Michigan Technological University

Graduate Course Descriptions
Effective Fall 2025

Accounting

ACC 5100 - Advanced Auditing and Fraud Examination

An in-depth study of auditing with a focus on fraud examination from an external auditor's perspective. The course utilizes problems, cases, and projects using digital evidence and analytical tools relating to fraud examination and forensic accounting.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Major(s): Accounting, Accounting and Analytics; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): ACC 4100

ACC 5200 - Financial Statement Analysis, Modeling, and Valuation

Study of financial statement analysis and concepts of valuation utilizing accounting based financial information. Methods are applied to encompass decision making, communication, and judgment using problems, cases, and projects.
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): Accounting, Accounting and Analytics; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ACC 5500 - Strategic Cost Accounting

This course focuses on the use of managerial accounting information in making strategic business decisions. Topics include contemporary costing methods, statistical analysis of profit and cost centers, advanced optimization and cost modeling techniques, and performance evaluation.
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; Must be enrolled in one of the following Major(s): Accounting, Accounting and Analytics; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ACC 5600 - Tax and Tax Analytics for Decision Makers

Study of advanced planning techniques, including data and scenario analysis, to provide effective tax decision making through development of analytical, research, and professional communication skills.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Accounting, Accounting and Analytics; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ACC 5700 - Accounting Analytical Methods and Emerging Technologies

This course focuses on the utilization of data analytics and emerging technologies to solve contemporary accounting/auditing problems.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Major(s): Accounting, Accounting and Analytics; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ACC 5900 - Current Issues in Accounting

This course examines current issues in the accounting profession. Designed as a capstone course to further understand concepts introduced through the analysis of contemporary accounting issues.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Summer
Restrictions: Must be enrolled in one of the following Major(s): Accounting, Accounting and Analytics; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ACC 5990 - Special Topics in Accounting

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

Aerospace Engineering

AE 5570 - Advanced Space Mechanics

This course introduces the concepts of spacecraft motion, derivation of the model equations, and analytical and numerical solutions. Two-body problems, orbit determination, orbit transfer maneuvers, interplanetary trajectories, and rendezvous problems will be discussed.
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): Mechanical Eng-Eng Mechanics, Mechanical Engineering

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: Fall, in even years
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 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: (3-0-0)
Semesters Offered: Fall, in even years
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 3510 or CH 3520 or ENVE 4504 or CEE 4504

ATM 5519 - Atmospheric Biogeochemistry

Study of the relationship between atmospheric composition, global change, and the circulation of major elements through the Earth system. Responses of ecosystem emissions to changes in landuse, biodiversity, nutrient supply, plant stressors, and climate change are discussed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): CH 1150

ATM 5640 - Atmospheric Physics

Essential elements of atmospheric physics, including thermodynamics, aerosol and cloud physics, radiative transfer, and atmospheric fluid dynamics.
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): MA 3530 and PH 2300

ATM 5680 - Geophysical Fluid Dynamics

Fundamentals forces and conservation laws that govern fluid flow; applications to the atmosphere and ocean, 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: Spring, in even years
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: Must be enrolled in one of the following Level(s): Graduate

Business Administration

BA 5200 - Information Systems Management and Data Analytics

Focuses on management of IS/IT within the business environment. Topics include IT infrastructure and architecture, organizational impact of innovation, change management, human-machine interaction, and contemporary management issues involving data analytics. Class format includes lecture, group discussion, and integrative case studies.
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; Must be enrolled in one of the following Major(s): Accounting, Data Science, Engineering Management, Applied Natural Resource Econ., Health Informatics, Accounting and Analytics, Business Administration

BA 5300 - Financial Reporting and Control

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; Must be enrolled in one of the following Major(s): Applied Natural Resource Econ., Business Administration, Engineering Management, Accounting and Analytics, Accounting

BA 5400 - Financial Risk Management and Decision Making

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: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Applied Natural Resource Econ., Engineering Management, Accounting, Business Administration
Pre-Requisite(s): BA 5300

BA 5610 - Operations 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: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Data Science, Engineering Management, Applied Natural Resource Econ., Accounting, Business Administration

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: Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MA 2710 or MA 2720 or MA 3710 or EET 2010 or CEE 3710 or BUS 2100

BA 5700 - Managing Behavior in Organizations

Discusses managing effectively within the environmental context of the organization. Topics include corporate culture, managing in a global environment, planning and strategy, organizational structure, human resources management, managing change, leadership, motivation, communication, conflict management, and teamwork.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Applied Natural Resource Econ., Engineering Management, Accounting, Business Administration

BA 5710 - Business and Corporate Strategies

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: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Applied Natural Resource Econ., Engineering Management, Accounting, Business Administration
Pre-Requisite(s): (BA 5300 and BA 5400(C) and BA 5700 and BA 5800) or MGT 4000

BA 5720 - 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: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Applied Natural Resource Econ., Engineering Management, Accounting, Business Administration

BA 5740 - Managing Innovation and Technology

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: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Data Science, Engineering Management, Applied Natural Resource Econ., Accounting, Business Administration

BA 5770 - Managing Change

This course focuses on theory, research, and practice of both 'planned' and 'unplanned' change. The course considers the dynamics of change in complex organizations, variables which facilitate or impede change, and how to lead change and motivate others to change.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Applied Natural Resource Econ., Engineering Management, Accounting, Business Administration
Pre-Requisite(s): BA 5700

BA 5780 - Managing in the Global Environment

Course topics may include the following: impact of international political, economic, technological, and social environment forces, currency risks, cross-cultural management issues, strategic challenges for multinational companies, and international joint ventures and alliances.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Applied Natural Resource Econ., Engineering Management, Accounting, Business Administration
Pre-Requisite(s): BA 5700 and BA 5400(C)

BA 5800 - Marketing, Technology, and Society

The course facilitates students' improvement of analytical skills, information processing techniques, and cultural competence in the globalized marketing environment. Focuses are placed on strategic marketing management, high-tech product marketing, global consumer behavior, branding, and online marketing.
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): Data Science, Engineering Management, Applied Natural Resource Econ., Accounting, Business Administration

BA 5900 - MBA Internship

An opportunity to apply the business principles and skills learned in the MBA program to an organizational environment. The guided experience is integrated with coursework to achieve personalized learning objectives.
Credits: variable to 3.0; Repeatable to a Max of 3
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Engineering Management, Applied Natural Resource Econ., Business Administration

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; Must be enrolled in one of the following Major(s): Engineering Management, Applied Natural Resource Econ., Business Administration

Biomedical Engineering

BE 5000 - Biomedical Masters 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 5115 - Finite Element Modeling

The course teaches both fundamentals of finite element theory and hands-on experience for bio-engineers.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5200 - Cellular and Molecular Biology 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: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5230 - Stem Cell and Tissue Engineering

This course will introduce basic concepts of tissue engineering; scaffold materials and biotechnologies for tissue engineering; basic concept of stem cells; review of stem cell sources and related policies; current progress in stem cell research, and application of stem cells in tissue engineering and regenerative medicine.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5250 - Biomedical Optics

Light plays a significant role in modern clinical diagnostics and in the clinical treatment of disease. Examples include non-invasive surgery, optical biopsy, and cancer therapy. This course will focus on the study of how light propagates through biological tissue.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5300 - Polymeric Biomaterials

This course focuses on the use of polymeric materials in biomedical engineering. Topics will include synthesis and characterization of polymers, structure-properties relationships, degradation behavior, and biomedical applications for polymeric biomaterials.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5330 - Biomimetic Materials

This course introduces students to biologically inspired approaches to design functional biomaterials. Topics include the discovery and incorporation of biological designs into novel materials and their application in the biomedical field.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5335 - Smart Polymers

This course introduces students to smart polymers that change their physical properties in response to various environmental stimuli. Topics include the molecular origin of the stimuli responsiveness of these materials and their application in the biomedical field.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5340 - Biocompatibility

Students will learn the general principles and biomedical engineering applications of biocompatibility. Students will be able to critically read the international standards in the are of biocompatibility.
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 College(s): College of Engineering
Pre-Requisite(s): BE 2400 or BE 4200 or BE 5200

BE 5350 - Cell Biomechanics and Mechanical Transduction

This course is designed to introduce the mechanical analysis and characterization of mammalian cells. Mechanotransduction, whereby cells detect loading and respond to the morphology and mechanical properties of the surrounding extracellular matrix, will be emphasized.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5410 - Medical Imaging

This course covers the physical nature of the interactions between the waves and matter, especially the biological tissues, principle imaging modalities used in modern medicine and the common techniques used for processing of the resulting images.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5412 - Theory of Medical Imaging

Course is about the theoretical aspects of medical imaging. Three main components are; Wave- matter interactions generating the signals for image formation; Techniques for image construction; and Mathematical techniques and computer algorithms for processing of images.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MA 1160 or MA 1161

BE 5510 - Cardiovascular Engineering

The course introduces and reviews fluid dynamics in the context of cardiovascular flows. Applications include analysis of unsteady blood flow, flow through heart valves, blood flow and cardiac chamber fluid-structure interaction, and flow related blood damage.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 2020 and BE 3350 and BE 3550

BE 5530 - 3D Bioprinting

This course will cover the principles of 3D bioprinting to develop therapeutic products. Topics include tissue engineering, introduction of 3D bioprinting techniques, biomaterials and chemistries for the development of bioinks, cell-bioink interactions, and case studies of the application of 3D bioprinting in healthcare.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
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): BE 2400 and BE 3800

BE 5650 - Neural Basis of Rehabilitation Engineering

Basic neuroscience topics underlying sensorimotor control will be introduced. Different types of neuromuscular disorders and current techniques used for diagnosis, assessment, and rehabilitation interventions will be studied.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
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): BE 3350 and BL 2010 and BL 2011 and BL 2020 and BL 2021

BE 5655 - Neural Prosthetic Systems

This course will cover systems that use electrical stimulation to restore normal function following injury or disease. The underlying biophysical basis and technology for treatment, clinical applications and challenges will be studied. Topics include spinal cord stimulation for pain relief, cochlear implants, brain and neuromascular stimulation.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
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): BE 3700 and BL 2010 and BL 2011 and BL 2020 and BL 2021

BE 5670 - Micro & Nano Technologies

This course will introduce students to micro- and nano- technologies and the processes involved in their manufacturing. Particular emphasis will be on their use in biomedical applications. Goal is to provide information beneficial in research and development, and the industry.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
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: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5701 - Advanced Statistical Methods for Engineering

Introduction to the design, conduct, and analysis of statistical studies, with an emphasis on engineering applications. This course covers fundamental statistical concepts, including descriptive and graphical methods, probability models, parameter estimation and hypothesis testing, and experiment design, and data interpretation.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MA 1160 or MA 1161

BE 5755 - Medical Devices

An introduction to medical devices used for diagnosis, monitoring, and treatment in clinical medicine. Topics covered include product planning, reliability, clinical trial design, regulatory as well as technical aspects of common medical devices.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BE 3700

BE 5760 - Numerical Techniques in Biomedical Engineering

An introductory course on numerical techniques consists of three main components: solution of linear and non-linear sets of equations; computer modeling of physiological systems and medical devices; and numerical optimization of 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
Pre-Requisite(s): MA 1161 or MA 1160 or MA 1135 or MA 1121

BE 5770 - Biomedical Microcontrollers

The focus of this course is to provide biomedical engineering students the necessary skills to develop microcontroller-based devices. Provides basic knowledge on computer programming languages, microcontrollers, digital circuits, and microcontroller development kits. Students will design and fabricate a microcontroller-based device using a microcontroller development kit for a specific biomedical application.
Credits: 3.0
Lec-Rec-Lab: (1-0-2)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5850 - Tissue Mechanics

This course integrates continuum mechanics, experiments, and computational methods to understand soft tissue mechanics. The first half of the course is dedicated to building continuum mechanics foundation, which will be used to formulate constitutive equations for arteries and the heart in the second half.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5870 - Computer Vision for Microscopic Images

This course teaches how to quantify data out of images, typically from optical microscopes. It covers thresholding, image derivatives, edge-detection, watershed, multi-scale and steerable filters, 3D image processing, feature extraction, PCA, classification, convolutional neural networks, particle tracking, and diffusion analysis.
Credits: 3.0
Lec-Rec-Lab: (0-1-2)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BE 5900 - Biomedical Engineering Masters 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 5930 - Biomedical Engineering Topics

Biomedical engineering courses will be offered on new or emerging technical subjects depending on student demand and faculty interest and expertise.
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 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 Doctoral 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

Biological Sciences

BL 5012 - Graduate Seminar in Biology

Graduate students will listen to seminars given by visiting scientists that pertain to various research topics in biology. Through assignments students will gain experience in summarizing seminars and learning what makes a "good' seminar.
Credits: 1.0; May be repeated
Lec-Rec-Lab: (1-0-0)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BL 5021 - Biochemistry II

Dynamic aspects of living systems. Broad exposure to cellular metabolic pathways, intermediary metabolism and its regulation and bioenergetics.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, Summer
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

