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Graduate Course Descriptions Effective Fall 2007

Atmospheric Science	Business	Biomedical Engineering
Biological Sciences	Civil & Environmental Engrg	Chemistry
Chemical Engineering	Computer Science	Computational Science & Engr
Economics	Education	Electrical Engineering
Exercise Science & Health	Engineering Fundamentals	Forest Resources & Env Science
Geolog. & Mining Engrg & Sci.	Humanities	Mathematical Sciences
Mechanical Eng. - Engrg. Mech.	Materials Science & Engrg	Physics
Social Sciences	Technology	University Wide

Atmospheric Science

ATM 5100 - Atmospheric Sciences Research Discussion
A weekly discussion of recent literature in the atmospheric sciences. Often coordinated with atmosphere-related seminars in the Remote Sensing seminar series.
Credits: 1.0; May be repeated
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

ATM 5200 - Special Topics in Atmospheric Sciences
Advanced study of topics in the atmospheric sciences. The subject matter may vary from term to term depending on the needs and interests of students.
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

ATM 5515 - Atmospheric Chemistry
Study of the photochemical processes governing the composition of the troposphere and stratosphere, with application to air pollution and climate change. Covers radical chain reaction cycles, heterogeneous chemistry, atmospheric radiative transfer and measurement techniques for atmospheric gases.
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): CH 3520 or CE 4501

ATM 5640 - Atmospheric Physics
Essential elements of atmospheric physics, including thermodynamics (e.g. adiabatic processes, phase transformations, stratification), aerosol and cloud physics (e.g. nucleation, Kohler theory, growth by condensation and collection), and radiative transfer (e.g. Beer's law, transfer equations with and without scattering).
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2008-2009 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MA 3530 and PH 2300

ATM 5680 - Atmospheric Fluid Dynamics
Fundamentals forces and conservation laws that govern fluid flow; applications to the atmosphere, including balanced flow (pressure gradient and Coriolis Force), vorticity dynamics, turbulence, waves, and boundary layers.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2007-2008 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): MA 3530 and PH 2300

ATM 6999 - Doctoral Research
Independent research conducted in partial fulfillment of the requirements of the Atmospheric Sciences doctoral degree.
Credits: variable to 12.0; May be repeated; Graded Pass/Fail Only
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

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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 faulty.
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, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BA 3400 or EC 3400

BA 5410 - Finance II
Focuses on central issues in corporate finance, such as capital structure, dividend policy, lease versus buy, working capital management, mergers and acquisitions, risk management, financial engineering, pension fund management, and fixed-income securities.
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 5400

BA 5460 - Derivative Securities
Studies futures, forwards, and option pricing and their uses for speculation, arbitrage and hedging. The option pricing framework is extended to cover exotic options and options embedded in real assets.
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): BA 5400

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 5620 - Supply Chain Management
Designing and managing channels of distribution, purchase and movement of goods, and transportation systems. Emphasizes design of appropriate marketing channels, advanced topics in inventory control, facility location, routing of physical flows among facilities, and design and evaluation of transportation systems.
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

BA 5630 - Operations Strategy
Application and case studies are used to address issues in operations management, quality, research and development, capacity planning, budgeting, marketing, supply chain, and technology to provide an interdisciplinary, quantitative focus on decision making and strategic planning for operations.
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): BA 5610

BA 5640 - Global Operations & Logistics
Case analysis, in-depth article reviews, and course projects are used to address issues in the design and management of global supply chains. Topics include global sourcing strategies, strategic alliances, demand and supply uncertainties, logistic network design, managing variability and risk, supply chain interactions and the value of information.
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 5610

BA 5650 - Project Management
Focuses on project definition, selection, planning, scheduling, implementation, performance monitoring, evaluation and control. Emphasis will be on product, service and process development and emerging concepts related to development on the internet. Some advanced concepts in resource constraint management and design matrix are included.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BA 5670 - Business Process Simulation
Discrete event and continuous simulation modeling techniques applied to the analysis of business processes. Special- purpose simulation software will be used to analyze cases and problems from the manufacturing and service sectors.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BA 2100 or MA 2710 or MA 3710 or MA 3720

