monitoring of development processes of rural communities in tropical countries.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**FW 5800 - Master's Graduate Seminar**

Presentation by students of current forest resource- related problems and research. Some instruction on presentation skills.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5810 - Research Methods in Natural Resources**

Overview of science and scientific research, research problem selection, study plan and proposal preparation, with literature review and scientific hypothesis testing. Students prepare a proposal or paper on their individual research and go through a peer review of their proposal/ paper.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 5850 - Effective Grantsmanship Workshop**

Ability to write successful grant application is an important part of graduate education. Students will learn basic techniques of grant writing for federal, industrial, and international funding agencies and will submit a well-organized proposal for peer review in the class.

**Credits:** 1.0

**Lec-Rec-Lab:** (1-0-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**FW 5998 - Forest Resources and International Forestry Master's Research**

An original investigation in theoretical or experimental natural resources and submission of a thesis or report in partial fulfillment of the requirements of the Master of Science degree conducted while in a Peace Corps program.

**Credits:** variable to 9.0

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): Sch of Forest Res & Envir Sci

**FW 5999 - Forest Resources and Environmental Science Master's Research**

An original investigation in forest science, ecology, and forest molecular genetics that culminates in a Master's degree.

**Credits:** variable to 15.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 6800 - Doctoral Graduate Seminar**

A seminar course in which current forest resource related problems and research are presented by students in the class. Some instruction on presentation skills.

**Credits:** 1.0; Repeatable to a Max of 2

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 6980 - Graduate Teaching**

Development of teaching skills through assisting in instruction. Students gain experience in course organization, lecture and laboratory instruction, and laboratory preparation.

**Credits:** variable to 4.0; Repeatable to a Max of 4; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**FW 6999 - Forest Resources and Environmental Science Doctoral Research**

An original investigation in theoretical or experimental natural resources and submission of a dissertation in partial fulfillment of the requirements of the PhD degree.

**Credits:** variable to 15.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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**Geolog. & Mining Engrg & Sci.**

**GE 5001 - Intercultural Natural Hazards Communication in Latin America**

Perception of risk and hazards in Latin American cultures. Available technology for mitigation and its practicality and perception. Working effectively with hazard agencies. How to measure mitigation effectiveness. Indigenous and European over prints in Latin American life.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-2-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore

**GE 5040 - Evolution of Structures in Deformed Rock**

How rocks deform on a microstructural to hand specimen scale. Topics include dislocations, work hardening and recovery processes, annealing and recrystallization, slip systems, preferred orientation mechanisms, and foliation development, with independent project on selected topic.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5050 - Structural Analysis and Interpretation**

Analysis of deformed rock structures from hand specimen to outcrop and map scales. Topics include mechanics of cleavage development and folding, shear zones and vorticity, strain measurement, style group analysis, overprinting relationships, mapping and hemispherical projection techniques.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5100 - Advanced Geomorphology and Glacial Geology**

In-depth study of surficial processes that shape landforms and determine the composition and character of the Earth's surface. Processes studied include glacial, fluvial, wind, mass movement, and wave action. Emphasizes the role of past and present climate. In-depth report and presentation on two separate topics required.

**Credits:** 4.0

**Lec-Rec-Lab:** (3-0-3)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** GE 2000

**GE 5110 - Sequence Stratigraphy**

The study of sedimentary rocks interpreted as a series of packages separated by time-significant surfaces. Also examines the processes controlling generation of the time-significant surfaces (eustasy, tectonics, and sediment supply).

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5120 - Basin Analysis**

The evolution of sedimentary basins is influenced by the tectonic mechanisms that initially form the basin, the sediments that are deposited in the basins (composition and environments), and post-depositional processes (thermal, hydrologic, chemical and tectonic) that modify the basin fill. Course examines sedimentary basins as a record of past events.



**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **GE 5130 - Geology of the National Parks: Field Experience**

A two-week, field-based course taught in National Parks Course requires a project and special assignments. Lab fee costs dependent upon location.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-4-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **GE 5140 - Paleoclimatology**

This course will investigate the geologic evidence of global climate and the mechanisms that are interpreted to produce climate change.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

### **GE 5150 - Advanced Natural Hazards**

Exploration of how to develop comprehensive plans to mitigate the impact of natural hazards on humans. Requires a project and report.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-3)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **GE 5180 - Volcanology**

Volcanoes and how they work. Volcanic products, their recognition, and significance. Applies chemistry, physics, and fluid mechanics in a volcanological context.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **GE 5185 - Special Topics in Volcanology**

A special offering class devoted to an advanced topic in volcanology of topical interest, such as Megaeruptions, Convergent Plate Boundary volcanism or Volcanic Landslides. The class will be built around lectures from 6 different universities, linked via videoconferencing.

**Credits:** 2.0; May be repeated

**Lec-Rec-Lab:** (1-1-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Major(s): Geological Engineering, Geology, Geophysics; May not be enrolled in one of the following Class(es): Freshman,

Sophomore

**GE 5187 - Volcanological Field Seminar**

Field Seminars of 1-3 weeks to volcanological sites of interest. These are offered in association and following GE5185. The field seminars are complemented by the preceding semester's classes, which examine the broad context of the field events. The two classes may be taken together as 4 credits or separately.

**Credits:** 2.0; May be repeated

**Lec-Rec-Lab:** (0-0-6)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Major(s): Geological Engineering, Geology, Geophysics; May not be enrolled in one of the following Class(es): Freshman, Sophomore

**GE 5190 - Volcanic Hazards**

Historic and current volcanic hazards and crises are studied including roles of scientists and engineers, public responses, impacts of volcanic emissions, medical aspects, the use of technology to mitigate the hazards, and the potential impacts of global scale events.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-1)

**Semesters Offered:** Fall

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Class(es): Graduate

**GE 5200 - Advanced Geochemistry**

Elements of modern geochemistry, including aqueous solutions, isotopes, age dating, etc., with an emphasis on concepts and quantitative methods. Project and report required.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-1-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5210 - Advanced Applied Geochemistry**

Monitoring techniques, collection of field data, processing, and analysis of geochemical data to study near-surface environmental systems. Project and report required.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-3)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5220 - Aqueous Geochemistry**

Introduction to quantitative methods in aqueous geochemistry with emphasis on calculation of aqueous equilibria relevant to natural systems such as carbonate equilibria.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-1-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **GE 5270 - Volcanic Clouds**

Synthesis of recent advancements in volcanic cloud research along with theoretical background and practical experience in the study, understanding and remote sensing of volcanic clouds. Techniques covered are also applicable to other atmospheric phenomena although volcanic ash, gas and aerosol remote sensing is the main focus.

**Credits:** 4.0; Repeatable to a Max of 8; Graded Pass/Fail Only

**Lec-Rec-Lab:** (2-0-6)

**Semesters Offered:** On Demand

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **GE 5300 - Clay Mineralogy and X-ray Diffractometry**

The identification of clay minerals using X-ray diffractometry methods. Reviews clay mineral structures, chemistry, and physical properties and demonstrates applications in diagenesis, petroleum geology, weathering/soils, and sedimentation.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-3)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **GE 5400 - Global Geophysics and Geotectonics**

Plate tectonics and the internal structure of the earth using information from seismology, geomagnetism gravity, and heat flow. A term project/report is required.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** (MA 3150 or MA 3160) and PH 2200 and (GE 2000 or GE 2200)

### **GE 5405 - Geophysics for Archaeology**

Principles and practice of non-invasive archaeological geophysics (remote sensing) such as magnetometry, ground penetrating radar and resistivity. Data interpretation will involve basic computation, contouring, three-dimensional visualization programs, interpretation and archaeological significance. Activities include fieldwork, data analysis and presentation, and short reports. The mathematical content of the class will be minimal.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-1)

**Semesters Offered:** Fall

### **GE 5415 - Matlab for Geosciences**

Matlab programming as applied to graphing single and multiple one-dimensional data sets, contouring two- dimensional data sets, slice and movie presentations of three-dimensional data

sets, loading data, convolution, cross and autocorrelation and frequency analysis, specialized computations for geophysics and geology.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-1)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Major(s): Applied Geophysics, Geological Engineering, Geology; May not be enrolled in one of the following Class(es): Freshman, Sophomore

### **GE 5450 - Potential Field Theory in Gravity and Magnetic Applications**

The fundamentals of potential theory and the application to gravity and magnetic studies of the crust and lithosphere. Topics include Newtonian & magnetic potential, magnetization, regional gravity fields, the geomagnetic field, forward & inverse modeling. Fourier-domain modeling and transformations.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MA 3160 and PH 2200 and GE 3040

### **GE 5500 - Paleomagnetism and Environmental Magnetism**

Origin and interpretation of the natural remanent magnetism in rocks and its use in deciphering the geologic past. Applications studied are plate tectonic movements, environmental change, stratigraphic correlation, and the earth's magnetic field.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** GE 2000

### **GE 5600 - Advanced Reflection Seismology**

Principles and application of reflection seismic techniques. Includes acquisition, data processing, and 2D/3D data interpretation. Project and report required.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-1-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **GE 5610 - Quantitative Reservoir Characterization**

Develop and integrate several aspects of reservoir characterization using data from actual oil and gas fields. The various aspects include well logs, seismic data, production data, and geologic/outcrop inference. Geostatistical routines and integrated software suites.

**Credits:** 3.0

**Lec-Rec-Lab:** (1-2-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5650 - Special Topics in Petroleum Geology**

The study of current topics in petroleum geology. Research papers and reports are required.