BL 5025 - The Scientific Profession

The practice of sciences for graduate students, including how to plan a research project, grantsmanship, publication, navigating the job market, and timely issues (e.g. ethical conduct, diversity and bias, etc.).
Credits: 2.0
Lec-Rec-Lab: (0-2-0)
Semesters Offered: Spring
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, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BL 5034 - Advanced Evolutionary Ecology

This is an advanced course that looks at the study of ecology and evolutionary biology at the community level: how populations interact with the abiotic environment and each other to determine patterns of diversity, distribution, and abundance of plants and animals.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BL 5035 - Bioimaging

Current concepts in light and electron microscopy and scanning probe techniques. Theory and practice of fluorescence (including confocal and multi-photon), atomic force, scanning and transmission electron, and video microscopy as applied to biological specimens with an emphasis on sample preparation. Emphasis will be placed on application of advanced techniques. Half semester course.
Credits: 2.0
Lec-Rec-Lab: (0-4-0)
Semesters Offered: Fall, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

BL 5038 - Epigenetics

An introduction to the fundamentals of epigenetic control that is not encoded by genomic DNA sequences of an organism. Topics include major regulatory mechanisms including DNA methylation, histone modification, and non-coding RNA (ncRNA) mediated gene regulation.
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

BL 5044 - Human Pathophysiology

Course will cover abnormal function (physiology) and investigate the signs and symptoms of major diseases in humans. Extension of Anatomy & Physiology by working through the systems of the human body. Course will include a clinical focus and case-study approach.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 2010 and BL 2020

BL 5051 - Scientific Writing and Publishing

This course is designed to give graduate students the skills necessary to write and publish scientific journal articles. Topics covered include: general principles of scientific writing, plagiarism and ethics in publishing, critical evaluation of scientific articles, and using reviewers' comments to improve the quality of articles.
Credits: 2.0
Lec-Rec-Lab: (2-0-0)
Semesters Offered: Fall
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

BL 5052 - Fluorescence and Video Microscopy of Biological Sciences

Hands-on training in fluorescence microscopy and video microscopy. Students prepare biological specimens of their choice for observation. Emphasis will be placed on application of advanced techniques. Half semester course.
Credits: 2.0
Lec-Rec-Lab: (0-2-6)
Semesters Offered: On Demand
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): BL 5035

BL 5070 - Environmental Toxicology

Introduction to the range anthropogenic pollutants released into the environment. Concepts of bioaccumulation, biomagnification and environmental persistence, modes of toxicity and detoxification, transport and fate in aquatic and terrestrial ecosystems. Toxic equivalent factors and quotients, regulatory guidelines and practices.
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): Medical Laboratory Science, Biochem & Molec Biology-Bio Sc, Bioinformatics, Pharmaceutical Chemistry
Pre-Requisite(s): BL 1020 or BL 1040 or (BL 1200 and BL 1210) or (BL 1400 and BL 1410) and CH 1160

BL 5120 - Environmental Remediation

Toxicology of major environmental pollutants, their dose-response relationships and fundamentals of environmental remediation. Topics include physical, chemical, and biological remediation methods and effect of environmental toxins on biological systems. Laboratory will involve the application of chemical and biological remediation techniques.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Fall, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

BL 5141 - Algae

The Lake Superior watershed has a rich, diverse, algal flora inhabiting numerous acid bogs, peatlands, ponds, lakes, fens, streams, rivers. This course emphasizes field collections and microscopic identification and includes discussions of algal culture techniques, invasives, blooms, limnology, and algal biotech.
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

BL 5145 - Plant-Microbe Interactions

Interactions between plants and microorganisms in the environment. Topics include microbial virulence, signaling, gene expression, beneficial interactions and disease resistance in plants. Laboratory will focus on plant biochemical and microbiological methods as they relate to environmental problems.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Fall, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

BL 5153 - Applied Genome Editing

This course offers training in genome editing design and implementation. Practical demonstrations of genome editing will be included. The history and ethics of genome editing will be discussed. Graduate students will propose a genome editing project.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
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, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BL 5300 - Applied Bacterial Genomics

This course is an overview of techniques involved in genomics including hands-on experience in next-generation sequencing (NGS) platforms, and NGS sequence analysis including de novo assembly, gene annotation, and analysis including comparative genomics, pathway mapping, and core and pan genome analysis.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years

BL 5310 - Applied Eukaryotic Genomics

This course is designed as a hands-on experience in eukaryotic genomic experiments involving next generation sequencing (NGS) techniques, including eukaryotic gene annotation, comparative genomics, and gene regulation analyses.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 2200 and BL 2210

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

BL 5371 - Advanced Cell Biology

This course is to develop an understanding of the structure and function of the cell. Course topics include details of basic genetic mechanisms, cell structure and function, and examination of cells in their social context.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): (BL 2200 or BL 3012) and (CH 2420 or BL 4010)

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

BL 5390 - Special Topics in Medical 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: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

BL 5395 - Stable Isotopes in Ecology

Fundamentals of stable isotope ecology and biogeochemistry. Topics include stable isotope systematics and principles, application to ecological questions across levels of organization, interpretation and manipulation of stable isotopic data, and critical evaluation of the literature.
Credits: 2.0
Lec-Rec-Lab: (2-0-0)
Semesters Offered: Fall, in even years
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 3490 and (BL 3020 or CH 1150 and CH 1151)

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

BL 5410 - Developmental Biology

The course will cover developmental biology topics from gametogenesis over fertilization, embryonic development to postembryonic development, including aging. Developmental genetics and the evolution of development (evo-devo) are an important component of this course.
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): BL 2200 and (BL 3012(C) or BL 4370(C))

BL 5421 - Lake Superior Exploration

Field intensive course with significant time spent on a research vessel (R/V Agassiz or some other) where students will learn the use of a variety of state-of-the-art techniques to characterize biological communities and measure important physical and biological processes.
Credits: 3.0
Lec-Rec-Lab: (4-0-6)
Semesters Offered: Summer, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BL 5440 - Microbial Ecology

Interactions between microorganisms and between microorganisms and the environment with focus on the processes mediated by and controls on microbial life, and the methods used in the rapidly evolving field of microbial ecology. Emphasis on primary literature, discussion, and the integration of microbial ecology topics into professional writing.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BL 5447 - Stream Ecology

Field course combining river and stream ecosystem and foodweb study with fishes in lake systems. Students will be exposed to research methods used in lakes for comprehensive abiotic and biotic understanding.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall, in even years, Summer, in even years

BL 5451 - Advanced Ecology

This course will provide advanced coverage of ecological pattern, science, and theory of aquatic and terrestrial systems and their interface. Topics will range from individuals and populations to communities and landscapes. Lectures and discussions will be guided by published literature.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BL 5461 - Ecosystem Ecology

History, key concepts, and practice of ecosystem ecology in aquatic and terrestrial environments. Emphasizes inter-connectedness of energy and nutrient flows globally and in regional case studies.
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): BL 3400 and CH 1122 or (CH 1160 and CH 1161)

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 5503 - Graduate Research Seminar Biomolecular

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

BL 5678 - Biological Sciences Field Service

This course provides a supervised field experience in biological sciences, natural resources, and community development.
Credits: 1.0; May be repeated
Lec-Rec-Lab: (0-0-3)
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 Major(s): Biological Sciences

BL 5752 - Cancer Biology

Emphasis on characteristic genetic, molecular, and cellular changes leading to cancer. Topics will include the role of tumor viruses, oncogenes, tumor suppressors, immortalization, apaptosis, and angiogenesis in cancer initiation, and/or progression. Consideration of current therapies and future directions for treatment.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BL 5800 - Molecular Diagnostics

This course describes advanced concepts in molecular diagnostics as applied to the practice of laboratory medicine. Students are introduced to the theory and techniques used in paternity testing, identification of microorganisms, diagnosis of human disease. Graduate students will apply molecular approaches to their thesis research projects.
Credits: 4.0
Lec-Rec-Lab: (3-0-2)
Semesters Offered: Spring
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; May be repeated; 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 15.0; May be repeated; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer

Biochemistry Molecular Biology

BMB 6010 - Advanced Biochemistry

Course will focus on the relationships between structure and function of proteins, nucleic acids, lipids, and carbohydrates. Specific topics include enzyme catalysis; binding and allosterism; protein-protein, protein-carbohydrate, and protein-nucleic acid interactions; membrane function, and, signal transduction.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BMB 6020 - Advanced Molecular Biology

Course will focus on gene structure, gene duplication, gene expression, gene regulation, DNA recombination, DNA repair and transposition. Comparison between prokaryotes and eukaryotes will be drawn. Genomics and modern biotechnology methods will be discusses. Classic and current papers may accompany the lecture material. Foundations in basic biochemistry and molecular biology are required for this course.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BMB 6030 - Modern BMB Laboratory

This is an intensive laboratory course that focuses on protein chemistry, nucleic acid chemistry, genomics and biotechnology. Students will rotate between research labs of four faculty where they will gain in-depth laboratory experience in modern biochemistry and molecular biology.
Credits: 3.0
Lec-Rec-Lab: (0-0-9)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

BMB 6990 - Doctoral Research in Biochemistry and Molecular Biology

Original research that culminates in a PhD dissertation.
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

Civil & Environmental Engineering

CEE 5030 - Building Information Modeling

Project-based learning will involve the use of industry BIM software, including Autodesk Revit and Navisworks. The focus will be on applying BIM to civil and construction engineering projects, such as building modeling, 4D visualization, and crash detections, with an emphasis on residential cases. BIM theories will also be introduced.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall

CEE 5101 - 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): CEE 3101

CEE 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

CEE 5109 - Sustainable Pavement Engineering and Civil Engineering Materials

This class will develop fundamental knowledge of sustainable pavements, recycled materials, asphalt and concrete materials, basic concept of characterization of pavement materials, data analysis, and basic modeling procedures. The course will cover a wide range of advanced knowledge of sustainable pavements and materials.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Permission of instructor required
Pre-Requisite(s): CEE 3101

CEE 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

CEE 5201 - Advanced Structural Analysis

The study of nonlinear structural analysis techniques, especially energy methods, applied to elastic buckling analysis, large deflections of beams, second-order effects in frames, and plastic analysis of steel structures.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): CEE 4201 or CEE 5203

CEE 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): CEE 4201 or CEE 5203

CEE 5203 - Matrix Structural Analysis

Analysis of trusses and frames by the direct stiffness method. Use of a typical commercial computer code is stressed as a tool for complex structures. Introduces three-dimensional structures.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Fall, Spring
Pre-Requisite(s): CEE 3202

CEE 5211 - Structural Concrete Design

Introduction to design of reinforced concrete structural components. Analyze and design reinforced concrete beams, columns, and footings. Understand material behavior, limit state criteria, and practical detailing considerations. Application of the ACI 318 to cast-in-place and precast systems.
Credits: 4.0
Lec-Rec-Lab: (0-3-2)
Semesters Offered: Spring
Pre-Requisite(s): CEE 3202

CEE 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: Fall
Pre-Requisite(s): CEE 4213 or CEE 5211

CEE 5213 - Concrete and Masonry Building Systems

Design of reinforced concrete two-way slabs and reinforced masonry systems for buildings. Includes design of bearing walls, shear walls, lintels, pilasters, slender columns, torsional beams and connections. A design project may be included during the semester.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Pre-Requisite(s): CEE 4213 or CEE 5211

CEE 5221 - Steel Design I

Behavior and design of structural steel members using both ASD and LRDF approaches. Covers material behavior, external loads, and the design of tension, compression, and flexural members (rolled, built-up, and composite), and simple welded and bolted connections.
Credits: 4.0
Lec-Rec-Lab: (0-3-2)
Semesters Offered: Fall
Pre-Requisite(s): CEE 3202

CEE 5223 - Steel Design II

Additional topics in steel design including beam-columns, floor vibrations, diaphragms, buckling behavior of thin elements, torsional buckling, and beam and column bracing. Includes an introduction to cold-formed steel design.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): CEE 4223 or CEE 5221

CEE 5231 - Structural Timber Design

Introduction to the use of wood as a structural engineering material. Includes design of beams, columns, nailed and bolted connections, trusses, and panels. Overview of engineered timber systems including glulam, LVLs, I-joists, and cross-laminated timber.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): CEE 3202 or CMG 3250

CEE 5233 - Advanced Structural Timber Design

Advanced design of timber structures, including glulam tapered and curved beams, arches, and traditional timber frames, advanced shear wall design, advanced connection design, including timber connectors and cross-laminated timber design.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in odd years
Pre-Requisite(s): CEE 4233 or CEE 5231

CEE 5241 - Structural Dynamics

Free and forced vibration of undamped and damped single degree of freedom systems. Seismic design using the equivalent lateral force method. Introduction to multi-degree of freedom systems and transmissibility.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Summer
Pre-Requisite(s): CEE 4201(C) or CEE 5203(C)

CEE 5242 - Advanced Structural Dynamics

Earthquake engineering and advanced dynamic analysis. Includes modal analysis, time history response of multiple degree-of-freedom systems, and base isolation.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): CEE 5241