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, Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
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, Spring
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 5740 - Management of Technology and Innovation
An evolutionary strategic perspective is taken viewing how technology strategy evolves from underlying technological competencies, patterns of innovation, sources of external technological knowledge and modes of transfer.
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

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 5760 - Corporate Social Responsibility & Business Ethics
Explores corporate social responsibility (CSR), business ethics, and corporate governance. Topics include organizational and environmental forces which drive CSR (e.g., sustainability, fair trade, globalization); stakeholder theory; the strategic context of CSR; and implementation of CSR into strategy and culture.
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

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

BE 5110 - Neuroengineering
Brief overview of neuroanatomy, neurophysiology, and neurobiology followed by introductions of more advanced topics including neural tissue engineering, neural/electrode interfaces, and functional electrical stimulation.
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 5200 - Biology for Engineers II
Covers, at an advanced level, the general principles and engineering applications of science and biology, including cell biology, physiology, molecular biology, genetics, and biotechnology.
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 5300 - Advanced Polymeric Biomaterials
A specialized study of polymers used in biomedical engineering. Topics include: processing-structure-properties relationships for polymers, polymer fibers and composites, degradation of polymers, and medical applications for composite biomaterials.
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 5440 - Genetic Engineering
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 5510 - Cardiovascular Engineering
Fundamental cardiovascular pathology and the biomedical engineering approaches being developed and used toward problems resulting in significant cardiovascular deficiency such as myocardial infarction, chronic kidney disease, atherosclerosis, and heart valve disease.
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 5550 - Biostatistics for Health Science Research
An overview course of biostatistical methods used in the health sciences. Topics include a review of undergraduate statistical concepts, NIH, CDC, and FDA guidelines for clinical trial research, proper use of biostatistical methods including anova models, logistic regression, risk analysis, survivorship analysis and any other statistical methods that are common in the enrolled students' discipline.
Credits: variable to 4.0
Semesters Offered: On Demand
Pre-Requisite(s): MA 2720 or MA 3710

BE 5660 - Active Implantable Devices
Implantable devices that are actively delivering therapy and acting as monitoring tools will be covered. Emphasis will be on the technology and its application. Devices include electrical stimulators, pumps & diagnostic instrumentations.
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 - Biosensors
This course introduces the student to the fundamentals of biosensor development and applications. It provides an understanding of biological components, immobilization methods, transducers, and fabrication 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

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 - Offered alternate years beginning with the 2005-2006 academic year
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 5020 - Enzymology
Detailed biochemical analysis of enzyme structure-function relationships, enzyme mechanisms, and enzyme kinetics. Topics include details of advanced protein and ribozyme structure, enzyme co-factors and other post-translational modifications, spectroscopy as applied to kinetic measurements and structural determination, as well as the rational design and directed evolution of enzyme function and stability for biotechnological applications.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring - Offered alternate years beginning with the 2007-2008 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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 - Offered alternate years beginning with the 2002-2003 academic year
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 - Offered alternate years beginning with the 2002-2003 academic year
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 - Offered alternate years beginning with the 2000-2001 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 3210 or BL 3310

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 - Offered alternate years beginning with the 2007-2008 academic year
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 - Offered alternate years beginning with the 2007-2008 academic year
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 - Offered alternate years beginning with the 2000-2001 academic year
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 5502 - Biological Sciences Seminar
A seminar course for the presentation, interpretation and integration of current research topics.
Credits: 1.0; Repeatable to a Max of 97
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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 - Offered alternate years beginning with the 2004-2005 academic year
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 - Offered alternate years beginning with the 2005-2006 academic year
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

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 - Offered alternate years beginning with the 2003-2004 academic year
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 - Offered alternate years beginning with the 2001-2002 academic year
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 - Offered alternate years beginning with the 2000-2001 academic year
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 - Offered alternate years beginning with the 2001-2002 academic year
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 - Offered alternate years beginning with the 2004-2005 academic year
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 - Offered alternate years beginning with the 2001-2002 academic year
Pre-Requisite(s): CE 3332 or (BA 3610 and BA 3700)