**Credits:** variable to 4.0; Repeatable to a Max of 8

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5760 - Advanced Engineering Evaluation of Mineral Deposits**

Analysis and design of programs to explore and evaluate various types of mineral deposits. An integrated project includes factors such as geological characteristics, economics, regulations, and environmental impact. Requires an independent project on an approved topic.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-3)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5770 - Mineral Deposit Exploration Models**

Systematic study of the characteristics, distribution, and origin of economic metallic and nonmetallic mineral deposits, and the development of models for exploration with emphasis on selected deposits. Laboratory stresses the study of mining districts and development of exploration and genetic models.

**Credits:** 4.0

**Lec-Rec-Lab:** (3-0-3)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** GE 2300 and GE 2310

**GE 5780 - Exploration and Environmental Geochemistry**

Application of geochemical data collection and analysis to the exploration of metallic and nonmetallic mineral deposits and evaluation of environmental consequences of extraction.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** GE 3200

**GE 5800 - Mathematical Modeling of Earth Systems**

Introduction to numerical techniques for mathematical modeling of various earth-system phenomena, including groundwater flow, heat transfer, and atmospheric transport. Numerical techniques covered include finite-difference, finite-element, collocation, and characteristic methods. Students write their own mathematical models. Prerequisite: experience in programming computer languages such as FORTRAN.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5810 - Flow and Transport in Subsurface Systems**

Analysis of fluid flow in geologic materials, including groundwater flow, solute and contaminant transport, heat flow, and petroleum movement. Develops fundamental transport equations and numerical methods for solving these equations.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5850 - Advanced Groundwater Engineering and Remediation**

Computer modeling and other advanced topics in the analysis hydrological systems, contaminant transport and fate, and subsurface remediation systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-3)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Class(es): Graduate

**GE 5900 - Geological Engineering Seminar**

Seminar course dealing with geological subjects of current interest.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5910 - Geology Seminar**

Seminar course dealing with geology subjects of current interest.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5920 - Geophysics Seminar**

Seminar course dealing with geophysics subjects of current interest.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 5930 - Special Topics in Geological Engineering**

Study and discussion of geological engineering topics.

**Credits:** variable to 9.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**GE 5940 - Special Topics in Geology**

Study and discussion of geology topics.

**Credits:** variable to 9.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**GE 5941 - Special Topics in Mineralogy**

The study of special topics in mineralogy using the Seaman Mineral Museum.

**Credits:** variable to 3.0; Repeatable to a Max of 6

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**GE 5950 - Special Topics in Geophysics**

Study and discussion of geophysics topics.

**Credits:** variable to 9.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**GE 5960 - Special Topics in Mining Engineering**

Study and discussion of mining engineering topics.

**Credits:** variable to 9.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**GE 5994 - International Geological Practicum**

Geological field work outside of the U.S. used by Peace Corps Master International students during their field assignments. May be used repeatedly up to 12 credits.

**Credits:** 1.0; Repeatable to a Max of 12

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Major(s): Geological Engineering, Geology, Geophysics

**GE 5998 - International Geology Master's Research**

An original investigation in theoretical or experimental natural geological hazard mitigation and submission of a thesis or report in partial fulfillment of the MS degree conducted while in the Peace Corps Program.

**Credits:** variable to 9.0

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering

**GE 5999 - Master's Graduate Research**

Research of an acceptable geological engineering, mining engineering, geology, or geophysics problem and preparation of a thesis.

**Credits:** variable to 15.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**GE 6999 - Doctoral Graduate Research**

Original research of an acceptable geological engineering, mining engineering, geology, or geophysics problem and preparation of a PhD dissertation.

**Credits:** variable to 15.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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**Humanities**

**HU 5001 - Proseminar in Rhetoric and Technical Communication**

An introduction to the issues, goals, and scholarly methods across the disciplinary areas represented in the Rhetoric and Technical Communication Program.

**Credits:** 1.0; Repeatable to a Max of 5

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

**HU 5002 - Rhetoric, Composition and Literacy Studies**

This course considers key theoretical, pedagogical, and historical issues and events that have linked the fields of rhetoric, composition, and literary studies.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

**HU 5003 - Technical Communication and Technology Studies**

This course considers key historical, pedagogical, and theoretical issues in technical communication, scientific communication, and technology studies. Considerable attention is paid to the practice and critique of technical communication and technology in academic and non-academic settings.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)



**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

### **HU 5004 - Communication in Cultural Contexts**

This course considers key issues in how cultural contexts and processes of communication affect representation, understanding, and practice.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

### **HU 5005 - Knowledge and Inquiry in the Humanities**

This course considers a range of methods, methodologies, and approaches to research that inform scholarship in RTC program. Approaches may include qualitative, ethnographic, quantitative, rhetorical, feminist, historiographic, hermeneutic, literary, and interpretive methods.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

### **HU 5010 - Organizational Communication**

Theoretical review of the role of communication in organizations. Emphasizes critical interpretive approaches.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5011 - Technology, Culture and Communication**

Examines philosophical and theoretical concepts for understanding the cultural role of technology such as causality, determinism, progress, identity, agency, articulation, assemblage, social space, control, and change.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5012 - Communication Theory**

Traces the development of communication theories. Emphasizes interactions among theoretical, political, historical, and socio-cultural factors.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5020 - Composition Theory**

An introduction to such issues in composition theory as the relationships of thought to language, of spoken to written language, of reading to writing, of writing to learning, and of process to product.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5021 - Literacy Theory and Research**

A study of the social, cultural, and ideological implications of literacy practices using a variety of historical, theoretical, and ethnographic accounts.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5030 - Linguistic Analysis**

The study of linguistic theories and methods for analyzing oral, written, and/or electronic texts. Topics may include how societies construct and are constructed through language; gender, ethnicity, power, class, and region in sociolinguistic variation; theories of discourse; pragmatics; semantics; and methods, ethics, and coding in data collection and analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5040 - Reading Literature**

An introduction to theoretical perspectives on the reading of literature in the context of considerations of particular literary texts. Will also include some discussion of the reading of nonliterary texts.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5050 - Intercultural Communication**

A critical examination of cross-language and cross-cultural equivalences and differences through the study of acculturation, values, traditions, role expectations, perceptions, stereotypes, and gender issues as well as other verbal and nonverbal problems and issues of communication. Emphasizes the dimensions of communication within a comparative cultural context.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5060 - Issues in Social, Political, and Legal Philosophy**

An introduction to diverse issues in social, political and legal philosophy. Topics may include the justification of social and political institutions, liberalism and its critics, democracy and consent, analysis of basic political and legal concepts, the nature of law and legal interpretation, critical evaluation of legal practices and theories.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5070 - History and Theory of Rhetoric I**

History and theory of rhetoric, focusing on ancient times but extending into the Middle Ages.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5071 - History and Theory of Rhetoric II**

History and theory of rhetoric, focusing on modern times but extending back to the Renaissance.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5080 - Computer Applications in Technical Communication**

An examination of how industry and educational institutions employ computers to create, design, and distribute information. Emphasizes such topics as interactive computer-assisted instruction, computerized telecommunications, word processing, document design, and graphics.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5081 - Writing Applications in Technical Communication**

A writing-intensive course focusing on special writing assignments for professional technical communicators, such as company annual report narratives and internal magazine articles, especially articles focusing on scientific and technical research.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5090 - Writing Literary Nonfiction**

Writing and editing nonfiction for publication in Blue Ice Anthology, a general interest journal

published in the Department of Humanities. Course includes study of theory and techniques of literary nonfiction

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5091 - Writing for Publication**

Practice in writing to the requirements of professional publications and in identifying the rhetorical considerations of writing for different publications.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5092 - Grammar and Editing for Professionals**

An examination of the text-based decisions professional editors make as they prepare manuscripts for publication. Through practice on real documents, students obtain strategies for text editing, acquire a professional vocabulary for communicating effectively with authors, and sharpen their grammar and proofreading skills.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5100 - Qualitative or Quantitative Humanistic Research**

Course addresses qualitative or quantitative methods. Field methods in the humanities include the three foundations of qualitative methods; participant observation, interviews, and cultural text analysis. Quantitative methods of inquiry include philosophical foundations of empirical research, structure of quantitative inquiry, modes of observation, and data analysis. Students conduct preliminary research projects.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5110 - Backgrounds of Critical Theory**

Study of major critical theories that have influenced contemporary theories such as feminist theory, postmodern theory, cultural studies, critical pedagogy, and discourse theory. Focuses on primary texts in Marxist theory, structuralism, poststructuralism, and phenomenology, and introduces students to the challenges of reading theoretical texts and texts in translation.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5111 - Critical Perspectives on the Environment**

Philosophical, rhetorical, literary, or cultural studies approaches to the environment. Topics may include environmental communication and advocacy; environmental ethics, law, and philosophy; environmental literary texts; etc.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5112 - Critical Perspectives on Science and Technology**

Philosophical, rhetorical, literary, or cultural studies perspectives on science and technology. Topics may include philosophy of science, philosophy of technology, rhetoric of science, rhetoric of technology, etc.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5113 - Cultural Studies**

Introduction to the theoretical history, methods, and practice of cultural studies. Includes the influence of literary humanism, Marxism, structuralism, subcultural studies, feminism, postmodernism, articulation theory, Deleuze and Guattari.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5114 - Introduction to Visual Representation**

A critical survey of selected theoretical, philosophical, and methodological issues that inform various disciplinary perspectives on the study of the visual, such as sociology, film and television theory, communication, and art history.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5115 - Literacy, Technology, Society and Education**

Examines the linkage between technology and literacy in the U.S. and the ways in which this linkage has been established in public schools, workplace programs, or university settings.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 5116 - Rhetorics of Difference/Alterity**

A critical examination of discourses, theories, and representations of otherness or difference

according to race, gender, sexuality, class, age, nationality, ethnic background, and other socio-cultural categories. May include discussion of issues of self-representation within and among groups, the rhetorics of exile or diaspora, colonial and postcolonial constructions of identity.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5117 - Theories of Language**

Study of major theories of language that have influenced contemporary work on discourse, language, and literacy. Focuses on language theorists from one or more of a variety of disciplines, such as philosophy, linguistics, literary studies, psychology, anthropology, and rhetoric.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5118 - Theories of Pedagogy**

Contemporary theories of pedagogy that influence current approaches to teaching writing, including feminist pedagogy, critical pedagogy, liberatory pedagogy, and psychological and developmental approaches to pedagogy.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5900 - Independent Study**

Guided research under the direction of a member of the graduate faculty. Open to advanced master's students in RTC only. Students must meet with their supervising instructor and receive approval of their study plan from the Director of RTC before registering.