CEE 5244 - Loads for Civil Structures

The course focuses on the theory and building code requirements for civil structural loadings that are used in design. The loads and load combinations will include dead loads, occupancy live loads, snow loads, wind loads, and seismic loads.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): CEE 3202

CEE 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

CEE 5261 - Bridge Analysis and Design

Introduction to design and behavior of short and medium span bridges. Topics include aesthetics, preliminary design and layout, design of prestresses and plate girders bridges, deck design, foundation design. Project may alternate between structural steel and prestressed concrete member design.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): CEE 4213 and CEE 4223

CEE 5350 - Infrastructure Life Cycle Engineering

The course examines how life cycle assessment (LCA), life cycle costing analysis (LCCA), green rating systems, value engineering and alternative project delivery systems influence design decisions and project outcomes. Topics will be discussed within the context of the underlying scientific principles and relevant standards.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Spring, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

CEE 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

CEE 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. Includes airport pavement design and rehabilitation.
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): CEE 3401 and CEE 3101

CEE 5402 - Traffic Flow Theory

This course is an introduction to traffic flow theory. Course is concerned with the behavior of vehicular traffic as a complex system through the development of mathematical models of these processes. Topics will include macroscopic and microscopic traffic flow theory, as well as connected and automated vehicles.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): CEE 4402

CEE 5404 - Transportation Planning

An introduction to urban transportation planning, planning data collection, transportation planning models, and development and evaluation of transportation plans. Includes extensive use of transportation planning software to evaluate transportation plans in multimodal networks.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall

CEE 5414 - Railroad Engineering

Rail transportation systems require infrastructure, vehicles, motive power and energy, and control systems to move goods and people. This multi-disciplinary course provides students with understanding of these system components and related engineering and technology enabling efficient operation of today's system.
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

CEE 5417 - Transportation Design

Introduction to computer aided geometric design of highways and railways. Covers design principles and use of standards for horizontal and vertical alignments and cross sections, including road intersections, railway turnouts and grade crossings. Students develop engineering drawings and related cost estimates for road/rail project.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): CEE 3401 and SU 2000

CEE 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

CEE 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

CEE 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: (2-0-2)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): CEE 4502

CEE 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): CEE 5501

CEE 5504 - Water Quality Modeling in Natural Systems

Application of mathematical modeling to water quality management. Models are developed to simulate natural phenomena, mass transport, and reaction kinetics in lake and river ecosystems. Students will construct simple models and be introduced to state of the art modeling tools.
Credits: 3.0
Lec-Rec-Lab: (0-2-3)
Semesters Offered: Spring
Pre-Requisite(s): CEE 4505 or BL 4450

CEE 5507 - Water Distribution and Wastewater Collection

Application of basic principles in civil and environmental engineering to the analysis and design of water distribution systems, wastewater collection systems, and their appurtenances. Analysis of research on some topic of the course.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Spring

CEE 5508 - Global Biogeochemistry

This course gives an overview of important biogeochemical processes occurring in land, air, and water. An emphasis is put on modeling as an integrating tool.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in odd years
Pre-Requisite(s): CEE 4501

CEE 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, in even years
Pre-Requisite(s): CEE 4501 or CH 3510

CEE 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: Fall, Summer
Restrictions: Permission of instructor required

CEE 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: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

CEE 5517 - Soil Biogeochemistry

Study of the relationship between soil composition and the circulation of major elements through the earth system. Responses of biogeochemical cycles of the elements in agricultural, forest, grassland, and wetland soils to changes in landuse, biodiversity, nutrient supply, plant stressors, and climate change will be discussed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): CH 1150

CEE 5518 - Aquatic Biogeochemistry

Covers interactions among chemical, biological, and physical processes within aquatic ecosystems as well as role of aquatic ecosystems in global biogeochemistry. Modeling as an integrative tool is stressed.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

CEE 5519 - Atmospheric Biogeochemistry

Study of the relationship between atmospheric composition, global change, and the circulation of major elements through the Earth system. Responses of ecosystem emissions to changes in landuse, biodiversity, nutrient supply, plant stressors, and climate change are discussed.
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

CEE 5520 - Introduction to Hydrodynamic Modeling

Introduce fundamental concept and numerical methods used in hydrodynamic modeling, physical process in the hydrodynamic system and their numerical representation using governing equations. Students construct simplified numerical models with application to problems of coastal oceans and large lakes, as well as engineering systems of interest to environmental and other engineers.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): MA 3520 or MA 3521 or MA 3530 or MA 3560

CEE 5521 - Bioremediation Engineering

Introduction to the microbiological and engineering fundamentals of bioremediation. Topics include relevant microbial biochemistry, physiology, and ecology; necessary site data; design and operation of current and emerging bioremediation systems; monitoring methods for bioremediations projects; and technical evaluation of selected case studies.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

CEE 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

CEE 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

CEE 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

CEE 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

CEE 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

CEE 5610 - Water Resources System Modeling & Design

Solve complicated, open-ended real-world water resources problems in natural and built systems by developing and executing models using state of the practice technologies. Includes programming to manage large datasets and validation or calibration and optimization of models for design.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): CEE 3620 or CEE 3650

CEE 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: Fall, in even years, Spring, in even years
Pre-Requisite(s): CEE 3620 and (CEE 3710 or CEE 3502 or MA 3710)

CEE 5625 - River and Floodplain Hydraulics

Analysis and modeling strategies of open channel systems, including natural channels, designed channels, flow transitions, non-uniform flow, and unsteady flow.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Pre-Requisite(s): CEE 3620

CEE 5630 - Advanced Hydrology

Students will understand hydrologic processes such as transpiration, evaporation, infiltration, base flow, and surface runoff. Students will learn principles of hydrometeorology, principles of sustainability applied to surface water resources, how to collect/analyze hydrologic data, and how to predict/estimate hydrologic responses.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years, Spring, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): CEE 3620

CEE 5640 - Stormwater Management and LID

Design techniques for stormwater collection, conveyance, infiltration, and detention storage systems are discussed, both traditional stormwater management systems and newer approaches based on the philosophy of low impact development (LID) that seek not to alter the natural ecology of a site.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Summer
Pre-Requisite(s): CEE 3620

CEE 5650 - Hydraulic Structures

Application of basic principles fluid mechanics in civil and environmental engineering to the analysis and design of hydraulic structures. Analysis of research on some topic of the course.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): CEE 3620(C)

CEE 5665 - Stream Restoration

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): CEE 3620

CEE 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): CEE 3620 and EC 3400

CEE 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

CEE 5730 - Probabilistic Analysis and Reliability

Examines probabilistic analysis of engineering systems including first-order methods, Monte Carlo simulation, and time-to-failure analysis. Reliability analysis will include capacity/demand reliability and system reliability. Emphasis will be on civil and environmental engineering systems.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Pre-Requisite(s): CEE 3502 or CEE 3710 or MA 3710

CEE 5740 - Frequency-Domain Modeling and Identification of Continuous Civil Engineering Systems

Introductory course in modeling of continuous systems with an emphasis on frequency and complex-domain analysis for civil engineering systems. Potential applications include system identification and control. Preliminary topics include data acquisition and signal conditioning, Fourier, Laplace, and Z-transforms.
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): MA 3520 or MA 3521 or MA 3530

CEE 5760 - Optimization Methods in Civil and Environmental Engineering

Decision analysis and optimization techniques, including linear programming, nonlinear programming, and dynamic programming. Computer-based solutions of design problems in various civil and environmental engineering specialty areas are considered.
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
Pre-Requisite(s): MA 2160 and (MA 2320 or MA 2321 or MA 2330)

CEE 5811 - Fundamentals of Soil Behavior

The course will focus on the fundamentals of soil behavior through coursework and laboratory investigation. Coursework will include soil formation, composition, engineering properties, conduction phenomena, strength, and volume change.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): CEE 3810

CEE 5820 - Advanced Foundation Engineering

This course is designed to provide students in civil engineering with methods of analysis and design for various geotechnical systems. Topics to be covered include subsurface investigations, footings, pile foundations and drilled shafts, earth pressure theories, retaining walls, and slope stability analysis.
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): CEE 3810

CEE 5840 - Advanced Soil Mechanics

This course focuses on advanced soil mechanics topics such as stress and strain, failure criteria, volume change and strength, stress paths, critical state soil mechanics, and unsaturated soil mechanics. The course presents essential concepts, theories, and testing approaches for explaining the engineering behavior of geomaterials.
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
Pre-Requisite(s): CEE 3810

CEE 5850 - Ground Engineering

This course will focus on geotechnical site investigation methods and ground improvement technologies.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): CEE 3810

CEE 5870 - Multiphysics of Porous Materials

Overview of multiphysics, typical multiphysical phenomena in porous materials, and the simulation of these phenomena using numerical techniques.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Fall, in even years

CEE 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

CEE 5900 - Special Topics in CEE

Graduate level topics of interest related to both civil and environmental engineering.
Credits: variable to 3.0; Repeatable to a Max of 6
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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

CEE 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

CEE 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

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

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

CEE 5993 - Engineering with Developing Communities

Study of applying appropriate, community-based, and sustainable engineering in developing communities. Concepts of human-centered design and sustainable development are covered. Topics are drawn from several areas of engineering, including water and wastewater treatment, construction materials, solid waste, energy, and information systems.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate; May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): CE 3620 or CEE 3620

CEE 5997 - Natural Resources Engineering Field Service

This course provides a supervised field experience in natural resources engineering and community development.
Credits: 1.0; May be repeated
Lec-Rec-Lab: (0-0-3)
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

CEE 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

CEE 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): Environmental Engineering, Engineering - Environmental, Civil Engineering

Chemistry

CH 5110 - Medicinal Chemistry: Mechanism of Drug Action

Focuses on structural and mechanistic approaches to pharmaceuticals and drug action. General principles of absorption, distribution, action, metabolism, and toxicity of drugs will be presented followed by action of drug classes such as antibiotics, cardiovascular, and anti-inflammatory drugs.
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 5120 - Medicinal Chemistry: Drug Design

Focuses on the important concepts in the design and synthesis of drugs. Rational basis for drug design including synthetic, computational, and biochemical concepts will be discussed. Topics include structure-activity relationships, synthesis and reaction mechanism, and case studies of drugs.
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 5130 - Professional Development: Chemical Safety

The course will examine Michigan Tech's Chemical Hygiene Plan, understand responsibilities as lab workers, learn how to write Standard Operating Procedures, how to conduct safety inspections, how to be safer in a chemical lab environment and review OSHA rules and regulations regarding conducting research in a chemical laboratory.
Credits: 1.0
Lec-Rec-Lab: (1-0-0)
Semesters Offered: Fall
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): CH 3510 or CH 3540

CH 5140 - Introduction to Pharmaceutical Analysis

This course will present a systematic introduction to chemical analysis of pharmaceutical raw materials, finished pharmaceutical products, and of drugs in biological fluids, which are carried out in pharmaceutical laboratories worldwide.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

CH 5240 - Advanced Mass Spectrometry

Advanced instrumentation and methods are the focus of this course. Design of various mass analyzers and their advantages and limitations will be reviewed. Advanced identification methods such as tandem mass spectrometric analysis and exact mass analysis will be discussed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): CH 4212 or (CH 4210 and CH 4211) or CH 4222 or (CH 4220 and CH 4221)

CH 5241 - Advanced Mass Spectrometry Laboratory

Students will learn how to perform mass spectrometry (MS) experiments to identify and quantify molecules. The experiments will include the following method approaches: electrospray ionization (ESI), matrix associated laser desorption ionization (MALDI) and tandem MS analysis (MS/MS).
Credits: 1.0
Lec-Rec-Lab: (0-0-1)
Semesters Offered: Spring, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Co-Requisite(s): CH 5240
Pre-Requisite(s): CH 4212 or (CH 4210 and CH 4211) or CH 4222 or (CH 4220 and CH 4221)

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 5330 - Bioinorganic Chemistry

The course focuses on the recent advances in Bioinorganic Chemistry and in particular the role of metals in biochemistry. The course explores the methods for studying of bioinorganic enzymes and will focus on the roles of different main group and transition metals in proteins, enzymes and nucleic acids.
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): CH 4710 or BL 3020 or CH 4110

CH 5410 - Advanced Organic Chemistry: Reaction Mechanisms

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

CH 5412 - Spectroscopy of Organic Chemistry

Emphasizes spectral data interpretation to determine structures of organic compounds. Discuss proton and carbon nuclear magnetic resonance (including two-dimensional techniques), training to perform structural analysis (UV, NMR, MS); will be given unknown organic molecules for analysis and structural elucidation.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

CH 5420 - Advanced Organic Chemistry: Synthesis

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

CH 5440 - Molecular Modeling

The course focuses on the principles and applications of the methods for molecular modeling of large molecules. The students will learn the principles of molecular mechanics (MM), molecular dynamics (MD), combined quantum mechanics and molecular mechanics (QM/MM) and their applications for understanding molecular and biomolecular systems.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Fall
Pre-Requisite(s): CH 3510 and CH 2510