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 - Offered alternate years beginning with the 2006-2007 academic year

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, Spring
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: (0-2-1)
Semesters Offered: Spring
Pre-Requisite(s): CE 4505

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 - Transport and Transformation of Organic Pollutants
Assessment of factors controlling environmental fate, distribution, and transformation of organic pollutants. Thermodynamics, equilibrium, and kinetic relationships are used to quantify organic pollutant partitioning and transformations in air, water, and sediments. Use of mass balance equations to quantify pollutant transport.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2005-2006 academic year
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/Visspectroscopy, 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 5512 - Applied Boundary Layer Meteorology
Study of how forcing phenomena affect transport of water and chemicals in the atmospheric boundary layer and how this transport is measured in the field, including relevant aspects of fluid dynamics, boundary layer structure, surface energy balance, and flux measurement.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2006-2007 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

CE 5515 - Atmospheric Chemistry
Study of the photochemical processes governing the composition of the troposphere and stratosphere, with application to air pollution and climate change. Covers radical chain reaction cycles, heterogeneous chemistry, atmospheric radiative transfer, and measurement techniques for atmospheric gases.
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): CE 4501 or CH 3520

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 - Offered alternate years beginning with the 2005-2006 academic year
Pre-Requisite(s): MA 2160

CE 5620 - Stochastic Hydrology
Application of statistics to problems in surface hydrology. Topics include the flood flow and streamflow frequency analysis, goodness-of-fit tests, model selection, treatment of historical and censored data, regionalization and regression, time series analysis, Bayesian inference, sensitivity and uncertainty analysis methods.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Pre-Requisite(s): MA 3710 and 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, Spring
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 ENT 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

Investigates the stability of both natural and anthropogenic derived structures. Studies include the application of engineering geology to slope issues, slope stability analysis procedures, computational methods. Also covers the design and analysis of soil nail walls.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
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 5221 - Mass Spectroscopy and Fluorescence
Fundamentals and applications of gas chromatography-mass spectroscopy, liquid chromatography-mass spectroscopy and fluorescence spectroscopy.
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

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 - Transport and Transformation of Organic Pollutants
Assessment of factors controlling environmental fate, distribution, and transformation of organic pollutants. Thermodynamics, equilibrium, and kinetic relationships are used to quantify organic pollutant partitioning and transformations in air, water, and sediments. Use of mass balance equations to quantify pollutant transport.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)

Semesters Offered: Fall - Offered alternate years beginning with the 2005-2006 academic year
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 5515 - Atmospheric Chemistry
Study of the photochemical processes governing the composition of the troposphere and stratosphere, with application to air pollution and climate change. Covers radical chain reaction cycles, heterogeneous chemistry, atmospheric radiative transfer, and measurement techniques for atmospheric gases.
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): CH 3520 or CE 4501

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: Fall
Pre-Requisite(s): CH 3520

CH 5570 - Advanced 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 5900 - Chemistry Seminar
Graduate seminar in 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 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 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 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 5720 - Advanced Mineral Processing
Topics in mineral processing of current interest. Will cover grinding, flotation, agglomeration, pollution prevention, surface chemistry, and other areas where rapid advancement is occurring.
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

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

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 - Graduate 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 - Advanced Topics in Computation Theory

Advanced formal models and logics for computation such as Turing machines, abstract state machines, B method, pi-calculus, circuit model, and parallel models. Advanced topics on time and space complexity, approximation algorithms for NP-complete problems.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Pre-Requisite(s): CS 4311

CS 5321 - Advanced Algorithms

Design and analysis of advanced algorithms. Topics include algorithms for complex data structures, probabilistic analysis, amortized analysis, approximation algorithms, and NP-completeness. Design and analysis of algorithms for string-matching and computational geometry are also covered.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Pre-Requisite(s): CS 4321

CS 5331 - Parallel Algorithms

Advanced topics in the design, analysis, and performance evaluation of parallel algorithms. Topics include advanced techniques for algorithm analysis, memory models, run time systems, parallel architectures, and program design, particularly emphasizing the interactions of these factors.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): CS 4431 and CS 4331