**Credits:** variable to 6.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

### **HU 5901 - Directed Reading**

Directed reading in a focused area under the direction of a member of the graduate faculty, open to advanced MS students in RTC. Students must file a plan of study and receive approval from the supervising faculty and the Director of RTC before registering.

**Credits:** variable to 6.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

### **HU 5902 - Internship**

Work experience under the direction of a member of the graduate faculty, for advanced MS

students. May be conducted on or off campus. Work off campus requires additional direction by an off-campus supervisor. Students must receive approval from their supervising instructor and the Director of RTC before registering.

**Credits:** variable to 6.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

### **HU 5931 - Oral, Written and Visual Communication Pedagogies**

A study of pedagogical techniques, technologies, evaluation, and assessment. Topics may include practical strategies and theories of rhetorical analysis, reflective speaking practices, critical visual design, and composition. GTAs in the RTC program in their first year of teaching are required to enroll in two consecutive semesters of this course.

**Credits:** 2.0; Repeatable to a Max of 4

**Lec-Rec-Lab:** (0-1-1)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5932 - Practicum in Teaching Technical Communication**

GTAs who teach undergraduate classes in technical and scientific communication meet weekly to discuss strategies for teaching the course, to read pertinent material, and to develop policy.

Veteran GTAs mentor GTAs new to the course.

**Credits:** 2.0; Repeatable to a Max of 4

**Lec-Rec-Lab:** (0-1-1)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5933 - Practicum in Modern Language Pedagogy**

Discussion and development of effective pedagogical practices and reading of research, scholarship, and theory of modern language pedagogy. GTAs will observe modern language classes regularly and reflect on their own and others' practices. Required of all GTAs in the RTC program in their first year of language teaching at MTU.

**Credits:** 2.0; Repeatable to a Max of 4

**Lec-Rec-Lab:** (0-1-1)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **HU 5990 - Thesis**

Individual research or scholarship under the direction of a graduate faculty advisor. Open to students in the master's program in rhetoric and technical communication. Students must meet with their advisors before registering.

**Credits:** variable to 10.0; Repeatable to a Max of 10; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

**HU 5991 - Special Projects**

Individual projects under the direction of a graduate advisor. Open to master's students in RTC only. Students must meet with their advisors before registering.

**Credits:** variable to 6.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

**HU 6001 - Special Topics in RTC**

The study of special topics within or across the areas of rhetoric, technical communication, and the humanities.

**Credits:** variable to 3.0; Repeatable to a Max of 9

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6010 - Special Topics in Communication**

In-depth examination of topics in communication.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6020 - Special Topics in Composition**

In-depth examination of theoretical perspectives on composing. May include discussion of current-traditional, expressivist, social constructionist, and postmodern perspectives.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6040 - Special Topics in Literature**

Advanced study of topics in American, British, and world literature.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6050 - Special Topics in Modern Languages and Literatures**

Advanced study of topics in modern languages and literatures. May include intercultural studies of non-English literature and film around an integrated theme; the study of non-English fiction and non-fiction with attention to theoretical and critical approaches; or more applied studies such as language for special purposes, second-language acquisition, and translation.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand



**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6060 - Special Topics in Philosophy**

Advanced study of selected topics in philosophy. Possible topics include philosophy of literature, philosophy of mind, continental European philosophy, analytic philosophy, theories of truth, philosophical issues in cognitive science, and contemporary feminist philosophy.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6070 - Special Topics in Rhetoric**

Advanced study of special topics in rhetorical theory or history, such as women in rhetorical history, the sophists, non-Western rhetorics, Aristotelian rhetoric, cultural backgrounds to the history of rhetoric, and rhetorical criticism.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6080 - Seminar in Technical Communication**

May include study of the theoretical backgrounds of technical communication, the history of technical communication, rhetoric of technical communication, technical communication program administration, and technical communication pedagogy.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6110 - Special Topics in Contemporary Critical Theories**

Study of particular contemporary theoretical perspectives that are influential in rhetoric and technical communication research. Topics might include cultural studies, theories of representation, feminist theory, marxist theory, postmodern theory, or intensive study of influential individual theorists.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6111 - Special Topics in Gender Studies**

An inquiry into the ways in which gender is constituted within and affects rhetorical, representational, and communicative processes, situations, and structures.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6112 - Special Topics in New Media**

A study of the design and evaluation of interactive texts on the computer, with emphasis on critical and theoretical issues raised by the visuality, shifting word-image ratio, and interactivity possible on computer screens.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6114 - Special Topics in Visual Representation**

A critical examination of selected topics in visual representation, with an emphasis on the theoretical, industrial, cultural, international and national, and aesthetic contexts that inform an understanding of particular visual media. May include such topics as genre studies, reception theory and theories of spectatorship, gender and visual representation, etc.

**Credits:** 3.0; Repeatable to a Max of 9

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**HU 6900 - Independent Study**

Guided research under the direction of a member of the graduate faculty. Open to advanced doctoral students in RTC only. Students must meet with their supervising instructor and receive approval of their study plan from the Director of RTC before registering.

**Credits:** variable to 6.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

**HU 6901 - Directed Reading**

Directed reading in a focused area under the direction of a member of the graduate faculty, for advanced PhD students in RTC. Credit varies according to the nature of the reading. Students must file a plan of study and receive approval from the supervising faculty and the Director of RTC before registering.

**Credits:** variable to 6.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

**HU 6902 - Internship**

Work experience under the direction of a member of the graduate faculty, for advanced PhD students. May be conducted on or off campus. Work off campus requires additional direction by an off-campus supervisor. Students must receive approval from their supervising instructor and the Director of RTC before registering.

**Credits:** variable to 6.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

### **HU 6990 - Doctoral Research**

By arrangement with the instructor directing the PhD dissertation

**Credits:** variable to 10.0; Repeatable to a Max of 10; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric & Tech Communication

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## **Mathematical Sciences**

### **MA 5201 - Combinatorial Algorithms**

Basic algorithmic and computational methods used in the solution of fundamental combinatorial problems. Topics may include but are not limited to backtracking, hill-climbing, combinatorial optimization, linear and integer programming, and network analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MA 5211 - Discrete Optimization**

Optimization problems (traveling salesman, minimal spanning tree, linear programming, scheduling, etc.), simplex algorithm, primal-dual algorithms, complexity, matching, weighted matching, spanning trees, matroid theory, integer linear programming, approximation algorithms, branch-and-bound, local search, polyhedral theory.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

### **MA 5221 - Graph Theory**

Review of basic graph theory followed by one or more advanced topics which may include topological graph theory, algebraic graph theory, graph decomposition or graph coloring.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MA 5301 or MA 4209

### **MA 5222 - Design Theory**

Methods for the construction of different combinatorial structures such as difference sets, symmetric designs, projective geometries, orthogonal latin squares, transversal designs, steiner

systems and tournaments.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** and MA 5301 MA 4209

### **MA 5231 - Error-Correcting Codes**

Basic concepts, motivation from information transmission, finite fields, bounds, optimal codes, projective spaces, duality and orthogonal arrays, important families of codes, MacWilliams' identities, applications.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** MA 5301

### **MA 5232 - Cryptography**

Classical cryptography, public key systems, signature schemes, key exchange, authentication codes, secret sharing schemes, protocols.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** MA 5221

### **MA 5301 - Finite Groups and Finite Fields**

Basic theory of finite groups (subgroups, normality, homomorphisms, abelian groups, cyclic groups, commutators, order, cosets, index, conjugacy, simple groups, Sylow Theorems), basic theory of finite fields (prime fields, irreducible polynomials, Galois groups, trace), families of groups defined over finite fields (linear groups).