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, in odd years
Pre-Requisite(s): CEE 4501 or CH 3510

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 3510 or ENVE 4501 or ENVE 4504 or CEE 4501 or CEE 4504

CH 5517 - Soil Biogeochemistry

Study of the relationship between soil composition and the circulation of major elements through the earth system. Responses of biogeochemical cycles of the elements in agricultural, forest, grassland, and wetland soils to changes in landuse, biodiversity, nutrient supply, plant stressors, and climate change will be discussed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

CH 5519 - Atmospheric Biogeochemistry

Study of the relationship between atmospheric composition, global change, and the circulation of major elements through the earth system. Responses of ecosystem emissions to changes in landuse, biodiversity, nutrient supply, plant stressors, and climate change are discussed.
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

CH 5520 - Chemical Kinetics

An advanced study of chemical reaction rates, collision theory, enzyme kinetics, reaction dynamics, transition state theory, photochemistry, atmospheric chemistry, including methods of analysis and theory of rate processes.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Pre-Requisite(s): CH 3510

CH 5535 - Physical Chemistry III - Molecular Driving Forces from Fundamentals to Applications

Advance course design to bridge concepts in thermodynamics, kinetics, and quantum chemistry through the application of statistical mechanics to understand the molecular driving forces acting in chemical/physical/material/biological systems at both microscopic, and macroscopic level.
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 3510 and 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: (2-0-3)
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 5665 - Surface and Interface Science for Chemical and Materials Analysis

Coursework and hands-on laboratory experiences explore physical and chemical properties governing surface processes and the appropriate analysis techniques used to study interfaces and surface chemical reactions. Topics include principles of physical chemistry and materials science for understanding and applying modern surface analysis.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: On Demand
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

CH 5800 - Special Topics in Graduate Chemistry

Discussion of special topics in chemistry at the graduate level.
Credits: variable to 3.0; 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

CH 5820 - Independent Study in Chemistry

Individualized project-based course designed to integrate academic and professional interests to foster student's career goals. Project can be on or off-campus, internship, or combination of these, to enhance the student's expertise and develop career-relevant skills.
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; Must be enrolled in one of the following Major(s): Chemistry

CH 5900 - Chemistry Graduate Seminar

Graduate seminar in chemistry.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

CH 5990 - Chemistry Master Research

An original investigation in chemistry for students seeking an MS degree.
Credits: variable to 9.0; 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 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: 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 9.0; May be repeated; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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 5315 - Chemical Process Dynamics, Automation, and Control

This course provides theoretical and practical knowledge needed to design, select, evaluate, and manage today's complex control systems and advanced control strategies. On-line plant simulation software is used to analyze data for the design of control systems.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Summer
Pre-Requisite(s): CM 3310 or EE 3160

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 5510 - Advanced Interfacial Engineering

Examines the physics and chemistry of interfaces, and the relevance of these principles in engineering applications. It may include liquid surfaces, electric double layer, surface forces, contact angle phenomena, surfactants, adsorption, surface energy, emulsions.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

CM 5621 - Research Essentials

This course is intended to improve skills necessary for planning, conducting, analyzing, and presenting research; ethical and responsible conduct, critical evaluation of existing literature, written and oral communication, and experimental design and analysis.
Credits: 2.0
Lec-Rec-Lab: (0-0-3)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

CM 5715 - Advanced Biochemical Processes

Introduction to fundamental and applied industrial biochemical processing. Topics may include basic cell and genetic design, enzymes, metabolism, bioreactor analysis and design, bioseparations and industrial applications. Graduate expectations will exceed those of the undergraduate course. Not open to students with credit in CM4710.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

CM 5721 - Literature Reviews in Chemical Engineering

Literature review course promotes learning and critical scrutiny of chemical engineering literature, on a topic pertinent to the student's research. Discussion of articles will increase knowledge breadth and depth for research. Enhances research communication skills via reviews and discussions.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
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): Chemical Engineering
Pre-Requisite(s): CM 5621

CM 5780 - Advanced Biomanufacturing and Biosafety

Students to perform as an engineer in a biomanufacturing facility. Focus is on mammalian cell culture derived products and federal laws in biosafety. Process design software explored. Regular literature review required. Not open to students with credit in CM4780.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

CM 5860 - ChE Industrial Capital Projects

Process and project design principles applied to realistic problems, including project evaluation and management. Problems include safety, environmental, and operability constraints. Emphasizes the profit motive in industry and the role of the chemical engineer.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): CM 4855

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; 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

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: variable to 3.0; 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

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 5001 - National Cybersecurity Policy and Law

This course introduces the role of government in securing cyberspace. Students examine national cybersecurity policy and law. Topics include federal, state, and local entities involved in cybersecurity, relevant laws and regulations, concepts of civil liberties, intellectual property, privacy, development/diffusion of standards, and national security.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall

CS 5010 - Applied Computer Science

A capstone project course. Students identify and apply appropriate computer science principles in the solution of a significant problem in an application domain outside computer science.
Credits: 3.0; Repeatable to a Max of 6
Lec-Rec-Lab: (0-1-4)
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): CS 4321

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 5130 - Compiler Design, Theory, and Optimization

Design and theory of programming language translators and the theory and implementation of optimizers. Topics include: intermediate representations, advanced code generation, control- and data-flow analysis, advanced compiler optimization, dynamic compilation, global register allocation and instruction scheduling.
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): CS 4121

CS 5311 - Theory of Computation

Topics covered include Turing machines and their variants, the halting problem and decidability, computability, reducibility, NP-completeness, time and space complexity, and topics from recursive function theory. The course starts with a brief review of the computation models from CS3311.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Pre-Requisite(s): CS 3311

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, Spring
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 5341 - Quantum Computing

Quantum Computing (QC) with emphasis on computational aspects of physical quantum systems. Topics include classic vs. quantum computation, introduction to Quantum Mechanics (QM), quantum information, quantum gates and circuits, teleportation, reversible computation, Fourier sampling, Simon's algorithm, Grover's algorithm, Shor's algorithm.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): CS 4321

CS 5350 - Modern Cryptography

This course covers the knowledge of modern cryptography including perfectly secret encryption, private-key cryptography, hash functions, etc. Course focuses on how to conduct crypto-analysis and how to achieve provable security for different cryptographic protocols based on the "proof by reduction" techniques.
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 4471 or CS 5471 or CS 4723 or EE 4723

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: Fall, 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: Fall, Spring
Pre-Requisite(s): CS 4431

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: Fall, Spring
Pre-Requisite(s): CS 4411 and CS 4461

CS 5471 - Computer Security

This covers fundamentals of computer security. Topics include practical cryptography, access control, security design principles, physical protections, malicious logic, program security, intrusion detection, administration, legal and ethical issues.
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): CS 3411 or CS 4411

CS 5472 - Advanced Topics in Computer Security

This course covers various aspects of producing trusted computer information systems. Topics include network perimeter protection, host-level protection, authentication technologies, formal analysis techniques, and intrusion detection. Current systems will be examined and critiqued.
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 4471 or CS 5471 or SAT 4520

CS 5481 - Systems Performance Analysis

Analysis of the performance of computer systems. Topics include: measurement techniques and tools, probability theory and statistics, experiment design and analysis, simulation, queuing models. Course includes a significant experimental component.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): CS 4411 and MA 2720

CS 5611 - Computer Graphics: Advanced Rendering and Modeling

Topics include polygonal objects, lighting models, shadows and textures, ray-tracing, radiosity, photon mapping, parametric curves and surfaces, meshes, and mesh modeling.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): CS 4611

CS 5631 - Data Visualization

Introduction to scientific and information visualization. Topics include methods for visualizing three-dimensional scalar and vector fields, visual data representations, tree and graph visualization, large-scale data analysis and visualization, and interface design and interaction techniques.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): CS 4611 or CS 5611

CS 5641 - Immersive Virtual Environments

An introduction to immersive virtual environment technologies and their applications. Topics include: wall-sized displays, head-mounted displays, 3D displays, orientation and position tracking, human perception, and recent research utilizing virtual reality systems.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): CS 4611(C)

CS 5740 - Development of Trusted Software

This course exposes students to the concepts of secure software development. Students will learn how to develop high-quality software that is resistant against cyber- attacks, by minimizing the number of vulnerabilities that can be exploited by an attacker. Topics include: access control, race conditions, buffer overflows, code injection, fuzzing techniques, cryptographic software, web application and Java security.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Pre-Requisite(s): CS 4471

CS 5751 - Dependable & Secure CPS-IoT

The scope of this course includes both theoretical and practical aspects of developing dependable and secure networks of resource-constrained devices. Topics include: rigorous modeling; design verification and validation; programming paradigms; and dependability aspects such as fault tolerance, security, and energy efficiency.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following College(s): College of Engineering, College of Computing; Must be enrolled in one of the following Class(es): Junior, Senior
Pre-Requisite(s): CS 2311

CS 5760 - Human-Computer Interactions and Usability Testing

Current issues in human-computer interaction (HCI), evaluation of user interface (UI) design, and usability testing of UI. Course requires documenting UI design evaluation, UI testing, and writing and presenting a HCI survey, concept or topic paper.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): CS 4760

CS 5761 - Human-Robot Interaction

Human-Robot interaction is a multi-disciplinary course dedicated to understanding, designing, and evaluating robotic systems for use by or with humans. Theory and research methodologies will be covered in a semester-long project with real robotic platforms. Topics include robot communication, control, supervision, teaming, and XR interfaces.
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

CS 5765 - Reimagining Technofuturism

Technologists in this course will reimagine the future of computing in ways that center people and communities. Connecting cultural competency and computing innovations requires us to consider not just what is created, but who it serves. The future of technology is not written in stone - we can imagine and create a new and better tomorrow for all.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Permission of instructor required

CS 5770 - Affective Design and Computing

An examination of emotions and affect in Human Factors and HCI. Topics may include brain and cognitive mechanisms and methods/techniques, affective computing, Kansei engineering, hedonomics, emotional design, and application domains.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand

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 5821 - Computational Intelligence - Theory and Application

This course covers the four main paradigms of Computational Intelligence, viz., fuzzy systems, artificial neural networks, evolutionary computing, and swarm intelligence, and their integration to develop hybrid systems. Applications of Computational Intelligence include classification, regression, clustering, controls, robotics, etc.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

CS 5831 - Advanced Data Mining

Data mining focuses on extracting knowledge from large data sources. The course covers data mining concepts, methodology (measurement, evaluation, visualization), algorithms (classification/regression, clustering, association rules) and applications (web mining, recommender systems, bioinformatics).
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 3425 or MIS 3100 or SAT 3210) and (MA 2330 or MA 2320 or MA 2321) and (MA 2710 or MA 2720 or MA 3710)

CS 5841 - Machine Learning

This course will explore the foundational techniques of machine learning. Topics are pulled from the areas of unsupervised and supervised learning. Specific methods covered include naive Bayes, decision trees, support vector machine (SVMs), ensemble, and clustering methods.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): CS 4821

CS 5851 - Advanced Natural Language Processing (NLP)

Students will study computer systems that process and understand human language. We focus on state-of-the-art natural language processing (NLP) algorithms that are trained on data. Students will read, analyze, and present current research in NLP.
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): CS 5841

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; 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 5994 - International Computer Science Field Experience

Field work and reporting from students in the Peace Corps Master's International Program in Computer Science.
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; Must be enrolled in one of the following Major(s): Computer Science

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 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

Computational Science & Engineering

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 - Theory of Computation

Topics covered include Turing machines and their variants, the halting problem and decidability, computability, reducibility, NP-completeness, time and space complexity, and topics from recursive function theory. The course starts with a brief review of the computation models from CS3311.
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 3311

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 5720 - Descriptive Modeling of Data using Statistical and Graphical Methods

Focuses on the fundamentals of probability theory and graph theory and how relevant concepts apply to describe, model, and analyze data sets. Topics include probability distributions, Bayes theorem, conditional independence, discrete and continuous models, regression models, hypothesis testing, and Markov chain methods.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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

Data Science

DATA 5891 - Data Science for Remote Sensing

A student team, project-based learning course. Students will work in teams to complete a project using real-world remote sensing data. The course will have sections related to computational analysis, sensors and sensing, as well as application domain knowledge.
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): UN 5550

Economics

EC 5000 - Microeconomic Theory

The study of consumer and producer choices, market demand and supply, and market structures. Not open to students with credit for EC3002.
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

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: 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): EC 3003

EC 5300 - Managerial Economics

Economic analysis of the operation of a business. Topics include optimization, demand theory and forecasting, production/cost analysis, market structure and strategic behavior, risk analysis, antitrust policy and regulation of safety and the environment, and international management.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Applied Natural Resource Econ., Engineering Management, Accounting, Business Administration

EC 5400 - Advanced Engineering Economics

Presents and demonstrates procedures and quantitative techniques used in capital budgeting and project evaluation and selection for industry. Topics include cash flow analysis, decision methods, risk and uncertainty, cost of capital, taxes and depreciation, and forecasting market variables. Topics presented with study problems, applying spreadsheet programs.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EC 3400