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: Fall, 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 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
Students will perform a full cycle of typical research activities on selected advanced research topics in networking, including literature survey, problem formulation, giving assumptions, providing a solution, providing a plan of evaluation, and presentation of results.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Pre-Requisite(s): CS 4461

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 5311 - Advanced Topics in Computation Theory
Advanced formal models and logics for computation such as Turing machines, abstract state machines, B method, pi-calculus, circuit model, and parallel models. Advanced topics on time and space complexity, approximation algorithms for NP-complete 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): 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 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 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, Summer
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 - Offered alternate years beginning with the 2002-2003 academic year
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: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, Summer
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: 3.0
Lec-Rec-Lab: (0-3-0)
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: 3.0
Lec-Rec-Lab: (0-3-0)
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 three 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

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 three 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 5410

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.
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

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 three 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 interraletedness 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 5565 - Developing Algebraic Thinking

Video case studies will be used as a context for the analysis of pedagogical and mathematical issues associated with the teaching and learning of fundamental algebraic ideas. Intended for teachers at the middle and early secondary school levels.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

ED 5570 - Lesson Study
Teachers will engage in an intensive method of improving instruction that includes designing a lesson with a group of colleagues, implementing the lesson in one of their classrooms, and collectively examining the lesson's effectiveness in engaging students in meaningful learning.
Credits: variable to 3.0; Repeatable to a Max of 3
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

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.
Credits: variable to 4.0; Repeatable to a Max of 12
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 life science.
Credits: variable to 4.0; Repeatable to a Max of 12
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.
Credits: variable to 4.0; Repeatable to a Max of 12
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.
Credits: variable to 4.0; Repeatable to a Max of 12
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.
Credits: variable to 4.0; Repeatable to a Max of 12
Semesters Offered: On Demand
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ED 5661 - Professional Development for Educators: Teaching Mathematics through Navigation
This course will cover the theory and practice of marine navigation. Students will learn navigation techniques and procedures while solving navigation problems using mathematics, charts, basic navigation instruments and electronic instruments.
Credits: 2.0
Lec-Rec-Lab: (0-1-2)
Semesters Offered: Summer
Restrictions: Permission of department required; 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.
Credits: variable to 4.0; Repeatable to a Max of 12
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.
Credits: variable to 4.0; Repeatable to a Max of 12
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.
Credits: variable to 4.0; Repeatable to a Max of 12
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.
Credits: variable to 4.0; Repeatable to a Max of 12
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.
Credits: variable to 4.0; Repeatable to a Max of 12
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

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 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

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

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
Pre-Requisite(s): ED 5700

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
Pre-Requisite(s): ED 5700

ED 5750 - Diagnosis and Remediation of Reading Problems

Identification of problems related to reading and language processing; identification and application of diagnostic, remediation and assessment strategies and instruments. Classroom specific experience in diagnosis and remediation of the total communication process.
Credits: 3.0

Lec-Rec-Lab: (0-2-2)
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): 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: Fall, Spring, 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 5410

ED 5920 - Teaching Internship - Preparation for International Teaching
Application of learning theory, including individual differences and content specific pedagogy, in a classroom setting, conducted under supervision of an experienced secondary teacher. Preparation for placement in teaching position with the Peace Corps. Requires completion of MTTC Basic Skills Test.
Credits: variable to 6.0
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): ED 4710(C) or ED 5810(C)

ED 5921 - International Teaching Internship
Application of learning theory, including individual differences and content specific pedagogy, in an international classroom through Peace Corps service. Internship is conducted under the supervision of an experienced secondary teacher. Requires completion of MTTC Basic Skills Test.
Credits: variable to 12.0
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): ED 4710 or ED 5810

ED 5994 - Field Work in International Science Education
Field work and reporting from students in the Peace Corps Master's International Program in Science Education.
Credits: 1.0; Repeatable to a Max of 10
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

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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: Spring - Offered alternate years beginning with the 2007-2008 academic year
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 - Offered alternate years beginning with the 2004-2005 academic year