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MA 4310

### **MA 5302 - Rings and Modules**

A continuation of MA5301. Topics include rings and fields, ideal theory, polynomials, Galois theory, modules, and linear operators.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** MA 5301

**MA 5330 - Topics in Linear Algebra**

A graduate-level study of fundamental ideas in linear algebra and its applications. Reviews basic operations, block computations, vector spaces and decompositions, operators, eigenvalue problems, canonical forms, generalized inverses and singular value decompositions, functions of matrices, and applications.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MA 5401 - Real Analysis**

A graduate-level study of the Lebesgue integral including its comparison with the Riemann integral; the Lebesgue measure, measurable functions and measurable sets. Integrable functions, the monotone convergence theorem, the dominated convergence theorem, and Fatou's lemma.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MA 5405 - Complex Variables**

The Cauchy-Goursat theorem; the argument principle and winding numbers; the Riemann mapping theorem; conformal mappings and application in hydrodynamics; Poisson's formula and the Dirichlet problem for harmonic functions; analytic continuation; infinite products; the gamma and zeta functions, and the distribution of primes.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MA 5504 - Mathematical Modeling**

Construction, analysis, and testing of mathematical models (continuum, discrete, deterministic, or stochastic). Possible models include acoustical, biological, chemical, dynamical, ecological, economics, electromagnetics, financial, geological, mechanical, medical, metallurgical, optical, process, robotics, systems, thermal, material (solid, liquid, gas, plasma, multiphase) dynamics.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MA 5510 - Ordinary Differential Equations I**

First order equations, general theory of linear equations, constant coefficient equations, matrix methods, singular points, infinite series methods, plane autonomous systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** and MA 4330 MA 4450

**MA 5524 - Functional Analysis**

Metric spaces, Banach spaces, Hilbert spaces, fundamental convergence and mapping theorems, spectral theory, weak topologies and weak compactness, unbounded operators and their adjoints, fixed point theorems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** (MA 4330 or MA 4610) and MA 4450

**MA 5531 - Asymptotic and Perturbation Methods**

Addresses asymptotic expansions for integrals, method of steepest descent, stationary phase, etc.; asymptotic expansions for differential equations, regular perturbation methods, Linstedt-Poincare expansions, multiple scales, and averaging, singular perturbation methods, matched asymptotic expansions, composite expansions, etc.; specific applications in mechanical vibrations, boundary layer heat transfer, and fluid flows.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MA 5532 - Bifurcation and Stability Theory**

Study of the branching of solutions to nonlinear problems and their stability. Employs asymptotic and functional and analytic techniques to study stationary (steady) and Hopf (time-periodic) bifurcations. Analyzes specific applications in elastic buckling, Benard convection, hydrodynamic stability, and chemical reaction-diffusion systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MA 5545 - Applied Integral Equations**

Linear integral equations of the first and second kind, Fredholm theory with applications, Hilbert-Schmidt theory with applications, computational methods for approximate solutions of integral equations.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MA 5548 - Mathematical Continuum Mechanics**

Lagrangian and eularian coordinate systems, stress and strain in elastic, viscoelastic, and plastic materials. Constitutive equations, viscosity, balance laws of fluid and solid mechanics, elasticity,

Euler equations, and Navier-Stokes equations.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MA 5565 - Partial Differential Equations**

Theory of partial differential equations. Covers classification, appropriate boundary conditions and initial conditions, PDEs of mathematical physics, characteristics, Green's functions, and variational principles.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** and MA 4330 MA 4450

### **MA 5626 - Numerical Approximation Theory**

Analysis and design of algorithms (for the numerical solution of industrial and financial problems) using the following bodies of theory: difference calculus and interpolation, summation calculus and quadrature, function approximation and data representation, linear and nonlinear optimization, and mathematical programming.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** MA 3520 or MA 3521 or MA 3530 or MA 3560 or MA 4630

### **MA 5627 - Numerical Linear Algebra**

Analysis and design of algorithms for the numerical solutions of linear systems of equations using direct and iterative methods; eigenvalue problems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** or MA 4630 MA 4330

### **MA 5628 - Numerical Ordinary Differential Equations**

Analysis and design of algorithms for the numerical solutions of ordinary differential equations.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** MA 3520 or MA 3521 or MA 3530 or MA 3560 or MA 4630

### **MA 5629 - Numerical Partial Differential Equations**

Analysis and design of algorithms for the numerical solution of partial differential equations.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** MA 4630 or MA 5628 or MA 4515

### **MA 5630 - Numerical Optimization**

Numerical solution of unconstrained and constrained optimization problems and nonlinear equations. Topics include optimality conditions, local convergence of Newton and Quasi-Newton methods, line search and trust region globalization techniques, quadratic penalty and augmented Lagrangian methods for equality-constrained problems, logarithmic barrier method for inequality-constrained problems, and Sequential Quadratic Programming.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** MA 4330 or MA 4610 or MA 4630 or MA 5627

### **MA 5640 - Computational Fluid Dynamics**

Topics include equations of continuum mechanics, principles and applications of numerical methods to discretize equations, stability and error analysis, linear and nonlinear solvers, boundary conditions, incompressible and compressible flows, transient and stationary flows, pre- and post-processing, and applications.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Permission of instructor required

### **MA 5701 - Statistical Methods**

Introduction to design, conduct, and analysis of statistical studies, with an introduction to statistical computing and preparation of statistical reports. Topics include design, descriptive, and graphical methods, probability models, parameter estimation and hypothesis testing.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MA 5711 - Mathematical Statistics I**

Review of distribution theory and transformation theory of random variables. Topics include sufficiency; exponential and Bayesian models; estimation methods, including optimality theory; basics of confidence procedures and hypothesis testing, including the Neyman-Pearson framework.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall



**Pre-Requisite(s):** and MA 4760 and MA 4770 MA 4450

**MA 5712 - Mathematical Statistics II**

Optimal tests and decision theory. Other topics may include regression and analysis of variance, discrete data analysis, nonparametric models.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** MA 5711

**MA 5721 - Stochastic Processes**

Markov chains and their stationary distributions; Markov processes; second-order processes, including Gaussian processes and Brownian motion; differentiation and integration of second-order processes, white noise, and stochastic differential equations.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** MA 3710

**MA 5731 - Linear Models**

A unified development of linear statistical models that includes the following topics: matrices and quadratic forms, normal and chi-square distribution theory, ordinary and generalized least squares modeling, estimability, estimation and tests of hypothesis.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** MA 4710 and MA 4720 and MA 4760 and MA 4330

**MA 5740 - Advanced Sampling Methods**

Runs concurrently with MA 4740 and covers the same topics as MA 4740, but students meet an additional one hour per week to prove results and discuss advanced topics. Students cannot receive credit for both MA 4740 and MA 5740.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-4-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** MA 5701 and MA 4770

**MA 5750 - Statistical Genetics**

Application of statistical methods to solve problems in genetics such as locating genes. Topics include basic concepts of genetics, linkage analysis and association studies of family data, association tests based on population samples (for both qualitative and quantitative traits), gene

mapping methods based on family data and population samples.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

### **MA 5761 - Computational Statistics**

Introduction to computationally intensive statistical methods. Topics include resampling methods, Monte Carlo simulation methods, smoothing technique to estimate functions, and methods to explore data structure. This course will use the statistical software S-plus.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring

**Pre-Requisite(s):** MA 4770(C)

### **MA 5791 - Categorical Data Analysis**

Structure of 2-way contingency tables. Goodness-of-fit tests and Fisher's exact test for categorical data. Fitting models, including logistic regression, logit models, probit and extreme value models for binary response variables. Building and applying log linear models for contingency tables.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

### **MA 5901 - Teaching College Mathematics I**

Survey key issues in undergraduate mathematics education, including course preparation, assessment, student learning, developing assignments, instructional strategies, technology, motivating students and institutional resources. The lab involves practical training in the computer algebra system used in the mathematics lab.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-1)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Major(s): Mathematics; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **MA 5903 - Introduction to Scientific Programming**

Topics include program control, input/output, data structures, procedural and modular programming, and floating point arithmetic. Emphasis on techniques and structures for computational mathematics. Requires programming assignments and projects.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**MA 5980 - Special Topics in Mathematics**

Special topics in mathematics.

**Credits:** variable to 12.0; Repeatable to a Max of 48

**Semesters Offered:** Fall, Spring, Summer

**MA 5999 - Graduate Research in Mathematics**

Original investigation in theoretical, or applied mathematics, and submission of a thesis in partial fulfillment of the requirements for the master's degree in mathematics.

**Credits:** variable to 12.0; Repeatable to a Max of 48; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**MA 6200 - Advanced Topics in Discrete Mathematics**

Reflects the current research interests of the discrete mathematics faculty. Topics may include but are not limited to finite fields, permutation groups, projective geometries, design theory, graph theory, coding theory, probabilistic methods, extremal set theory, and combinatorial matrix theory.

**Credits:** variable to 12.0; Repeatable to a Max of 48

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MA 6201 - Finite Geometries**

Introduction to finite geometries and its links to groups and codes. Topics include projective and affine geometries over finite fields, geometric description of error-correcting codes, bilinear forms and their groups (the classical groups, geometric algebra), group geometries (Dynkin diagrams, projective planes, generalized quadrangles), coordinatization of projective planes.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** MA 5301

**MA 6301 - Permutation Groups and Enumeration**

Introduction to finite groups, permutations and their applications. Covers a review of finite group theory (Lagrange's theorem, simple groups, p-groups, Sylow theorems), permutation groups (Burnside's lemma, orbit formula, primitivity, t-fold transitivity, linear groups, the Mathieu groups). Applications include Polya theory (counting group orbits) and its use in chemistry, construction of combinatorial designs.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** MA 5301

**MA 6302 - Algebraic Curves and Algebraic Codes**

Introduction to the theory of algebraic curves, equivalent algebraic function fields (main theorems Riemann-Roch theorem and Hasse-Weil theorem) and the construction of error-correcting codes from algebraic curves with finite fields of constants.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** MA 5301

**MA 6700 - Advanced Topics in Statistics**

Topics may include but are not limited to experimental designs, methods of quality improvement, discrete data analysis, regression analysis, sampling theory, multivariate methods, resampling methods, statistical computing, integral and measure theory, stochastic processes, asymptotic methods, optimization, modeling, nonparametric and parametric statistics.

**Credits:** variable to 12.0; Repeatable to a Max of 48

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MA 6701 - Probability**

Review of discrete probability, probability measures, random variables, distribution functions, expectation as a Lebesgue-Stieltjes integral, independence, modes of convergence, laws of large numbers and iterated logarithms, characteristic functions, central limit theorems, conditional expectation, martingales, introduction to stochastic processes.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** MA 3720 and MA 4450

**MA 6980 - Special Topics in Mathematics**

Special topics in mathematics.

**Credits:** variable to 12.0; Repeatable to a Max of 48

**Semesters Offered:** Fall, Spring, Summer

**MA 6999 - Mathematical Sciences Doctoral Research**

Taken in partial fulfillment of the doctoral thesis requirement.