EC 5620 - Energy Economics

Introduction to the institutional, technical, and economic issues of the production and use of energy resources, including petroleum, natural gas, coal, nuclear, electric utilities, and alternative energy. Research project applies economic analysis to supply, distribution, and use of energy resources, including environmental and social consequences.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in odd years
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

EC 5630 - Mineral Industry Economics

Analyzes the economic aspects of the production/use of minerals in society. Uses economic analysis to explain behavior and policy implications for issues of supply, demand, markets, and foreign trade for important minerals. Analyzes the impact of government policies on the minerals industries.
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

EC 5640 - Natural Resource Economics

Analyzes the economic aspects of producing/using natural resources. Nonrenewable resources and renewable resources are discussed. The economics of land use, macroeconomic topics such as economic growth, sustainability and green accounting are considered.
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): EC 2001 or EC 3002

EC 5650 - Market Failure & Environment

Considers the efficient and equitable use of environmental resources. Measures the benefits and costs of decreasing pollution and protecting scarce ecological resources; addresses market failures and the economic valuation of environmental amenities. Requires students to learn quantitative and technical techniques to determine the efficient use of resources.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EC 2001 or EC 3002

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 5994 - Field Work in Applied Natural Resource Economics

Field work and reporting from students in the Peace Corps Master's International Program in applied natural resource economics.
Credits: 1.0; May be repeated
Lec-Rec-Lab: (0-1-0)
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; May be repeated; Graded Pass/Fail Only
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate

Education

ED 5100 - College Teaching

Focuses on instructional planning, delivery, and assessment in a higher education context. Students learn to write objectives, apply backward design, create objective- linked high-engagement classroom activities, and assess student learning. Additional topics include course syllabi, teaching portfolios, and teaching philosophy statements.
Credits: 1.0
Lec-Rec-Lab: (0-2-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Co-Requisite(s): ED 0510

ED 5460 - Psychology of Learning

The course focuses on learning across the lifespan, and varied contexts including school, work, formal and informal settings. Topics will include cognition and tools, psychology of STEM school subjects, and culture and cognition. Students will investigate specific aspects of learning depending on interests.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

Electrical & Computer 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: (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, Electrical & Computer Engineer; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
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: (3-0-0)
Semesters Offered: Spring, in odd years
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, Electrical & Computer Engineer; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): EE 4222

EE 5221 - Advanced Electric Machinery and Drives

Advanced electromechanics of rotating and linear machines. Topics include dynamic analysis of machines, reference frame transformations, reduced order models, models of mechanical loads, power electric drives for motors, and digital simulation of machines and electric drive systems. Applications discussed will include renewable energy and electric propulsion systems.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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, in even years
Pre-Requisite(s): EE 4221 and EE 4222(C)

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: Fall, in even years, Spring, in even years
Pre-Requisite(s): EE 5223(C)

EE 5227 - Advanced Power Electronics

Advanced topics of circuits for electrical energy processing. Covers switching converter principles for dc-dc, ac-dc, and dc-ac power conversion. Other topics include harmonics, pulse-width modulation, classical feedback control, nonlinear control, magnetic components, power semiconductors, and digital simulation.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 4227

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: (3-0-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering, Electrical & Computer Engineer

EE 5231 - Energy Control Center Applications

Monitoring and control technologies for control centers that govern electrical power transmission systems. Topics include study of historical power blackouts, state estimation, alarm processing, fault diagnosis, telecommunication assessment, defense strategies, system-wide restoration, and visualization.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor required
Pre-Requisite(s): EE 3120

EE 5232 - Power System Optimization

Linear, non-linear, and integer programming, simplex method, branch and bound, steepest descent method, convex, stochastic, and distributed optimization, interior-point method, evolutionary algorithm, optimal power flow, unit commitment, vot/var optimization, state estimation, feeder reconfiguration.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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, load flow, short- circuit and stability formulations, constrained optimization methods for load flow and state estimation, and time-domain simulation methods for transient analysis.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
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 & Computer Engineer
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 primary system design, applications for capacitors, voltage drop, power loss, distribution system protection, and introduction to advanced distribution automation.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, Summer, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 4221

EE 5251 - Distribution Engineering II

Course covers fundamentals of feeded reconfiguration for distribution systems. The unbalanced three-phase power flow will be used throughout the course for fault location, fault isolation and service restoration, outage management for crew coordination, trouble tickets, and switching procedure management.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Pre-Requisite(s): EE 5250

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: (3-0-0)
Semesters Offered: On Demand
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

EE 5275 - Energy Storage Systems

Designing energy storage solutions for grid, vehicle and portable/autonomous systems. Quantitative and qualitative analysis of energy storage aging, cost, and performance improvement.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring

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, Electrical & Computer Engineer

EE 5295 - Advanced Propulsion Systems for Hybrid Electric Drive Vehicles

Hybrid electric vehicles (HEV) will be studied and simulated using advanced powertrain component analysis and modeling. An in-depth analysis and study of power flows, losses, and energy usage are examined for isolated powertrain components and HEV configurations. Simulation tools will be developed and applied to specify powertrain and vehicle components and to develop control and calibration for a constrained optimization to vehicle technical specifications.
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
Pre-Requisite(s): MEEM 4295 or ME 4295 or EE 4295

EE 5296 - Powertrain Integration for Vehicle Electrification

Lab-based, hands-on course examining propulsion integration for vehicle electrification. Covers requirements, vehicle development process, component specification, thermal management, controls, safety, and calibration. Course project on optimizing electrified vehicle performance through modeling and experimentation.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: 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
Pre-Requisite(s): MEEM 4296(C) or EE 4296(C)

EE 5300 - Mathematical and Computational Methods in Engineering

Overview of problem-solving tools and techniques in engineering, considered from both the analytical and computational point of view. Systems of linear equations, eigenvalue and eigenvector computations, boundary value and initial value problems, Fourier analysis, large-scale systems, optimization. Mathematical modeling and computer programming.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following Major(s): Electrical & Computer Engineer, Electrical Engineering, Computer Engineering; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

EE 5315 - Cyber Security of Automotive Systems I

Modern automotive control and communications systems from a cyber security perspective. Topics include: V2X communications, vehicle attack surfaces and vulnerabilities, in-vehicle networks, threat analysis and vulnerabilities, security mechanisms and architectures, security requirements analysis, hardware security modules, and standards.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical & Computer Engineer, Computer Science, Mechanical Engineering, Mechatronics, Mechanical Eng-Eng Mechanics, Computer Engineering, Electrical Engineering
Pre-Requisite(s): MEEM 5300 or ME 5300 or EE 5455

EE 5365 - In-Vehicle Communication Networks

Course focuses on in-vehicle system domains and their requirements, and in-vehicle communication bus Controller Area Network (CAN) and its related physical layers standards. It also covers other buses such as LIN, FlexRay, MOST, Ethernet, as well as introduction to V2V and V21.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical & Computer Engineer, Computer Science, Engineering Mechanics, Mechanical Engineering, Computer Engineering, Electrical Engineering
Pre-Requisite(s): EE 3250 or EE 4250

EE 5367 - Connected and Autonomous Vehicle Technology

Principles, technologies, standards and applications of connected and autonomous vehicles. Topics include vehicular mobility modeling, physical layer considerations, routing protocols, automotive cybersecurity, as well as autonomous vehicles sensors technologies, sensor data fusion techniques, and autonomous vehicles challenges.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
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 & Computer Engineer, Computer Science, Engineering Mechanics, Mechanical Engineering, Computer Engineering, Electrical Engineering
Pre-Requisite(s): EE 5365 and EE 4272

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, Electrical & Computer Engineer
Pre-Requisite(s): EE 3140

EE 5415 - Applied Optics and Photonics

Rigorous study of nonlinear optics, anisotropic, optical materials, dielectric waveguides, directional couplers, semiconductor optics, light sources, lasers, and photodetectors.
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
Pre-Requisite(s): EE 3090 or PH 3210 or EE 4411

EE 5430 - Electronic Materials

A study of the physical principles of electronic materials, their applications in solid-state devices, and future trends in their development.
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 5435 - High-Speed Circuit Design

With increasing operating frequency of integrated circuit, high-speed design becomes excessive important. This course introduces the solution and techniques for dealing with high-frequency (~GHz) signals using transmission line theory, signal integrity analysis, etc.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years, Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical & Computer Engineer, Electrical Engineering, Computer Engineering

EE 5451 - Risk Assessment for Critical Infrastructure Protection

Risk assessment and vulnerabilities for industrial control environments including electrical power grids. Cyber-physical attack tools and techniques. Interaction of cybersecurity issues with physical systems and physical security. Limitations of current cybersecurity technologies. Design and cost considerations for various defensive methods.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Permission of instructor required
Pre-Requisite(s): EE 3120

EE 5455 - Cybersecurity of Industrial Control Systems

General introduction to cybersecurity of industrial control systems and critical infrastructures. Topics include NIST and DHS publications, threat analysis, vulnerability analysis, red teaming, intrusion detection systems, industrial networks, industrial malware, and selected case studies.
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 & Computer Engineer, Cybersecurity, Mechatronics, Computer Science, Computer Engineering, Electrical Engineering

EE 5460 - Solid State Devices

A study of the physical principles and evolution of solid-state devices, such as transistors: from conventional to novel types utilizing hetero-junctions and quantum effects; light emitting devices, semiconductor lasers; and displays of various types.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

EE 5461 - Mobile Networks

This course will explore the 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: (3-0-0)
Semesters Offered: Spring, Summer
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): EE 4272 or CS 4461

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 5471 - Microfabrication Laboratory

A hands-on laboratory experience in which the students fabricate devices with micro-and nano- scale dimensions. Lecture component covers safety training, background on microfabrication processes and systems, and facility tours to observe additional systems.
Credits: 2.0
Lec-Rec-Lab: (1-0-3)
Semesters Offered: Fall, Spring
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

EE 5480 - Advanced MEMS

This course will cover advanced topics dealing with MEIXIS technologies, transduction mechanisms, and microfabricated sensors and actuators.
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 5490 - Solar Photovoltaic Science and Engineering

Solar photovoltaic materials, the device physics of photovoltaic cells and practical applications of solar electric systems engineering.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

EE 5500 - Probability and Stochastic Processes

Theory of probability, random variables, and stochastic processes, with applications in electrical and computer engineering. Probability measure and probability spaces. Random variables, distributions, expectations. Random vectors and sequences. Stochastic processes, including Gaussian and Poisson processes. Stochastic processes in linear systems. Markov chains and related topics.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering, Electrical & Computer Engineer; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

EE 5511 - Information Theory, Inference, and Learning Algorithms

Introduction to the mathematical foundations for information theory, inference and learning algorithms. Topics include data compression, channel coding, Bayesian inference, clustering, marginalization, Monte-Carlo methods, Markov models, and Bayesian learning networks.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years, Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 5500(C)

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, Electrical & Computer Engineer
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: 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 & Computer Engineer, Electrical Engineering, Computer Engineering
Pre-Requisite(s): EE 5500

EE 5522 - Digital Image Processing

Fundamentals of image processing are covered including image representation, geometric transformations, binary image processing, compression, space and frequency domain processing. Computer programming in MATLAB and Python required.
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; Must be enrolled in one of the following Major(s): Electrical & Computer Engineer, Electrical Engineering, Computer Engineering

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: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 5527

EE 5526 - Microwave Engineering

Basics of microwave engineering. Topics include: microwave sources; wave equations and their solutions; wave propagation; reflection, and guiding; transmission line theory and practice; microwave network analysis and impedance matching; microwave resonators, filters, and dividers; left-handed materials and 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
Pre-Requisite(s): EE 3140 or EE 5140

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: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 4250

EE 5528 - Antenna Engineering

Topics include: basics of radiation theory, Hertzian dipole and loop antennas, near and far fields, bandwidth, gain and other antenna parameters, Yagi-Uda, bow-tie, cavity-backed and traveling wave antennas, microstrip solutions, miniaturization, substrates and superstrates.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Pre-Requisite(s): EE 5526

EE 5531 - Introduction to Robotics

Introduction to autonomous systems and robotics with focus on automated ground vehicles. Project based course using distributed computing to solve problems related to motion planning, perception, and localization. Requires experience with Linux operating systems variants, version control systems, and C++ or Python.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall, Spring
Restrictions: Permission of department 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

EE 5532 - Sensing and Processing for Robotics

Sensing modes, signal and image processing for industrial robotic automation processes. Emphasis placed on widely used sensors, including cameras and 3-D sensors for process control and computer vision for autonomous navigation.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Major(s): Electrical & Computer Engineer, Electrical Engineering, Computer Engineering; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): EE 5522

EE 5533 - Neuromorphic Robotic Systems

The course offers an interdisciplinary perspective on neuromorphic computing including neuroscience, algorithms, hardware implementations and applications. Through this course, the students will learn how build computational models of brain and use neuromorphic system to control robots.
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; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical & Computer Engineer