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 - Offered alternate years beginning with the 2004-2005 academic year
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 - Offered alternate years beginning with the 2008-2009 academic year
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 - Offered alternate years beginning with the 2003-2004 academic year
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 5260 - Wind Power
Wind turbines are the fastest growing segment of the generator mix being added to power systems today. There is a growing need to understand the many issues caused by these additions. This course covers the theoretical background, regulations, integration experience, and modeling.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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 5412 - Radar Remote Sensing
Fundamentals and overview of radar systems. Radar cross-section and detectability; ambiguity function; pulse compression techniques; spectrum estimation for underspread and overspread targets; TDOA: interferometry; multi-static and passive systems. Aperture synthesis (SAR) and antenna theory if time allows.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2008-2009 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 3140 and EE 3160

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: Fall, 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 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 5511 - Information Theory
Mathematical models for channels and sources; entropy, information, data compression, channel capacity, Shannon's theorems, and rate-distortion theory.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2007-2008 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 5500

EE 5512 - Coding Theory
General discussion on coding theory with emphasis on the algebraic theory of cyclic codes using finite field arithmetic, decoding of BCH and RS codes, convolutional codes and trellis decoding algorithms.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2008-2009 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 5511

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 5500

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 and EE 3160

EE 5525 - Wireless Communications

Principles of wireless communications systems. Projects may include cell phones, computer networks, paging systems, satellite communications, radio, television and telemetry.
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 5527 - Digital Communications

This course focuses on the basic principles that underlie the analysis and design of digital communication systems. Topics covered include: characterization of communication signals and systems, modulation schemes, optimum receiver design and performance analysis in AWGN and band-limited channels, concepts of information theory and channel coding, carrier and symbol synchronization, and ISI channel equalization.
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): EE 4250

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 5535 - Wireless Communications II - Advanced Topics

The objective of this course is to identify and understand some of the key research issues and recent research advances in wireless communications. This course will provide a brief introduction to wireless communication systems, visions and challenges, wireless channel modeling, channel estimation, diversity and fading. MIMO multi-antenna systems and space-time coding, as well as selected topics of contemporary interest, such as turbo coding, multi-carrier OFDM, and ultra-wideband 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): EE 4250 and EE 5527

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: On Demand - Offered alternate years beginning with the 2001-2002 academic year
Restrictions: Must be enrolled in one of the following Major(s): Computer Engineering, Electrical Engineering
Pre-Requisite(s): EE 5520

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 - Offered alternate years beginning with the 2005-2006 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 4261 or MEEM 4700 or MA 4330

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, Spring
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 - Offered alternate years beginning with the 2002-2003 academic year
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: Fall, Spring - Offered alternate years beginning with the 2003-2004 academic year
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 - Offered alternate years beginning with the 2004-2005 academic year
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 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 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

Exercise Science & Health

EH 5350 - Special Topics in Kinesiology
Selected additional topics in kinesiology for advanced students based on interests of faculty and students. Interested students should contact the Exercise Science, Health and Physical Education department.
Credits: variable to 9.0; Repeatable to a Max of 9
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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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 or (ENG 5101 and ENG 5102)

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
Pre-Requisite(s): ENG 5100 or (ENG 5101 and ENG 5102)

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; Repeatable to a Max of 6
Semesters Offered: Fall, Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): ENG 5100 or (ENG 5101 and ENG 5102)

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 5000 - Distinguished Ecologist Lecture Series
An opportunity to meet with some of the world's leading ecologists and to discuss their research. Pre- and post-lecture meetings enable students to review some of the research and discuss how it has impacted the field of ecology.
Credits: 1.0; May be repeated
Lec-Rec-Lab: (1-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5020 - Indentification & 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 5032 - Integrated Forest Inventory and Data Analysis
Sampling approaches for estimating overstory, understory, wildlife, and abiotic attributes in forested ecosystems. Includes parameter estimation at different scales such as stand, forest, and landscape and emphasizes data management and statistical analysis techniques.
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 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 - Offered alternate years beginning with the 2005-2006 academic year
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 - Offered alternate years beginning with the 2005-2006 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5098 - Advanced Wood Processing