**Credits:** variable to 12.0; Repeatable to a Max of 48; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

**MEEM 5110 - Fund of Mechanics/Elasticity**

Covers development of Cartesian tensors and indicial notation applied to vector analysis; analysis of stress, principal stresses, invariants, strain tensors, material derivatives, and continuity equations; basic conservation laws and constitutive relationships; the theory of elasticity, including 2-D problems in plane stress/strain, stress functions, and 3-D problems with polar symmetry.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MEEM 2150 and (MA 3520 or MA 3521 or MA 3530 or MA 3560)

**MEEM 5120 - Plasticity and Viscoplasticity**

Plastic stress-strain laws, yield criteria, flow rules, work hardening, flexure and torsion of bars, boundary-value problems, thick cylinders, spheres, discs, general 3-D, residual stresses, limit analysis, plane strain, slip line theory.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 5110

**MEEM 5150 - Advanced Mechanics of Matls**

A critical study of the basic concepts of stress, strain, and constitutive laws of solids, the physical significance of principle stresses, stress deviator and octahedral stress. Covers failure theories; two-dimensional elasticity theory; mechanics of sub-micron structures; torsion of prismatic bars, thick pressure vessels; special topics in beam theory; elements of elastic stability.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MEEM 2150

**MEEM 5160 - Experimental Stress Analysis**

Review of elastic stress-strain relationships. Covers theory and use of resistive strain gages, strain gage circuits, rosette analysis, static and dynamic strain measurement; discusses other current strain measuring techniques; introduces photoelasticity, Moire, and other optical techniques.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-2)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MEEM 2150

**MEEM 5170 - Finite Element and Variational Methods in Engineering**

Variational concepts and Euler-Lagrange equations and the application of these concepts in formulating boundary value problems and approximate methods, including finite-element method. Development of finite element methodology for problems in engineering.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MEEM 5175 - Failure of Materials in Mechanical Design - Theory and Design**

Identifies the modes of mechanical failure that are essential to prediction and prevention of mechanical failure. Discusses theories of failure in detail. Treats the topic of fatigue failure extensively and brittle fracture, impact and buckling failures at some length. A research/design project will be required. Cannot receive credit for both MEEM4170 and MEEM5175.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering

**MEEM 5180 - Mechanics of Composite Matls**

Introduces engineering properties and advantages of fibrous composites, the governing equations of mechanics of anisotropic, laminated materials. Develops micromechanics methods for predicting the elastic properties of the composite and classical lamination theory, including hydrothermal effects, and applies them to stress and failure analysis of composite structures.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 5110

**MEEM 5185 - Advanced Engineering Biomechanics**

Engineering mechanics applied to the human body in health and disease on injury, which includes mechanics of human biological materials and engineering design in musculo- skeletal system. Also studies on mechanics of posture (occupational biomechanics) and locomotion (sports biomechanics) using mathematical models of the human body. No credit for both MEEM4180 and MEEM5185.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate  
**Pre-Requisite(s):** MEEM 2150 and MEEM 2700

**MEEM 5200 - Advanced Thermodynamics**

A study of the principles of thermodynamics, including fundamental concepts and introduction of the analytical treatments of the first, second and combined first and second laws of thermodynamics. Topics include irreversibility, availability (exergy), thermodynamic relations, mixtures, chemical reactions, and chemical equilibrium.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MEEM 2200

**MEEM 5205D - Comp Methods in Thermal Sci (Distance Program)**

Introduces computational methods used to solve thermodynamic, fluid mechanic, and heat transfer problems. Discusses theoretical and practical aspects. Modern computational tools are used to reinforce principles and introduce advanced topics in thermodynamics, fluid mechanics, and heat transfer.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** MEEM 3230

**MEEM 5210 - Advanced Fluid Mechanics**

Develops control volume forms of balance laws governing fluid motion and applies to problems involving rockets, pumps, sprinklers, etc. Derives and studies differential forms of governing equations for incompressible viscous flows. Some analytical solutions are obtained and students are exposed to rationale behind computational solution in conjunction with CFD software demonstration. Also covers qualitative aspects of lift and drag, loss of stability of laminar flows, turbulence, and vortex shedding.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 3210

**MEEM 5230 - Advanced Heat Transfer**

Advanced topics on conduction, convection, radiation, and heat exchangers are covered. Emphasis is on problem formulation, and exact solutions, with some coverage of empirical results and computational techniques.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MEEM 3230

### **MEEM 5240 - Comp Fluid Dynamics for Engg**

Introduces finite-difference and finite-volume methods used in solving fluid dynamics and heat transfer problems. Covers numerical grid generation, turbulence modeling, and application to some selected problems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **MEEM 5250 - Internal Combustion Engines II**

Advanced topics in internal combustion engines with emphasis on CI operation, modeling of engines, modeling of combustion processes, tribology, second law applications, and other topics of current interest.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 4220

### **MEEM 5260 - Advanced Engine Laboratory**

Experimental studies of the effect of operating and design variables on the performance, efficiency, and exhaust emission of internal combustion engines.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-1-4)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 4220

### **MEEM 5270 - Advanced Combustion**

The objective is to understand basic combustion processes through detailed analysis. Introduces both analytical and modern experimental methods. Emphasizes liquid fuel combustion, flame propagation, and critical phenomena of ignition and extinction.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall



**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering  
**Pre-Requisite(s):** MEEM 4240

### **MEEM 5280 - Phase-Change & Two-Phase Flows**

Considers two-phase flow patterns for air-water, condensing, and boiling flows in the context of interface conditions (surface tension, etc.) and interfacial instabilities that lead to interfacial waves, droplet formation, etc. The course emphasizes development of model equations. Relevant experimental data leading to pressure drop correlations, interfacial shear model, etc., are discussed. The model equations and empirical correlations are used to estimate solutions of problems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 3230

### **MEEM 5401 - Design for Reliability**

Emphasizes the importance of reliability in design, covering basic concepts of series, parallel, standby and mixed systems. Uses conditional probability and multimode functions as methods for problem solution. Considers derating and reliability testing.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 3501

### **MEEM 5404D - Mechanism Syn/Dynamic Modeling (Distance Program)**

Students apply kinematic synthesis techniques in design and analysis of mechanical systems. They develop synthesis software to link to dynamic analysis packages such as ADAMS, I-DEAS, Unigraphics, etc. They investigate influences of process variation on system output and learn methods to minimize the variation influences.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 3502(C)

### **MEEM 5405D - Intro to the Finite Element Method (Distance Program)**

Introduces the use of the finite element method in stress analysis and heat transfer. Emphasizes the modeling assumptions associated with different elements and uses the computer to solve many different types of stress analysis problems, including thermal stress analysis and

introductory nonlinear analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 3502 and (MA 2320 or MA 2321 or MA 2330) and (MA 3520 or MA 3521 or MA 3530 or MA 3560)

### **MEEM 5408 - Design Automation**

Students learn fundamental theories and techniques used in mechanical CAD software development. Useful to all students using CAD software in their research and students specializing in design. Basic software engineering, math topics, geometry, solid modeling, design knowledge, design manipulation, and internet will be covered.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-4-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MEEM 5443 - Kinematics**

Students apply kinematic synthesis techniques in the design and analysis of mechanical systems and special purpose cams. They develop synthesis software to link to commercial dynamic packages, optimizing simple mechanisms and mechanical systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 3502

### **MEEM 5602D - Process and Product Design and Improvement**

Introduces value-engineering tools for product development and total quality management.

Topics include systems engineering fundamentals, quality function deployment, experimental design, robust engineering, failure mode and effects analysis, and engineering problem-solving techniques.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Campus(s): Extended University Programs

### **MEEM 5605D - Metal Forming Processes (Distance Program)**

Covers analytical and experimental study of metal forming processes, such as forging, extrusion, rolling, bending, stretch forming, and deep drawing as well as progressive die design for sheet metal stamping and design of dies for bulk forming.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 2500 and MEEM 2150

**MEEM 5610 - Advanced Machining Processes**

Covers mechanics of 2-D and 3-D cutting and their extension to commonly used processes such as turning, boring, milling, and drilling. Topics include force modeling, surface generation, heat transfer, tool life and dynamics.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-2)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MEEM 2500

**MEEM 5615 - Advanced Metal Forming**

Introduces fundamentals of plasticity theory and applies to the analysis of deformation processes. Processes considered are forging, extrusion, wire drawing, bending, deep drawing, and stretch forming. Emphasizes sheet metal formability.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MEEM 3502 or MEEM 2150

**MEEM 5625 - Precision Manuf and Metrology**

Presents theory and practice involved in the manufacturing and measuring of precision components. Topics include precision machining processes, precision machine/mechanism design, and dimensional metrology. Addresses current manufacturing challenges in the bearings, optics, and microelectronics industries.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-2)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MEEM 3502 and MEEM 3700

**MEEM 5640 - Micromanufacturing Processes**

Introduces the processes and equipment for fabricating microsystems and the methods for measuring component size and system performance. Fabrication processes include microscale

milling, drilling, diamond machining, and lithography. Measurement methods include interferometry and scanning electron microscopy. No credit for both MEEM4640 MEEM5640.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-2)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 3502(C)

### **MEEM 5645 - Numerical Analy Manuf Proc**

Nonlinear FEM and BEM analyses, modeling of bulk forming processes, sheet forming processes, machining processes, casting processes, grinding of ceramics.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 2500

### **MEEM 5650 - Advanced Quality Engineering**

Stresses the concepts and methods for quality and productivity improvement. Topics include principles of Shewhart, Deming, Taguchi; meaning of quality: control charts for variables, individuals, and attributes; process capability analysis; variation of assemblies; Monte Carlo simulation, multi-variate situations; and computer-based workshops. No credit for both MEEM4650 and MEEM5650.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MA 3710