EE 5542 - Algorithms and Optimizations

Study of methods to solve problems in electrical engineering that do not have a single analytic solution, and hence a best solution must be found iteratively. Algorithms and implementations are studied, with heavy emphasis on MATLAB coding of real problems, and evaluation of solutions.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical & Computer Engineer, Electrical Engineering, Computer Engineering
Pre-Requisite(s): EE 5300

EE 5650 - Biomedical Optics

Light plays a significant role in modern clinical diagnostics and in the clinical treatment of disease. Examples include non-invasive surgery, optical biopsy, and cancer therapy. This course will focus on the study of how light propagates through biological tissue.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years

EE 5715 - Linear Systems Theory and Design

Overview of linear algebra, Modern Control: state-space based design of linear systems, observability, controllability, pole placement, observer design, stability theory of linear time-varying systems, Lyapunov stability, optimal control, Linear Quadratic regulator, Kalman filter, Introduction to robust control.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical & Computer Engineer
Pre-Requisite(s): EE 3261 or MEEM 3750 or ME 3750

EE 5726 - Wireless Sensor Networks

Building blocks of wireless sensor networks, sensor node design, wireless communications, network protocols, data storage and retrieval, sensor localization and clock synchronization. Example application areas: robotics, autonomous vehicles and networks, power engineering, smart-grid, environment monitoring, and disaster relief.
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 5750 - Model-Based Embedded Control System Design

This course introduces embedded control system design using a model-based approach. Course topics include model-based embedded control system design, discrete-event control, sensors, actuators, electronic control unit, digital controller design, and communication protocols. Prior knowledge of hybrid electric vehicles is highly recommended.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
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 & Computer Engineer
Pre-Requisite(s): MEEM 4700 or ME 4700 or MEEM 4775 or ME 4775 or EE 3261 or EE 4261

EE 5777 - Advanced Open-Source 3-D Printing

An introduction to distributed additive manufacturing using open-source 3-D printing. Design, use, and maintenance of open-source electronics and self-replicating rapid prototypers (RepRap). Graduate students will be expected to complete coursework and an in-depth project.
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; Must be enrolled in one of the following College(s): College of Engineering

EE 5780 - Advanced VLSI Computer-Aided Design

Nanoscale chip design presents issues for IC designs and new market areas for design automation. This course provides a comprehensive introduction on layout design. Advanced algorithms and optimization techniques are presented to give students the skills needed for nanometer VLSI design.
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): CS 4321 and EE 4271

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, Electrical & Computer Engineer

EE 5811 - Automotive Systems

Automotive systems for light duty vehicles are examined from the perspectives of requirements, design, technical, and economic analysis for advanced mobility needs. This course links the content for the automotive systems graduate certificate in controls, powertrain, vehicle dynamics, connected and autonomous vehicles.
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): Automotive Systems & Controls, Electrical Engineering, Computer Engineering, Electrical & Computer Engineer

EE 5812 - Automotive Control Systems

Introduction to automotive control systems. Modeling and control methods are presented for: air-fuel ratio, transient fuel, spark timing, idle speed, transmission, cruise speed, anti-lock brakes, traction, active suspension systems, and hybrid electric vehicles, Advanced control methodologies are introduced for appropriate applications.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical & Computer Engineer, Electrical Engineering, Computer Engineering
Pre-Requisite(s): EE 3261 or MEEM 4775 or ME 4775

EE 5821 - Computational Intelligence - Theory and application

This course covers the four main paradigms of Computational Intelligence, viz., fuzzy systems, artificial neural networks, evolutionary computing, and swarm intelligence, and their integration to develop hybrid systems. Applications of Computational Intelligence include classification, regression, clustering, controls, robotics, etc.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

EE 5841 - Machine Learning

This course will explore the foundational techniques of machine learning. Topics are pulled from the areas of unsupervised and supervised learning. Specific methods covered include naive Bayes, decision trees, support vector machine (SVMs), ensemble, and clustering methods.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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 & Computer Engineer, Electrical Engineering, Computer Engineering

EE 5970 - Electrical and 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): Electrical Engineering, Computer 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 5994 - International Electrical and Computer Engineering Field Experience

Field work and reporting from students in the Peace Corps Master's International Program in Electrical and Computer 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; Must be enrolled in one of the following Major(s): Electrical & Computer Engineer, Electrical Engineering, Computer Engineering

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: (3-0-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 5200

EE 6320 - Cyber Security of Automotive Systems II

This course covers advanced topics in cyber security of automotive systems. Topics include modeling and simulation of cyber attacks on vehicle subsystems, communications security for V2X systems, vulnerabilities in cooperative vehicle infrastructures, threat analysis, and cyber security of SAE level 2, 3, and 4 autonomous driving 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; Must be enrolled in one of the following Major(s): Electrical & Computer Engineer, Computer Science, Mechanical Engineering, Mechanical Eng-Eng Mechanics, Computer Engineering, Electrical Engineering; Must be enrolled in one of the following Campus(s): Co-op and Online Course(s), Co-op Program, Off Campus, Off Campus MTU On-Line
Pre-Requisite(s): MEEM 5310 or EE 5310

EE 6702 - Nonlinear System Analysis and Control

Studies nonlinear systems from perspective of analysis/control system design. Explores fundamental properties for 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 and sliding mode control.
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): EE 5715 or MEEM 5715 or ME 5715

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

Electrical Engineering Technology

EET 5144 - Real-Time Robotics Systems

Covers the components of a robot system, safety, concepts of a work-cell system, geometry, path control, automation sensors, programming techniques, hardware, and software. Students taking this course have an opportunity to earn FANUC Industrial Certificate "FANUC CERT HandlingTool Operations and Programming", Students must pass safety assessment above 80% and fulfill additional course requirements to be eligible.
Credits: 4.0
Lec-Rec-Lab: (0-3-2)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EET 1411 or EET 2121 or PH 2230 or EE 2111 or EE 3010

EET 5147 - Industrial Robotic Vision System and Advanced Teach Pendant Programming

Procedures for setting up, teaching, testing, and modifying robot vision systems widely used in industrial automation. Introduces advanced Teach Pendant Programming to develop complex scenarios for integrating robots into industrial cells. Final project must demonstrate proficiency in setting up and programming an advanced robotic vision scenario. Students taking this course have an opportunity to earn FANUC Industrial Certificate "FANUC CERT 2D iR-Vision". Students must pass safety assessment above 80% and fulfill additional course requirements to be eligible.
Credits: 4.0
Lec-Rec-Lab: (0-3-3)
Semesters Offered: Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EET 4144 or EET 5144

EET 5311 - Control Systems

Topics include: Fourier and Laplace transforms, signal comparison techniques and transfer functions. Control techniques addressed will include feedback, stability, Bode and Nyquist diagrams, and PID controllers. Graduate students are expected to demonstrate ability in modeling/simulation techniques of linear systems.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Fall, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

EET 5373 - Advanced Programmable Controllers

Using Allen Bradley Contr Logix and SLC500 programmable controllers, course covers structured programming, Sequential Function Charts, networking, proportional integral differential control, data acquisition and interfacing. The course requires proposing, executing, and defending at the graduate level related to the course material project.
Credits: 4.0
Lec-Rec-Lab: (0-2-3)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EET 3373 or EE 3373

EET 5990 - Special Topics in Mechatronics

Mechatronics topic of interest to faulty and student.
Credits: variable to 3.0; Repeatable to a Max of 12
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

EET 5991 - Graduate Research in Mechatronics

Research/investigation on a topic related to the mechatronics field of study leading to the submission of a thesis or report in partial fulfillment of the requirements for the master's degree.
Credits: variable to 10.0; Repeatable to a Max of 10; Graded Pass/Fail Only
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): Mechatronics

EET 5992 - Practical Experience in Mechatronics

Independent study of a practical problem, design project, or emerging technology in mechatronics. Preparation of a written report and/or oral presentation.
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; Must be enrolled in one of the following Major(s): Mechatronics; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior, Senior

Engineering Fundamentals

ENG 5060 - Leadership in Group Environments

Develops collaborative leadership skills through active hands-on learning. Topics include collaborative software, communication, and group management strategies.
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

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 5120 - Crafting the Research Story

Equips students to communicate science effectively with diverse audiences. It covers clear, engaging speaking, storytelling, and ethical research and scientific publishing. Students will develop projects such as journal articles and deliver a scientific presentation, participating as speakers and critics.
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

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 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 5400 - Engineering Applications in the Life Sciences

Students will gain hands-on experience linking engineering technologies to the biological sciences. Participants will visit labs and field sites at Michigan Tech to observe and participate in current research. Topics covered include biofuels, environmental restoration, environmental toxins, and ecosystem measurement.
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 5515 - Introduction to Sustainability and Resilience

Introduction to sustainable development, resilience, and global grand challenges with emphasis on socio-technical systems. Key topics include earth systems literacy, policy development, corporate social responsibility, ecological economics, sustainability indicators, and industrial/societal applications (e.g. agricultural, mining sustainability, etc,).
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

ENG 5525 - Systems Analysis for Sustainability and Resilience

In-depth coverage of systems analysis using advanced tools and methods. Topics will include environmental life cycle assessments, social life cycle assessments, techno-economic assessments, material flow analysis, industrial ecology, and regional economic assessments.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

ENG 5670 - Experimental Design in Engineering

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: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering

ENG 5990 - Special Topics in Engineering

Engineering topics of interest to students and faculty that are not normally covered in the existing courses.
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

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: 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

ENG 5999 - Engineering Education Research

Research/investigation on a topic related to Engineering Education leading to the submission of a thesis, report, conference paper, or journal article in partial fulfillment of the requirements for a master's or doctoral degree.
Credits: variable to 10.0; 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

ENG 6999 - Doctoral Research

Research investigation on a topic related to Engineering Education leading to the submission of a thesis, conference paper, or journal article in partial fulfillment of the requirements for a doctoral degree.
Credits: variable to 10.0; 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

Enterprise

ENT 5950 - Graduate Enterprise Project Work

Interdisciplinary teams work as part of an enterprise to address real-world design projects or problems. Graduate students will actively participate in project work as defined by the team advisor, and provide technical expertise and mentorship to undergraduate team members.
Credits: variable to 3.0; Repeatable to a Max of 6
Semesters Offered: Fall, Spring
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

Forest Resources & Environmental 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 - Woody Plants of North America

Identification and ecology of forest plants with an emphasis on tree and shrubs. Includes systematic study of the major forest vegetation types of North America.
Credits: 2.0
Lec-Rec-Lab: (1-0-3)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5079 - Forest Management

Focus on forest resource management planning and decision making, emphasizing structured problem solving frameworks and decision support tools/models at forest and landscape scales. Course held at Ford Center, Alberta, MI.
Credits: 2.0
Lec-Rec-Lab: (1-0-1)
Semesters Offered: Fall, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Co-Requisite(s): FW 5700

FW 5081 - Professionalism in Forestry

This class engages professional students in practicing soft skills for a forestry and/or natural resources management career. Emphasis will be on networking, communicating clearly to their intended audience, handling meetings, leadership, and public presentations. The professional society's code of ethics will be explored.
Credits: 1.0
Lec-Rec-Lab: (1-0-0)
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): Forestry

FW 5082 - Gene Expression Data Analysis

This course is designed for students majoring in molecular biology, computer science, data science and related majors to develop fundamental but essential skills for manipulating, preprocessing, and analyzing high throughput gene expression data for pattern extraction and knowledge discovery.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): FW 4099 or CS 1121 or CS 1122 or CS 1131 or CS 1141 or CS 2321

FW 5083 - Programming Skills for Bioinformatics

Students will learn computer programming skills in Perl for processing genomic sequences and gene expression data and become familiar with various bioinformatics resources.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5084 - Data Presentation and Visualization with R

This course is designed for graduate students majoring in forestry, wildlife, ecology, and natural resource management and data science to develop fundamental but essential skills for data presentation and visualization through generating informative graphs with R.
Credits: 2.0
Lec-Rec-Lab: (1-0-2)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5088 - Economic Analysis of Forestry

Financial analysis and economic theory applied to forestry project analysis and selection, focusing on prices. Covers risk, capital markets, taxation, auctions, land valuation, harvesting decisions, and non-market valuation.
Credits: 2.0
Lec-Rec-Lab: (2-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5092 - Experimental Design for Forestry and Natural Sciences

This lab is designed for graduate students majoring in in forestry, wildlife, ecology, and natural resource management to develop fundamental but essential skills for designing experiments and analyzing data.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5100 - Advanced Terrestrial Ecology

Structure and function of terrestrial ecosystems, focusing primarily on upland forests. Roles of climate, population structure, competition for above and belowground resources, natural disturbance, management, and global change on ecosystem community composition, succession, carbon exchange, productivity, and nutrient cycling.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

FW 5115 - Restoration Ecology

Study the tools, challenges, and philosophical underpinnings associated with ecological restoration. Restoration of forest, grassland, and wetland communities (plant and animal) will be discussed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
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, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): BL 3400 or FW 3010 or FW 3012 or FW 3020