Wood is an abundant and widely-used raw material. Wood-based manufacturing plants in the upper midwest are toured during the week prior to the start of the Fall semester. Plant characteristics are discussed during class meetings.
Credits: 2.0
Lec-Rec-Lab: (1-0-3)
Semesters Offered: Fall

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 5115 - Restoration Ecology

Study the tools, challenges, and philosophical underpinnings associated with ecological restoration. Restoration of forest, grassland, and wetland communities (plant and animal) will be discussed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2004-2005 academic year
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 - Offered alternate years beginning with the 2004-2005 academic year
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 - Institutions and Natural Resource Management

Examines how institutions manage natural resources to meet their legal and social requirements and the demands of constituencies. Emphasis is on case study application.
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 5180 - Philosophy and Ethics of Conservation and Ecology

Covers the philosophy of science as it relates to ecological science and environmental ethics as it relates to natural resource management. Course

will be taught in the second half of spring semester.
Credits: 2.0
Lec-Rec-Lab: (0-2-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2007-2008 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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 - Offered alternate years beginning with the 2000-2001 academic year
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: 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
Design and analysis of univariate experiments using analysis of variance (ANOVA) and related techniques. Topics covered include factorial experiments and use of blocking and covariance analysis to control experimental error.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2001-2002 academic year
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, hierarchial 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 - Offered alternate years beginning with the 2004-2005 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5412 - Regression with the R Environment for Statistical Computing
Use of R for basic data manipulation, statistical summary and regression. Topics include installing R, data import and export, basic statistics, graphics and fitting of linear, non-linear and mixed-effects models.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2006-2007 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Co-Requisite(s): FW 5411

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 5540 - Advanced Terrestrial Remote Sensing
Remote sensing principles and concepts at the graduate level. Topics include camera and digital sensor arrays, types of imagery, digital data structures, spectral reflectance curves, applications and introductory digital image processing. Students are required to develop and complete a remote sensing project.
Credits: 4.0
Lec-Rec-Lab: (2-1-3)
Semesters Offered: Fall - Offered alternate years beginning with the 2008-2009 academic year
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 - Offered alternate years beginning with the 2005-2006 academic year
Restrictions: Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): FW 4540

FW 5620 - Herpetology
The biology of amphibians and reptiles, including evolution, zoogeography, ecology, behavior and physiology.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2007-2008 academic year
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: 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; May not be enrolled in one of the following Class(es): Freshman, Sophomore

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: Fall, 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: 3.0
Lec-Rec-Lab: (1-2-0)
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. Indigeous 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 5020 - Earth Systems Science I
Includes basic geologic content traditionally covered in university-level physical geology and historical geology. The courser contact is a stepping through geologic time from the present in to the past. The course will take a place-based approach, using the geologic record of Michigan.
Credits: 4.0
Lec-Rec-Lab: (0-4-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

GE 5030 - Earth Systems Science II
Focuses on material traditionally covered in courses on astronomy, meteorology, and oceanography. This course will also address content from the field by focusing on the Earth's climate system.
Credits: 4.0
Lec-Rec-Lab: (0-4-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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, slipsystems, 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, flovial, 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 - Offered alternate years beginning with the 2003-2004 academic year
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 - Offered alternate years beginning with the 2005-2006 academic year
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 5250 - Advanced Computational Geosciences
Introduction to quantitative analysis and display of geologic data using Matlab and Excel, covering basic Matlab syntax and programming, and analysis of one-dimensional (e.g. time series) and two-dimensional datasets (e.g. spatial data). Techniques are applied to geological datasets.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Spring
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 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 3160 and PH 2200 and GE 2000

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 - Offered alternate years beginning with the 2003-2004 academic year

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 5785 - Seismic Petrophysics
Seismic petrophysics describes the use of rock physics information and logging data in the interpretation of reflection seismic data. The theories and empirical models relating seismic properties to other properties of rocks will be reviewed, and the logging techniques responsible for identifying those properties discussed. Various approaches to the quantitative interpretation of seismic data are covered. For varying course credit, projects with real data will be conducted by students.
Credits: variable to 3.0
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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 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, historigraphic, 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 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: 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 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: 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 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: 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 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: 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 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: 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 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: 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 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