### **MEEM 5653 - Life-cycle Engineering**

Familiarizes students with the principles and techniques of life-cycle engineering. These techniques include design reviews, re-engineering, cost/benefit analysis, value engineering and design for "X." Upon completion, students should be adept at weighing the costs and benefits of product design decisions as they apply to a product from concept to retirement. Credit may not be received for both MEEM 4653D and MEEM 5653.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following College(s): College of Engineering

**Pre-Requisite(s):** MEEM 4900

**MEEM 5660 - Data Based Modeling & Control**

System modeling and analysis from observed data for computer-aided design and manufacturing, providing differential equation models. Computer routines for modeling, forecasting with accuracy assessment and minimum mean-squared error control. Underlying system analysis, including stability and feedback interpretation, periodic and exponential trends. Uses illustrative applications to real-life data, including team projects.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**MEEM 5670 - Experimental Design in Engg**

Review of basic statistical concepts. Models for testing significance of one or many factors. Reducing experimental effort by incomplete blocks, and Latin squares. Factorial and fractional factorial designs. Response surface analysis for optimal response.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Summer

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**MEEM 5680 - Optimization I**

Provides introductory concepts to optimization methods and theory. Covers the fundamentals of optimization, which is central to any problem involving engineering decision making. Provides the tools to select the best alternative for specific objectives.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**MEEM 5685 - Environmentally Responsible Design and Manufacturing**

Examines impact of engineering and, in particular, design/manufacturing decisions on the environment. Topics include sustainability; energy/material flows; risk assessment, life cycles, manufacturing process waste streams, product design issues, including disassembly/post-use product handling; techniques for pollution prevention. Requires course project. Credit may not be received for both MEEM4685 and MEEM5685.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**MEEM 5700 - Dynamic Meas/Signal Analysis**

Assessment of measurement system requirements: transducers, conditioners, and displays of

dynamic measurands. Time-, frequency-, probabilistic-, and correlative-domain approaches to dynamic signal analysis: sampled data, discrete Fourier transforms, digital filtering, estimation errors, system identification, calibration, recording. Introduction to wavelet analysis. All concepts reinforced in laboratory and simulation exercises.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-3)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MA 4520

### **MEEM 5701 - Intermediate Dynamics**

Intermediate study of several topics in engineering dynamics, including three-dimensional kinematics and kinetics, generalized coordinates, Lagrange's equation, and Hamilton's principle. Uses computer-aided dynamic simulation tools for analyzing dynamic systems.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MEEM 2700

### **MEEM 5702 - Analytical Vibroacoustics**

First in a series of two courses on vibro-acoustics to provide a unified approach to study noise and vibration. Emphasizes interaction between sound waves and structures. Presents advanced vibration concepts with computational tools. Discusses wave-modal duality.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 3700

### **MEEM 5703 - Exp Methods Vibro-Acoustics**

Covers operating data measurement and analysis, including multisource ODS. Includes signature analysis and order tracking; modal theory, modal scaling. FRF estimators; multiple input excitation techniques; parameter estimation methods; sound measurements and acoustic intensity; sound quality; field data acquisition, DAT; binaural recording and playback with equalization.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-3)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 5702 and MEEM 4701

**MEEM 5710D - NVH and Sound Quality (Distance Program)**

Noise Vibration and Harshness (NVH) is an important design consideration in the automotive, appliance, and machine tool industry. This course presents the fundamental concepts of noise and vibration measurement, modeling, and control. Lectures are supported with hands-on testing and analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-2)

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 3700

**MEEM 5715 - Linear Systems Theory and Design**

Overview of linear algebra, Modern Control; state-space based design of linear systems, observability, controllability, pole placement, observer design, stability theory of linear time-varying systems, Lyapunov stability, optimal control, Linear Quadratic regulator, Kalman filter, Introduction to robust control.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 4700 or EE 4261 or MA 4330

**MEEM 5990 - Special Topics**

Study of selected subjects related to mechanical engineering or engineering mechanics.

**Credits:** variable to 6.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

**MEEM 5999 - Graduate Research**

Research/investigation on a topic related to mechanical engineering or engineering mechanics leading to the submission of a thesis or report in partial fulfillment of the requirements for the master's degree.

**Credits:** variable to 15.0; Repeatable to a Max of 30; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics, Engineering Mechanics, Mechanical Engineering

**MEEM 6000 - Graduate Seminar**

Presentations/seminars on issues related to mechanical engineering and engineering mechanics. May include invited speakers from industry, government labs, and academe.

**Credits:** 1.0; Repeatable to a Max of 2

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MEEM 6120 - Hi Strain Rate Behav of Matl**

Covers stress-strain response of high strain rates, constitutive models, microstructural changes, wave propagation. Uses experimental methods to obtain dynamic response, dynamic fracture, adiabatic shear banding.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 2150

**MEEM 6130 - Engineering Fracture Mechanics**

Development of the stress and deformation fields present near the tips of cracks. Uses elasticity solutions, plasticity corrections, and numerical methods in modeling these fields. Introduces fracture criteria and explains the various parameters used to develop these criteria.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 5110

**MEEM 6140 - Theory of Plates and Shells**

A study of classical theory of plates and shells with applications. Includes solutions of plates and shells of various shapes; limitations and validity of classical theory; and variational methods.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MEEM 6230 - Conduction**

Fundamental aspects of conductive heat transfer applied to steady-state and transient conditions. Studies multidimensional conduction problems with exact and approximate solutions techniques.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 5230

**MEEM 6240 - Convective Heat Transfer**

An introduction to flow and boundary layer theory for forced and natural convection heat and



mass transfer. Includes derivation and application of the equations for conservation of mass, energy, and momentum; dimensional analysis and correlation of experimental results.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 5230

### **MEEM 6250 - Radiative Heat Transfer**

Fundamentals of thermal radiation for black, gray, nongray, diffuse, and specular surfaces. Includes radiation combined with conduction and convection at boundaries; properties for radiation in absorbing, emitting, and scattering media; and the engineering treatment of gas radiation in enclosures.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 5230

### **MEEM 6401 - Engg Design Optimization**

Covers mathematical optimization methods useful for engineering design optimization. Includes classical methods as well as new techniques. Emphasizes practical applications and the selection of optimization methods for the solution of specific problems in design.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MEEM 6670 - Data Dependent Systems**

Modeling of systems from multiple series of observed data. Includes interpretation and characteristics of vector difference-equation models; impulse response functions and modal analysis; spectrum analysis of the contribution of various system components to the measured responses; application to process control and design.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 4660 or MEEM 5660

### **MEEM 6680 - Optimization II**

Provides advanced concepts to optimization theory and methods with an emphasis on engineering problems. Covers design and manufacturing optimization problems in all engineering disciplines. Provides various optimization methods, including

unconstrained/constrained optimization, multiobjective optimization, and stochastic optimization.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 5680

### **MEEM 6701 - Advanced Acoustics**

Advanced concepts in acoustics with emphasis on modeling of sound sources, sound interaction with solid structures, transmission and radiation of sound. Discusses numerical acoustics, statistical energy analysis, and sound quality concepts. Provides beneficial background in basic vibrations and noise control.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MEEM 6702 - Nonlinear Sys Analy & Control**

Studies nonlinear systems from perspective of analysis/control system design. Explores fundamental properties of nonlinear differential equations in addition to describing functions, phase plane analysis, stability/instability theorems. Develops and applies control system design approaches for nonlinear systems, including feedback linearization, quantitative feedback theory, sliding mode control, and backstepping.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MEEM 6703 - Advanced Vibrations**

Free and forced vibration of continuous systems with applications to strings, shafts, beams, plates and membranes. Problems formulated using Hamilton's principle and Lagrange's equations. Approximate methods of solution include the Rayleigh-Ritz method and Galerkin's method.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MEEM 3700

### **MEEM 6705 - Advanced Dynamics**

Systematic study of principles of mechanics from a modern perspective. Includes rates of change of position and orientation; angular velocity and acceleration; linear velocity and acceleration; generalized coordinates and velocities; properties of distributed mass; generalized active and inertia forces for holonomic and nonholonomic systems; potential energy, kinetic energy, and virtual work.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MEEM 6990 - Special Topics**

Study of selected subjects related to mechanical engineering or engineering mechanics.

**Credits:** variable to 6.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

**MEEM 6999 - Doctoral Research**

Research/investigation on a topic related to mechanical engineering or engineering mechanics leading to the submission of a dissertation in partial fulfillment of the requirements for the PhD degree.