FW 5135 - Plant Community Ecology

Investigation of the theoretical underpinnings and quantitative tools associated with the study of plant communities.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5180 - Ethics of Conservation and Sustainability

Discusses relationship between ecological science and environmental ethics as it relates to natural resource management, conservation and sustainability.
Credits: 2.0
Lec-Rec-Lab: (0-2-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5201 - Forest Biometrics and Modeling

Overview and application of statistical techniques and sampling designs used in the forest environment for attribute monitoring and inventory. Use and evaluation of models that simulated forest development and their application in management and planning.
Credits: 2.0
Lec-Rec-Lab: (1-0-3)
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): Forestry

FW 5250 - Comparative Forest Management: Nordic vs. U.S. Practices

An analysis of forest management practices in Nordic countries and the United States, examining both similarities and differences in approaches to sustainable forestry. Through a comparative lens, students will explore the historical, ecological, and socio-economic contexts that shape forest management strategies in these regions.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: On Demand

FW 5330 - Applied Soil Science

A review of the chemical, physical, and biological properties of soil with emphasis on forest soils and emerging issues in forest management.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5340 - Population Genetics and Applied Forest Genetics

The course highlights populations genetic topics and deals with the effects of evolutionary factors on genetic diversity. The relevance of genetic variation patterns for the future management and conservation of forests is stressed. Quantitative methods in population genetics are presented.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years

FW 5368 - Forest Ecophysiology

Exploration of both classic and cutting-edge literature on the mechanistic aspects of tree and forest ecosystem function. Emphasis on the interactions between canopy structure, carbon flux, nutrient cycling, and water uptake in the context of global change.
Credits: 2.0
Lec-Rec-Lab: (0-2-0)
Semesters Offered: Fall, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

FW 5369 - Hydrology and Watershed Management

This survey course introduces the applications of hydrological concepts to evaluate the impacts of forest management and other land use activities/events on water yield, infiltration, evapotranspiration, stormflow, erosion, sedimentation, and water quality.
Credits: 1.0
Lec-Rec-Lab: (1-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5370 - Measuring Plants and the Environment

Hands-on exploration of instrumentation and data analysis techniques used in the study of forest ecophysiology and hydrology. Methods include: measurement of photosynthesis, respiration, sap flux, water potential, and micro-meteorological and hydrological variables.
Credits: 3.0
Lec-Rec-Lab: (0-2-3)
Semesters Offered: Fall, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

FW 5371 - Snow Hydrology

This course will cover snow formation in the atmosphere, snow accumulation and distribution, snow metamorphism, avalanche dynamics, snowmelt and runoff, remote sensing of snow properties, and the impact of forests and under-snow biogeochemical processes.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5376 - Advanced Forest and Environmental Resource Management I

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: 1.0; May be repeated
Lec-Rec-Lab: (0-0-3)
Semesters Offered: Fall, Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5378 - Field Methods

To gain real world experience in measuring, monitoring, and assessing various projects involving active management and conservation of our university forest resources.
Credits: 1.0
Lec-Rec-Lab: (0-0-3)
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): Forestry

FW 5411 - Applied Data Analysis

Using statistical tools to analyze data from ecology, forestry and environmental science. Topics include multiple linear, curvilinear and non-linear regression, hierarchical grouped data and mixed-effects models. Emphasis is placed on application of tools to real-world data using R.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Co-Requisite(s): FW 5412

FW 5412 - Data Analysis in R

Use of R for basic data manipulation, statistical summary and statistical analysis. Topics include installing R, data import, handling and manipulation, basic statistics, graphical outputs and fitting of linear, non-linear and mixed-effects models.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Co-Requisite(s): FW 5411

FW 5421 - Climate Change and Forested Systems

Provides an overview of climate change science, effects and adaptation. Students develop knowledge of climate change effects and adaption for real world forested ecosystem examples and learn how to communicate these climate change projects and plans with stakeholders.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5510 - Special Topics in Natural Resources

Independent study of a specific area of natural resources.
Credits: variable to 9.0; Repeatable to a Max of 9
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

FW 5515 - GIS Project Development

This course is designed for students that have taken an undergraduate GIS course. In this course, students will design a GIS project, collect data, conduct various spatial analyses, and present their outcomes via a written report.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Fall, Spring
Restrictions: Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): FW 3540

FW 5517 - Soil Biogeochemistry

Study of the relationship between soil composition and the circulation of major elements through the earth system. Responses of biogeochemical cycles of the elements in agricultural, forest, grassland, and wetland soils to changes in land use, biodiversity, nutrient supply, plant stressors, and climate change will be discussed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): CH 1150

FW 5519 - Atmospheric Biogeochemistry

Study of the relationship between atmospheric composition, global change, and the circulation of major elements through the Earth system. Responses of ecosystem emissions to changes in landuse, biodiversity, nutrient supply, plant stressors, and climate change are discussed.
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): CH 1150

FW 5540 - Remote Sensing of the Environment

Remote sensing principles and concepts. Topics include camera and digital sensor arrays, types of imagery, digital data structures, spectral reflectance curves, applications, and introductory digital image processing.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Fall
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Co-Requisite(s): FW 5541

FW 5541 - Remote Sensing of the Environment Lab

Applied introductory remote sensing analysis using industry standard software for digital image processing.
Credits: 1.0
Lec-Rec-Lab: (0-0-3)
Semesters Offered: Fall
Co-Requisite(s): FW 5540

FW 5550 - Geographic Information Science and Spatial Analysis

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 ArcGIS software package to solve resource management problems.
Credits: 4.0
Lec-Rec-Lab: (3-0-3)
Semesters Offered: Fall, Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): MA 2710 or MA 2720 or MA 3710

FW 5553 - Python Programming for GIS

An introduction to Python scripting and basic Python coding within ArcMap. Labs cover tasks found in typical GIS workflows. Students learn how to write and debug Python scripts, models and mapping programs.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall
Pre-Requisite(s): FW 5550 or FW 3540

FW 5554 - GPS Field Techniques

This course will provide hands-on experience with various types of GPS units and different applications of the technology. These applications include planning, data collection, data processing, and data management. Emphasis will be on practical applications of Global Positioning System technology.
Credits: 2.0
Lec-Rec-Lab: (1-0-3)
Semesters Offered: Fall, Summer
Restrictions: Must be enrolled in one of the following College(s): College of For Res & Env Sci; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): FW 3540 or FW 5550

FW 5555 - Advanced GIS Concepts and Analysis

This course moves beyond the fundamentals of GIS to explore the application of GIS technology to environmental monitoring and resource management issues. Students learn graphic modeling techniques, network analysis, 3D visualization, geodatabase construction and management, and multivariate spatial analysis.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): FW 5550

FW 5556 - GIS Project Management

Course provides exposure to data collection techniques, web mapping applications, and advanced database structures. Students will investigate GIS system design, GIS project planning and data management, learn map atlas creation and cartographic techniques, and discuss geospatial ethics.
Credits: 3.0
Lec-Rec-Lab: (1-0-4)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): FW 5550

FW 5557 - Applied Spatial Statistics

Focus on spatial statistical methods such as spatial regression, geographically weighted regression and cluster analysis. ArcMap is utilized for analysis.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): FW 5550

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: (3-0-1)
Semesters Offered: Spring, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): FW 5540

FW 5580 - UAS(Drone)Remote Sensing and Photogrammetry

Applied fundamentals of aerial image interpretation, analysis and accurate measurements. Flight fundamentals, digital imagery, LiDAR, sensors, cameras, and lenses. Remotely Piloted Aircraft flight mission planning, image acquisition, aerotriangulation, point cloud and DEM/DSM DEM/DSM generation.
Credits: 2.0
Lec-Rec-Lab: (1-0-1)
Semesters Offered: Summer
Restrictions: May not be enrolled in one of the following Class(es): Freshman
Pre-Requisite(s): MA 1032 and (FW 3540 or FW 5550)

FW 5635 - Wildlife Disease Ecology

Covers the ecology of wildlife disease including interactions of host physiology, behavior, pathogen biology, and environment in the transmission and evolution of diseases in wildlife populations. Discusses the role of disease management in conservation and the effects of global environmental change on disease dynamics and public health.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5678 - Natural Resources Field Service

This course provides a supervised field experience in natural resources and community development.
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; Must be enrolled in one of the following College(s): College of For Res & Env Sci

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, Summer
Co-Requisite(s): FW 5079

FW 5800 - Master's Graduate Seminar

Presentation by students of current natural resource- related problems and research. Some instruction on presentation skills.
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

FW 5801 - Masters Seminar in GIS

Students will review, present, and discuss current research and applications of geospatial technology. This course is designed for students in the professional MS in GIS degree program, but will be open to students in other programs.
Credits: 1.0; Repeatable to a Max of 4
Lec-Rec-Lab: (1-0-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

FW 5810 - Research Methods in Natural Resources

In this course students will discuss and gain experience of; developing frameworks for writing scientific manuscripts and short research proposals, conducting literature reviews, critically reviewing papers, creating effective scientific posters and presentations, and sharing research findings with media.
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 5811 - Advanced Responsible Conduct of Research in Natural Resources

Three four-hour workshops on advanced responsible conduct of research drawing on examples in natural resources. It covers the topics necessary for this training including ethical standards, publication practices, peer review process, conflict of interest and societal expectations.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Summer
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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
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
Semesters Offered: Fall, Spring, Summer
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

Geological & Mining Engineering & Sciences

GE 5115 - Advanced Environmental & Engineering Geophysics

Students will learn the geophysical methods including seismic (refraction, topography, and surface wave methods), ground penetrating radar (GPR), electromagnetic (EM), electrical resistivity, and gravity to address near surface environmental and geotechnical issues.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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 - Advanced 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 5195 - Volcano Seismology

Will prepare students, including those with no seismology background, to interpret seismic and acoustic signals from volcanoes. Topics: basic seismology, monitoring techniques, tectonic and volcanic earthquakes, infrasound, deformation over a range of time scales.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Spring, in even years
Pre-Requisite(s): (MA 1160 or MA 1161 or MA 1121 or MA 1135) and GE 2000 and PH 2100

GE 5215 - Time Series Analysis in Geosciences

Students will gain a solid foundation in time series analysis through theory and applications to geoscience data. Methods include regression, ARIMA models, linear Gaussian state-space models, and frequency-domain estimation. Work will be done in Python.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): GE 5280

GE 5225 - Mining Systems and The Environment

Develops the scientific basis for environmental management in ecosystems impacted by mining activities. Considers the origin, behavior, and fate of pollutants generated during the life of a mine. Introduces engineered approaches for mitigation, remediation and reclamation of environmental impacts.
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): CH 1150

GE 5260 - Scientific Communication

Provide practice and advanced strategies in preparing, critiquing, and evaluating written communication. Will cover knowing your audience, scientific manuscript and proposal writing, reviewing, critiquing, and interpreting feedback. Students will prepare and critique written communication.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Mining Engineering, Geophysics, Geological Engineering, Geology

GE 5280 - Python Programming in Geosciences

This course covers topics from Python programming basics to advanced tools and techniques for data processing and visualization in Geosciences. Students will learn in a hands-on environment with programming occurring interactively during class and assignments designed to strengthen the learning outcome.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

GE 5515 - Python for Geospatial Analysis

This advanced graduate-level course is designed to equip students with essential skills and techniques to perform geospatial data analysis using Python. This course emphasizes both theoretical concepts and hands-on practice, offering comprehensive insights into spatial data handling, visualization, statistical analysis, and application to real-world geospatial problems. Students will engage directly with real-world datasets through guided tutorials, comprehensive Jupyter notebook examples, and interactive classroom discussions.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): GE 5280

GE 5560 - Advanced Earthquake Seismology

Course covers fundamentals of the physics of earthquakes and seismic energy propagation, and seismic methods to determine Earth structure. Emphasis is placed on natural source techniques, with extension to exploration applications. Weekly labs apply techniques.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): GE 3050 and PH 2100 and MA 3160

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 5660 - Social Dimensions of Natural Hazards

This course introduces students to the interdisciplinary nature of natural hazards as well as the complexities of engaging with people of other cultures about geological hazards. Course is designed for and open to any student interested in gaining a global perspective on natural hazards, disaster risk, and social aspects of hazard mitigation.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring

GE 5840 - Advanced Computational Methods in Geomechanics

Advanced computer methods for the design problems encountered in geo-engineering projects. Applications to be selected from landslide stability analysis, slope stabilization and design, earth support systems, seepage, settlement, bearing capacity, and consolidation. Students will be introduced to limit equilibrium and finite element analysis.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Spring, in odd years
Pre-Requisite(s): CEE 3810 or GE 3890

GE 5870 - Geostatistics & Data Analysis

This course covers the handling of spatial and temporal data for knowledge discovery. Major topics include spatial interpolation, clustering, association analysis, and supervised and unsupervised classification. Students will learn how to use geostatistical and pattern recognition tools for geoscience applications.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Spring, in odd years

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 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 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

Human Factors

HF 5015 - Advanced Cognitive Task Analysis

Cognitive task analysis is a group of methods to model how experts do their work to design new human-machine systems, knowledge management systems, and use cases for new tools. Students will learn and practice several CTA methods including knowledge audit, cognitive wall walk, and critical decision method.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