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 - Offered alternate years beginning with the 2001-2002 academic year
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 - Offered alternate years beginning with the 2002-2003 academic year

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 - Offered alternate years beginning with the 2003-2004 academic year
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 combilateral structures such as difference sets, symmetric designs, projective geometries, orthogonal latin squares, transversal designs, steiner systems and tournements.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): MA 4209 and MA 5301

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 - Offered alternate years beginning with the 2002-2003 academic year
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 - Offered alternate years beginning with the 2002-2003 academic year
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 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 - Offered alternate years beginning with the 2005-2006 academic year
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 - Offered alternate years beginning with the 2001-2002 academic year
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 - Offered alternate years beginning with the 2003-2004 academic year
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 - Offered alternate years beginning with the 2002-2003 academic year
Pre-Requisite(s): MA 4450 and MA 4330

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 - Offered alternate years beginning with the 2005-2006 academic year
Pre-Requisite(s): (MA 4330 or MA 4610) and MA 4450

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 - Offered alternate years beginning with the 2000-2001 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MA 5548 - Mathematical Continuum Mechanics
Langrangian 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 - Offered alternate years beginning with the 2003-2004 academic year
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 - Offered alternate years beginning with the 2003-2004 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MA 4450 and MA 4330

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): MA 4330 or MA 4630

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 - Offered alternate years beginning with the 2000-2001 academic year
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 - Offered alternate years beginning with the 2003-2004 academic year
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 - Offered alternate years beginning with the 2002-2003 academic year
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 - Offered alternate years beginning with the 2003-2004 academic year
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): MA 4450 and MA 4760 and MA 4770

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 - Offered alternate years beginning with the 2003-2004 academic year
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 - Offered alternate years beginning with the 2000-2001 academic year
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 - Offered alternate years beginning with the 2006-2007 academic year

MA 5761 - Computational Statistics

Introduction to computationally intensive statistical methods. Topics include resampling methods, Montes 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
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 - Offered alternate years beginning with the 2005-2006 academic year

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 5920 - Statistics for Educators

Intended for practicing teachers, this course focuses on strengthening understanding of statistical topics required at the secondary level and associated pedagogical issues. Includes descriptive statistics, probablility, normal distribution, interpretation/analysis of univariate and bivariate data, and exploring variability in systems.
Credits: 4.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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, probabilitistic 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 Geometrics
Introduction to finite geometrics 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 - Offered alternate years beginning with the 2003-2004 academic year
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 - Offered alternate years beginning with the 2003-2004 academic year
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 - Offered alternate years beginning with the 2002-2003 academic year
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

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Mechanical Eng. - Engrg. Mech.

MEEM 5110 - Continuum 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, Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): MEEM 2150 and MEEM 5110

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 hygrothermal 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

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, Spring
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 - Offered alternate years beginning with the 2001-2002 academic year
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 - Offered alternate years beginning with the 2001-2002 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MEEM 4220 and MEEM 5200

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 - Offered alternate years beginning with the 2002-2003 academic year
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 multimodefunctions 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)

Student 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 - Offered alternate years beginning with the 2004-2005 academic year
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: 4.0
Lec-Rec-Lab: (0-3-2)
Semesters Offered: Fall
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 5655 - Introduction to Lean Manufacturing

Lean manufacturing is emerging globally as a paradigm by which business units must function to be globally competitive. Quality, cost, and delivery have become critical measures that impact profits and, in turn, the success of an organization. Significant improvements in all these three measures come from the continuous elimination of waste, or non-value added activities, in manufacturing. Numerous tools are available for the elimination of waste and making businesses lean. This course is intended to familiarize students with this new philosophy of lean manufacturing and arm them with a basic toolset that enables the identification, measurement, and elimination of non-value added activities.

Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2007-2008 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): School of Business & Economics, College of Engineering

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: Fall, 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 - Offered alternate years beginning with the 2001-2002 academic year
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, Spring
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 5705 - Introduction to Robotics and Mechatronics

Cross-discipline system integration of sensors, actuators, and microprocessors to achieve high-level design requirements, including robotic systems. A variety of sensor and actuation types are introduced, from both a practical and a mathematical perspective. Embedded microprocessor applications are developed using the C programming language. A final project is required including analysis, design, and experimental demonstration. Cannot receive credit for both MEEM4705 and MEEM5705.
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): MEEM 4700

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, Spring - Offered alternate years beginning with the 2005-2006 academic year
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 - Offered alternate years beginning with the 2001-2002 academic year
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 - Offered alternate years beginning with the 2001-2002 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MEEM 5110

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 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

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: On Demand
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: On Demand
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: Fall, 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 - Offered alternate years beginning with the 2005-2006 academic year
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, Spring - Offered alternate years beginning with the 2004-2005 academic year
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 - Offered alternate years beginning with the 2005-2006 academic year
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 5970 - Special Topics - Graduate Materials Science and Engineering
Special Topics in Materials Science and Engineering at the Graduate level.
Credits: variable to 4.0; Repeatable to a Max of 8
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required; 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, Spring, Summer
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: Fall, Spring - Offered alternate years beginning with the 2002-2003 academic year
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 - Offered alternate years beginning with the 2006-2007 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): PH 5210

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 - Offered alternate years beginning with the 2003-2004 academic year
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 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 - Offered alternate years beginning with the 2000-2001 academic year
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 - Offered alternate years beginning with the 2001-2002 academic year
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: On Demand
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 5640 - Atmospheric Physics
Essential elements of atmospheric physics, including thermodynamics (e.g. adiabatic processes, phase transformations, stratification), aerosol and cloud physics (e.g. nucleation, Kohler theory, growth by condensation and collection), and radiative transfer (e.g. Beer's law, transfer equations with and without scattering.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2008-2009 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): PH 2300 and MA 3530

PH 5680 - Atmospheric Fluid Dynamics
Fundamental forces and conservation laws that govern fluid flow; applications to the atmosphere, including balanced flow (pressure gradient and Coriolis force), vorticity dynamics, turbulence, waves, and boundary layers.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2007-2008 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): PH 2300 and MA 3530

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 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 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, Summer
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 5150 - Natural Hazards and Human Impacts
The interaction of humans and environment is examined through field study on the Keweenaw Peninsula. Focus on natural hazards, geological and geographical landscapes and processes. Integrates scientific and social scientific content knowledge with pedagogical approaches for K-12 teachers.
Credits: 3.0
Lec-Rec-Lab: (0-1-6)
Semesters Offered: Summer
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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 - Offered alternate years beginning with the 2004-2005 academic year

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 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 - Directed Reading/Independent Study
Directed reading or independent study 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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Technology

TE 5000 - Independent Study in Technology
Students undertake an independent study in an approved technology topic under the guidance of a School of Technology faculty member. The course of study may either be research or academic and is decided upon between the student and faculty member.
Credits: variable to 3.0; Repeatable to a Max of 6
Semesters Offered: On Demand
Restrictions: Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

TE 5001 - Special Topics in Technology
Topics of special interest in technology will be offered depending on student demand and faculty interest or expertise.
Credits: variable to 4.0; Repeatable to a Max of 12
Semesters Offered: On Demand

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

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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 Career Center Co-op Office, 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 instructor 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 - Offered alternate years beginning with the 2004-2005 academic year
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; May be repeated; 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 or revising a report, thesis, or dissertation. Open only to students who have completed all course and credit requirements. Limited access to advisor's time (about 1 hour per month based on the standard conversion of 1 credit = 1 contact hour per week). Requires advisor's permission to register. No access to labs and other campus facilities. Enrollment includes email and library privileges.
Credits: 0.3; May be repeated; 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 - Final-Term Graduate Registration
Meets final-term enrollment requirement for graduate students defending report, thesis or dissertation and returning from enrollment in UN 5951/5952. Students completing a coursework only degree may register with permission from the Graduate School. 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. If campus computing facilities are necessary, student must pay department's basic computing access fee.
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

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