**Credits:** variable to 15.0; Repeatable to a Max of 90; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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**Materials Science & Engrg**

**MY 5000 - Materials Science and Engineering**

Concepts of crystallography and crystal structure. Designed for students without a degree in materials science and engineering. Covers microstructural development as related to phase diagrams, kinetics of phase transformations, diffusion and materials processing. Relationship of properties to microstructure and processing. No degree credit given to students with materials undergraduate degrees.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MY 5100 - Thermodynamics and Kinetics I**

Solution thermodynamics and application to phase equilibria. Driving force for phase transformations. Chemical thermodynamics applied to materials processing. Corrosion and oxidation of metals. Applications to engineering situations.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MY 5110 - Thermodynamics and Kinetics II**

The kinetics of liquid-to-solid and solid-to-solid phase transformations. Diffusion-controlled phase transformations, including nucleation, growth, coarsening, spinodal decomposition,

eutectic and eutectoid transformations, cellular transformations, and massive transformations. Martensitic transformations.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MY 5100

### **MY 5200 - Advanced Scanning Electron Microscopy**

Basic design and operating principles of scanning electron microscope (SEM) with discussions on interactions of electrons with solids and resulting signal production, for analysis of heterogeneous materials using X-ray microanalysis, and applications to surface science. Includes practical training on advanced operation of SEM and FE-SEM (FE=field emission)\* instruments with an emphasis on the production of high resolution images and quantitative X-ray analysis of specimen composition based on real and virtual standards. (\*if available)

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-3)

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 5250 - Transmission Electron Microscopy**

Practical aspects of materials characterization by transmission electron microscopy.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-3)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 5260 - Crystallography & Diffraction**

Crystallographic concepts and diffraction analyses in materials science.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-3)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 5400 - Mechanical Behavior of Materials**

Elasticity and plasticity in solids. Dislocation interactions and strengthening mechanisms. High temperature deformation. Low and high temperature material forming operations. Fracture processes in materials.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 5430 - Electronic Materials**

A study of the physical principles, operational characteristics, models, and basic applications of

selected solid-state devices.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 5460 - Solid State Devices**

A study of the physical principles, operational characteristics and models and basic applications of solid state devices such as p-n junctions, metal-semiconductor junctions and transistors.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

### **MY 5470 - Semiconductor Fabrication**

Graduate level introduction to the science and engineering of semiconductor device fabrication.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **MY 5480 - Advanced MEMS**

This course will cover advanced topics dealing with MEIXIS technologies, transduction mechanisms, and microfabricated sensors and actuators and is continuation of EE4240/MY4240.

**Credits:** 4.0

**Lec-Rec-Lab:** (3-1-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** EE 4240 or MY 4240

### **MY 5480D - Advanced MEMS**

This course will cover advanced topics dealing with MEMS technologies, transduction mechanisms, and microfabricated sensors and actuators and is continuation of EE4240/MY4240.

**Credits:** 4.0

**Lec-Rec-Lab:** (3-1-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MY 4240D or EE 4240D

### **MY 5550 - Solid Surfaces**

The performance, durability, and stability of composites, coatings, films, advanced ceramics,

implants, and nano-technological products rely on the understanding, control and manipulation of surfaces and interfaces. This course provides both a fundamental and practical introduction to the concepts and theories of solid surfaces and solid-liquid interfaces. The capillary effects, electrical aspects of interfaces, and adsorption at materials surfaces, with their practical applications and consequences, are emphasized.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 5580 - Introduction to Scanning Probe Microscopy**

Students will learn basics of design and fundamental physics behind the scanning probe microscopy techniques. The lectures will also discuss analysis of the solid surfaces regarding roughness, topography, composition, heterogeneity, and adhesion properties using atomic force microscopy (AFM). Artifacts associated with inappropriate conditions in atomic AFM imaging will be discussed as well. Training in the operation of the AFM instrument and exploration of its capability during the laboratory sessions will complement the lectures.

**Credits:** 2.0

**Lec-Rec-Lab:** (1-0-3)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 5600 - Powder Processing**

Processing of metal and ceramic powders into bulk products. Powder manufacture and characterization, compaction, sintering, pressure-assisted consolidation to full density. Emphasis on principles underlying consolidation practices.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MY 2100

### **MY 5610 - Materials Recycling: Processing and Utilization**

Methods for materials recycling is the emphasis. Topics include the recycling of materials for steel, aluminum, automobile, foundry, glass, plastics, energy, construction, and other industries. Background of the industry, characteristics of materials, materials flow, and the processing and utilization methods to recycle the materials are presented.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

### **MY 5620 - Soft Materials**

An introduction to basic concepts, interactions, structures, and properties in soft materials. Topics include polymers, liquid crystals, colloids, surfactants and lipids, polymeric nano composites, and bio materials.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** MY 2100

### **MY 5750 - Bioapplications of Nanotechnologies**

The prospect of bioapplications of nanotechnologies, selected topics including nanodevices for biosensor and drug delivery, biocompatibility and toxicity of nanomaterials, nanostructured polymers for tissue engineering, design and operation of medical nanorobots, ethics and societal impacts of nanobiotechnology, etc.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 5900 - Graduate Seminar**

Graduate student presentations at departmental seminars.

**Credits:** 1.0; May be repeated

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 5990 - MS Thesis Research**

Fundamental and applied research in metallurgical and materials engineering. Taken by graduate students in partial fulfillment of the MS thesis requirements.

**Credits:** variable to 12.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 6100 - Computational Materials Science and Engineering**

Computational and analytical techniques applied to materials science and engineering problems. Develops student facility with modern computational techniques.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **MY 6110 - Advanced Topics in Materials Processing**

Advanced treatment of various unit operations of materials processing. Operations may include deformation processing, powder and particulate technology, solidification processing,

thermomechanical processing, optimum process selection, etc.

**Credits:** variable to 4.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MY 6200 - Advanced Topics in Materials Characterization**

Advanced concepts in materials characterization. Specific course content is tailored to meet the interests of the students and faculty.

**Credits:** variable to 4.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MY 6400 - Advanced Topics in Mechanical Behavior of Materials**

Advanced concepts in mechanical behavior of materials. Specific course content is tailored to meet the interests of the students and faculty.

**Credits:** variable to 4.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MY 6460 - CMOS Devices**

An in-depth treatment of field-effect devices.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** MY 5460

**MY 6480 - Thin Films**

Material Science of thin films.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**MY 6990 - PhD Thesis Research**

Fundamental and applied research in metallurgical and materials engineering. Taken by graduate students in partial fulfillment of the PhD thesis requirements.

**Credits:** variable to 12.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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**Physics**



**PH 5010 - Graduate Journal Club**

Presentation and discussion of current issues in physics and recent research by departmental faculty and others. One credit in journal club is required for all graduate degrees in physics.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**PH 5090 - Special Topics in Physics**

The subject matter may vary from term to term and year to year depending on the needs of advanced students.

**Credits:** variable to 3.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**PH 5110 - Classical Mechanics**

Lagrangian methods, symmetries and conservation laws, variational formulation, small oscillations, Hamilton's equations, contact transformations, Poisson brackets, Hamilton-Jacobi theory, Lorentz-invariant formulation.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**PH 5210 - Electrodynamics I**

Electrostatics and magnetostatics, boundary value problems, multipoles, Maxwell's equations, time-dependent fields, propagating wave solutions, radiation.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** PH 5320

**PH 5211 - Electrodynamics II**

Scattering and diffraction, special relativity, relativistic particle dynamics, Lorenz transformation, 4-vectors, transformation of fields, charges and currents, Thomas precession, retarded potentials, radiation from moving charges.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** PH 5210

**PH 5250 - Atomic and Molecular Physics**

An introduction to modern atomic, molecular, and optical physics. Special topics covered are cw field-atom interactions including atomic trajectory manipulation, laser theory, saturation spectroscopy, resonance fluorescence, quantum computing and Bose-Einstein condensation in atom traps.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** PH 3210 and (PH 4211 or PH 5210) and (PH 3411 or PH 5410)

### **PH 5310 - Statistical Mechanics**

Ensembles, partition functions and distributions, thermodynamic potentials, quantum statistics, ideal and nonideal gases, interacting systems. Applications may include classical and quantum liquids, phase transitions and critical phenomena, correlation functions, linear response and transport theory, or other topics.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **PH 5320 - Mathematical Physics**

Partial differential equations of physics, separation of variables, boundary value problems, Sturm-Liouville theory, Legendre and Bessel functions, inhomogeneous partial differential equations, Green's functions. Fourier series, Fourier and Laplace transforms, complex variables, evaluation of integrals by contour integration, linear algebra, matrix methods with emphasis on numerical applications.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **PH 5410 - Quantum Mechanics I**

Study of the postulates of quantum mechanics framed in Dirac notation, the Heisenberg uncertainty relations, simple problems in one dimension, the harmonic oscillator, the principles of quantum dynamics, rotational invariance and angular momentum, spherically symmetric potentials including the hydrogen atom, and spin.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **PH 5411 - Quantum Mechanics II**

Continuation of PH5410. Includes the study of symmetries and their consequences, the variational method, identical particles, the Hartree-Fock approximation time-independent perturbation theory, time-dependent perturbation theory, diatomic molecules with applications to

H2+, many-body perturbation theory, and the Dirac equation.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** PH 5410

### **PH 5450 - Introduction to Relativity**

An introduction to the ideas and results of general relativity, including a review of special relativity. Discusses applications to the properties of massive objects and cosmology.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **PH 5510 - Theory of Solids**

Free electron theory, Bloch's theorem, electronic band structure theory, Fermi surfaces, electron transport in metals and semiconductors. Lattice vibrations and phonons, other topics as time permits.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** PH 5320 and PH 5410

### **PH 5520 - Materials Physics**

Materials classification and structures; phase diagrams; lattice imperfections; quasiparticles; boundaries and interfaces; mechanical, electronic, optical, magnetic and superconducting properties of materials.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **PH 5530 - Selected Topics in Nanoscale Science and Technology**

Presentation and discussion of selected topics in nanoscale science and engineering. Topics include growth, properties, applications, and societal implication of nanoscale materials.

Evaluation: attendance and assignment.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**PH 5610 - High Energy Astrophysics**

An introduction to the ideas and results of astrophysics and high energy physics.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**PH 5630 - Imaging Systems**

An introduction to the theory, technology, and methods associated with imaging systems. Topics include telescopes and astronomical imaging, microscopes, aerial cameras and remote sensing instruments, and image recording technologies.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**PH 5910 - Atmospheric Physics**

Concepts in atmospheric physics. Covers radiative transfer, atmospheric thermodynamics, cloud physics, and remote sensing and imaging of Earth.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**PH 5920 - Scientific Instrument Fabrication**

Project-oriented introduction to scientific instrument design and machine shop techniques. The course introduces proper use and application of shop machinery, including lathe, drill press, band saw, mill, torch, and woodworking tools. Instrument design, bench layout, and drafting standards are included as well as laboratory safety training.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-0-4)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**PH 5950 - Graduate Electronics for Scientists**

A graduate-level, laboratory-based course in electronics for scientists. Covers foundations of analog electronics, including DC circuits, RCL filters, timers and tank circuits, diodes, FETs, OP Amps, and power circuits. Digital circuitry includes gates, counters, registers, D/A and A/D conversion, and microcontrollers.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-0-6)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**PH 5999 - Master's Research**

Master's-level research conducted under the direction of a graduate faculty advisor.

**Credits:** variable to 12.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor and department required; Must be enrolled in one of the following Level(s): Graduate

### **PH 6510 - Advanced Solid-State Physics**

Electron-electron interactions solids, lattice dynamics, transport, optical properties of solids, superconductivity.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** PH 5510

### **PH 6999 - Doctoral Research**

Independent research conducted in partial fulfillment of the requirements for the PhD degree. Scheduled by arrangement.

**Credits:** variable to 12.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor and department required; Must be enrolled in one of the following Level(s): Graduate

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## **Social Sciences**

### **SS 5010 - Directed Study**

Directed readings or research conducted under the direction of a member of the graduate faculty. Students must meet with their supervising instructor and receive approval of their study plan before registering.

**Credits:** variable to 4.0; Repeatable to a Max of 9

**Semesters Offered:** Fall, Spring

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **SS 5100 - Global Environmental Systems**

Survey of literature that connects global biological and physical processes with human adaptations, interventions and social systems. Study of range of human systems adapted to living in and with the environment. Topics include energy balance and transfer in the earth environment, ecosystems and energy flow, human intervention into geomorphological processes.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 5200 - Environmental Decision Making**

Group practicum in environmental decision making. Focuses on facilitating the decision making process associated with a community-based environmental concern or policy choice. Past projects include efforts to facilitate public participation in developing a forest management plan and participating in a review of the Torch Lake Area of Concern.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 5300 - Environmental Policy and Politics**

An overview of environmental policymaking and politics in the U.S. Emphasizes policies regarding air and water pollution, toxics and hazardous waste. Discussion of rulemaking, enforcement, and administration of laws by EPA. Investigation of environmental politics on national and community levels, with focus on social movements and citizen participation.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 5350 - Environmental Policy Analysis**

The role of economic analysis in environmental policy, including a detailed review of the major tools that are used at the federal, state, regional, and local levels. Special emphasis on benefit-cost analysis and comparative risk analysis.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** SS 5300

### **SS 5400 - Sociology of the Environment**

Provides students with an introduction to basic sociological concepts as they apply human relationships to the environment. Topics include social values, organizations, norms, ideologies, and political systems. Themes will include the relationship of expertise to lay knowledge, public participation, and urban-rural relationships.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 5405 - Geophysics for Archaeology**

Principles and practice of non-invasive archaeological geophysics such as magnetometry, ground penetrating radar, and resistivity. Data interpretation will involve basic computation, computer and hand contouring, three-dimensional visualization programs, interpretation and archaeological significance. Activities will involve fieldwork, work on data, and short reports. The mathematical content of the class will be minimal.

**Credits:** 3.0

**Lec-Rec-Lab:** (2-0-1)

**Semesters Offered:** Fall

**SS 5500 - IA Proseminar-I: History of Technology**

Provides a basic introduction to work in the history of technology. Students must also register for SS5501.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**SS 5501 - IA Proseminar II: Industrial Communities**

A graduate seminar covering the main components of anthropological studies of industrial communities. Introduces the methods and approaches of this field through reading and discussion of selected articles and case studies. Students must also register for SS5500.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**SS 5502 - IA Proseminar III: Historical Archaeology**

Graduate seminar covering the essential elements of historical archaeology through reading and discussion of selected articles and case studies. Students must also register for SS5503.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**SS 5503 - IA Proseminar IV: Material Culture Studies**

Graduate seminar covering the basic elements of material culture studies through readings, discussion, and projects. Students must also register for SS5502.

**Credits:** 2.0

**Lec-Rec-Lab:** (2-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**SS 5510 - Sustainable Futures I**

Covers introductory and intermediate concepts of Sustainable Development. Explores methods/tools for assessing sustainability (economic, environmental, societal impacts) of current and emerging industrial technologies. Explores relationships between government policies and markets for introducing sustainable technologies into national economies and corporations.

**Credits:** 3.0

**Lec-Rec-Lab:** (3-0-0)

**Semesters Offered:** Fall

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore  
**Pre-Requisite(s):** UN 2002

### **SS 5600 - Industrial Archaeology**

Directed readings and lectures in industrial archaeology using wide range of material from the historical engineering and archaeology literature. Central focus is on regional case studies. Students complete a substantial directed research project.

**Credits:** 4.0

**Lec-Rec-Lab:** (4-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 5700 - Archaeological Field Methods**

Practical experience in methods and techniques of field archaeology. Background readings followed by participation in site survey, testing, excavation, and record keeping. Students involved in ongoing research projects in upper Great Lakes Region. Offered with SS 3210. Graduate students complete independent project in addition to regular work. Recommended SS2020.

**Credits:** variable to 8.0; Repeatable to a Max of 16

**Semesters Offered:** Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 5800 - Documentation of Historic Structures**

Principles and practice of survey and documentation of historic structures. Techniques include reconnaissance survey, in-depth survey, measured drawings, architectural photography, primary research, and written descriptions. Students use survey and documentation to analyze historic structures.

**Credits:** 4.0

**Lec-Rec-Lab:** (4-0-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 5900 - Heritage Management**

Introduces the current field of heritage management; the legislation that underwrites its practice; the articulation of federal, state, and local governmental activity; the evolving philosophies of archaeologists and historic preservationists operating in the public interest; parallels on the international scene; and the impacts of heritage tourism.

**Credits:** 4.0

**Lec-Rec-Lab:** (4-0-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 5990 - Graduate Research**

Individual research work leading towards master's thesis or project. Open by arrangement to students in master's programs in the Department of Social Sciences.



**Credits:** variable to 10.0; Repeatable to a Max of 15; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 5998 - Peace Corps Fellows Off Campus Masters Research**

Work related research credit for Peace Corps Fellows students who are off campus in partial fulfillment of Masters degree requirements.

**Credits:** variable to 9.0; Repeatable to a Max of 12

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Sciences & Arts; Must be enrolled in one of the following Major(s): Environmental Policy

### **SS 6010 - Special Topics in Industrial Heritage**

Examines themes or topics related to studies of industrial heritage. May include such topics as advanced cultural resource & heritage management and tourism; industrial heritage field methods; international dimension of industrial heritage; government policy. May be repeated.

**Credits:** variable to 6.0; Repeatable to a Max of 12

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 6020 - Special Topics in Industrial History**

Examines themes or topics related to the study of industrial history of technology. Topics may include global history of industrialization; theoretical models of industrial evolution; and social history of technology and work. May be repeated.

**Credits:** variable to 6.0; Repeatable to a Max of 12

**Semesters Offered:** On Demand

**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

### **SS 6500 - Independent Study/Directed Reading**

Independent study or directed reading with appropriate faculty at the graduate level.

**Credits:** variable to 9.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

### **SS 6600 - PhD. Dissertation Research**

Fundamental and applied research in industrial heritage, industrial archeology, and history of technology. Taken by graduate students in partial fulfillment of the PhD thesis requirements.

**Credits:** variable to 9.0; May be repeated; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Social Sciences

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## **University Wide**

### **UN 5000 - Cooperative Education - Graduate**

Offered by each participating college or school-the graduate -level cooperative education course. Requires advisor approval, registration with the Office of the Graduate School, acceptability by a recognized employer. Student must have completed one full-time semester on the MTU campus.

**Credits:** variable to 12.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

### **UN 5001 - Responsible Conduct of Research**

This course explores ethical and policy issues arising during the conduct of research: authorship practices, animal/human subjects, scientists as citizens, scientific misconduct, data sharing/secrecy, intellectual property, technology transfer, social and ethical implications of genetic technologies, conflict of interest, and mentoring.

**Credits:** 1.0; Graded Pass/Fail Only

**Lec-Rec-Lab:** (1-0-0)

**Semesters Offered:** Summer

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore

### **UN 5951 - Graduate Status - Maintenance of Continuous Enrollment**

Meets continuous enrollment requirement for graduate students needing "time out" for special circumstances and for programs with inactive terms. No access to advisor's time or campus facilities; does include e-mail and library privileges.

**Credits:** 0.0; Repeatable to a Max of 97; Graded Pass/Fail Only

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

### **UN 5952 - Report, Thesis, Dissertation - Independent Writing & Revision**

Meets continuous enrollment requirement for graduate students engaged in writing report, thesis, or dissertation. Open only to students who have completed all course and credit requirements. Limited access to advisor's time. No access to labs and other campus facilities. Enrollment includes e-mail and library privileges.

**Credits:** 0.3; Repeatable to a Max of 97; Graded Pass/Fail Only

**Lec-Rec-Lab:** (0-.25-0)

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

### **UN 5953 - Terminal Graduate Registration**

Meets defense-term enrollment requirement for graduate students defending report, thesis or dissertation. Open only to students returning from enrollment in UN 5951/5952. Late enrollment after the billing due date carries standard late fee; no waivers granted. Variable credit assigned to bring total term enrollment to minimum 1.0 credits. Computer lab access is not included.

**Credits:** 1.0; Graded Pass/Fail Only

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

**Pre-Requisite(s):** UN 5951(C) and UN 5952(C)

**UN 5990 - Special Topics - Interdisciplinary**

Study of interdisciplinary special topics as specified by section title.

**Credits:** variable to 6.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

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