HF 5095 - Practicum

Independent activity where students apply their existing knowledge, skills, and methods already acquired in the program and demonstrate acquisition of new design-based knowledge, skills, and methods from the operational setting in which the practicum takes place.
Credits: variable to 6.0; Repeatable to a Max of 6
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

HF 5410 - Computational and Mathematical Models of Human Cognition and Behavior

This course focuses on analysis and use of computational and mathematical models of human cognition and behavior. Topics include models of memory, learning, information theory, decision making, vision, semantics, production systems, game theory, and network analysis.
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

HF 5420 - Human Factors in Healthcare

Course will explore the current human factors concepts and methods in health and medical applications.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

HF 5430 - Human-Artificial Intelligence Interaction

AI is increasingly becoming part of our lives, impacting how we work and what we know. This class explores how humans can become smarter about the AI we use, and how the AI can become better about helping users understand it, focusing on Explainable/Interpretable AI, trust, fairness, transparency, and related areas of human-AI interaction.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

HF 5850 - Human Factors Psychology

Advanced concepts critical to the design of human-technological systems, such as capitalizing upon human capabilities and compensating for human limitations. Topics may include perceptual and motor abilities, human error and cognitive engineering.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

HF 5860 - Human Factors Tools and Techniques

An overview of the tools and techniques used by human factors researchers and practitioners. Topics include task analysis, eye tracking, human error in systems, simulation, workload analysis, and physiological assessment techniques.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): PSY 5850

HF 5870 - Human-Centered Design

This course will focus on the human-system (computers, appliances, mobile devices, etc.) interaction regarding the design and development of products. Students will experience a complete cycle of the interaction design project, including analysis, design, and evaluation.
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

HF 5880 - Usability Assessment

Explore the concept of usability and how this is assessed and applied to various products, interfaces, systems, and information with a focus on heuristic evaluation, cognitive walkthroughs, card sorting, tree testing, surveys, interviews, and ISO standards.
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

HF 6990 - Special Topics in Human Factors

Study of special topics in human factors as designed by section title.
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

Humanities

HU 5000 - Introduction to Graduate Studies in Rhetoric, Theory, and Culture

Prepares students for graduate level work in the RTC program and introduces them to the fields of scholarly inquiry covered by graduate faculty.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
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, Theory and Culture

HU 5002 - Rhetoric and Composition

This course considers key theoretical, pedagogical, and historical issues and events that have linked the fields of rhetoric, composition, and literacy studies.
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, Theory and Culture, Rhetoric & Tech Communication

HU 5003 - Technical and Scientific Communication

This course considers key historical, pedagogical, and theoretical issues in technical and 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: 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, Theory and Culture, Rhetoric & Tech Communication

HU 5004 - Cultural Theory

Study of major cultural theories such as structuralism, poststructuralism, Marxism, feminist theory, postmodernism, cultural studies, postcolonial studies, and discourse theory.
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, Theory and Culture, Rhetoric & Tech Communication

HU 5006 - Continental Philosophy

Study of major figures and themes in continental philosophy. Topics might include: human being, temporality, historicity, tradition, language, perception, embodiment, intersubjectivity, politics, and technology. Approaches to these issues may include phenomenology, hermeneutics, deconstruction, feminist theory, and critical theory.
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 5007 - Critical Perspectives on Globalization

Examines different facets, stages, and manifestations of globalization, with an emphasis on critical discourses that seek to understand this phenomenon from humanistic and cultural perspectives.
Credits: 3.0; Repeatable to a Max of 6
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate

HU 5008 - Critical Approaches to Literature and Culture

Advanced study of genres, periods and movements in literature and culture. May include transnational movements, comparative studies, oral literature, electronic literature, literary and critical theory and other disciplines and/or arts.
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

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 5050 - Theories of Interculturality

A comparative, critical examination of cross-language and cross-cultural equivalencies and differences through the study of acculturation, values, traditions, role expectations, perceptions, stereotypes, and gender issues.
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 5070 - History and Theory of Rhetoric

History and theory of rhetoric, focusing on ancient rhetoric, alternative rhetorics, and/or modern rhetorical theory.
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 Creative Nonfiction

Writing and revising creative nonfiction in a workshop format. Course may include introduction to contemporary and historical works in the field, as well as study of its theories, techniques, and sub-genres.
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: variable to 3.0; Repeatable to a Max of 6
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate

HU 5100 - Qualitative Humanistic Research

Examination of qualitative methodology and compatible methods, with attention to modes of data collection and analysis, and ethical research practices, such as confidentiality and informed consent. Approaches may include ethnographic; phenomenological; narratological; rhetorical; historical; grounded theory; or standpoint theory.
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 5112 - Theoretical Perspectives on Technology

Philosophical, rhetorical, literary, and/or cultural studies perspectives on technology.
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 - Culture, Creativity, and Change

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 - Visual Theory and Analysis

A critical survey of selected theoretical, analytic and methodological issues that inform various disciplinary perspectives on visuality, visual culture, images, and image-based media, and visual representation.
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 - Approaches to Alterity and Difference

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 5119 - Fieldwork in International English Education

Fieldwork and reporting from students in the Peace Corps Master's International Program in Rhetoric and Technical Communication.
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

HU 5711 - Biomedical Research Ethics

Examination of bioethical issues in biomedical research. Topics include research on human subjects, on vulnerable populations, and animals, principles of ethical research, and societal expectations for researchers. This course qualifies for credit in Advanced RCR Training.
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

HU 5870 - New Media Theory

Examines development of theories explaining the cultural significance of new media technology in communication. Emphasizes strengths and weaknesses of these theories, the concept of "new", and emergent theories challenging the centrality of media in the digital and biotechnological age.
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, Theory and Culture, 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, Theory and Culture, 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, Theory and Culture, Rhetoric & Tech Communication

HU 5931 - Composition Pedagogy

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: variable to 3.0
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

HU 5932 - Practicum in Teaching Technical Communication

Principles of technical and scientific communication pedagogies and practices. Offers guidance in assignment design, institutional assessment, and policy development through discussion, classroom observation, and reading. One semester required for GTIs new to teaching HU3120.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor and department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): HU 5931

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: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor and department required; Must be enrolled in one of the following Level(s): Graduate

HU 5934 - Practicum in Communication Pedagogy

Principles of the practice and pedagogy of teaching communications. Offers guidance in class and assignment design, class policy, options for readings, and strategies for teaching. One semester required for graduate students new to teaching communications.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Fall, Spring
Restrictions: Permission of instructor and department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): HU 5931

HU 5935 - Graduate Level Writing Center Practicum

Study of theory and practice of writing center administration. Topics may include pedagogical and tutoring techniques, writing center assessment, and research methods.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor and department required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric, Theory and Culture
Pre-Requisite(s): HU 5931

HU 5936 - Practicum in Media Pedagogy

Principles of media studies pedagogies and practices. Offers guidance in class and assignment design, class policy, options for readings and strategies for teaching. Required for students new to teaching media.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor and department required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Rhetoric, Theory and Culture
Pre-Requisite(s): HU 5931

HU 5937 - Practicum in Teaching Literature

This course provides graduate students with a foundation for teaching undergraduate literature courses. Readings include articles on pedagogy and literary works. Students will compose a mock syllabus; write, respond to, and grade a reading assignment. Students may observe and teach classes.
Credits: 1.0; Repeatable to a Max of 2
Lec-Rec-Lab: (0-1-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor required

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; 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): Rhetoric, Theory and Culture, 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; 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; Must be enrolled in one of the following Major(s): Rhetoric, Theory and Culture, Rhetoric & Tech Communication

HU 5992 - Independent Study: Coursework Paper

Students prepare a coursework paper in preparation for the oral coursework defense.
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 Major(s): Rhetoric, Theory and Culture, Rhetoric & Tech Communication

HU 6000 - Special Topics in Literacy Studies

Advanced study of special topics in literacy studies including theories of pedagogy and relationships among literacy, technology, society, and education.
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 6002 - Culture and Social Justice

With a focus on culture and social ethics, this course will examine and contextualize the pursuit of social justice in multiple contexts.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand

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 6050 - Special Topics in Language and Literature

Advanced study of topics in languages and literature including U.S., British, and world. May include intercultural and comparative studies and the reading of literature, literary and critical theory, translation, and film.
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 philosophy, analytic philosophy, theories of truth, philosophical issues in cognitive science, contemporary feminist philosophy, and issues in social, political, and legal 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 and Composition

Advanced study of special topics in rhetorical or composition theory, history, or practice.
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 6090 - Special Topics in Pedagogy

Special topics in pedagogy. Offers guidance in course design and teaching strategies for a specific undergraduate course in Humanities.
Credits: 1.0; Repeatable to a Max of 3
Lec-Rec-Lab: (0-1-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor and department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): HU 5931

HU 6110 - Special Topics in Critical Inquiry

Advanced study of contemporary theoretical perspectives in rhetoric and technical communication. Topics might include cultural studies, theories of representation, feminist theory, Marxist theory, postmodern theory, critical perspectives on the environment.
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 6115 - Special Topics in Technical Communication

Advanced study of special topics in Technical Communication (TC). May include theories of TC; feminist studies of TC; study of TC in international contexts; theories and practices of usability; TC research methods and methodologies.
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, Theory and Culture, 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 9
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, Theory and Culture, 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, Theory and Culture, Rhetoric & Tech Communication

HU 6903 - Doctoral Qualifying Exam

Students prepare for comprehensive examination.
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): Rhetoric, Theory and Culture, Rhetoric & Tech Communication

HU 6990 - Doctoral Research

By arrangement with the instructor directing the PhD dissertation
Credits: variable to 10.0; 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): Rhetoric, Theory and Culture, Rhetoric & Tech Communication

Kinesiology & Integrative Physiology

KIP 5000 - Advanced Exercise Physiology

This course focuses on exercise physiology in both humans and rodents. Topics include detailed muscle physiology, fatigue mechanisms, the autonomic nervous system, advanced cardiovascular adaptations with exercise, exercise metabolism, and environmental exercise physiology. The importance of translational research will be highlighted.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Fall
Pre-Requisite(s): KIP 4100 and KIP 4110

KIP 5020 - Research Methods

This course provides a foundation in research methods in cognitive science and human factors, with an emphasis on experimental design, research ethics, and scientific communication. Course meets Michigan Tech's Advanced Responsible Conduct of Research (RCR) requirements.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

KIP 5100 - Advanced Biomechanics

This course includes the quantitative analysis of human motion through bioinstrumentation during dynamic performance. A detailed analysis of different movements and movement techniques, as well as investigations into the mechanics of tissues and their function, are included in this course.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Spring
Pre-Requisite(s): KIP 4200 and KIP 4210 and BE 3300

KIP 5200 - Advanced Strength and Conditioning

Advanced theory and practice in development and administration of comprehensive strength and conditioning programs for both the athlete and individual of any level. Includes knowledge, safety concerns and skill techniques necessary for teaching and administering any strength and conditioning facility.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Spring
Pre-Requisite(s): KIP 5000 or KIP 5100 or KIP 5300

KIP 5250 - Ergonomics

Introduction to ergonomics and work measurement with an emphasis on people in built and occupational environments. Discussion of methods for ergonomic assessment, evolution, and work measurement, with major topics including productivity and performance, manual materials handling, work-related musculoskeletal disorders, safety, training, legal issues, and adapting environments for special populations.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 2010

KIP 5300 - Advanced Motor Learning and Control

This course will provide the current theories and concepts involved in the processes of motor skill acquisition and performance from a behavioral perspective. Additional peer-reviewed literature will be utilized toward an oral presentation.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Spring
Restrictions: Permission of department required

KIP 5450 - Aging, Cognition, and Motor Behavior

Seminar on current research on age-related changes in cognitive function, motor behavior, and the interaction between cognitive decline and motor performance. Topics include the impact of aging on memory, attention, cognitive control, gait, balance, and motor learning.
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

KIP 5500 - Systems Physiology

A comprehensive systemic study of the physiological functions of the adult human, including an introduction to the underlying etiologies and clinical indicators of molecular, cellular, and tissue bases for common organ system diseases in humans.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

KIP 5510 - Molecular Physiology

Introduction on how different biochemical and molecular pathways of the cell work together to produce various physiological functions. Emphasis will be placed on the molecular and cellular mechanisms underlying physiological processes. Structure and function relationship will be addressed throughout the course.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

KIP 5700 - Graduate Seminar

Graduate seminars are designed to facilitate critical discussions of student research projects and peer-reviewed research in related fields. The presenter will provide an overview or seminar of the research of interest, which will establish the foundation for the discussion thereafter.
Credits: 1.0; Repeatable to a Max of 2
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Fall, Spring
Restrictions: Permission of department required
Pre-Requisite(s): KIP 5000 or KIP 5100 or KIP 5300

KIP 5711 - Biomedical Research Ethics

Examination of bioethical issues in biomedical research. Topics include research on human subjects, on vulnerable populations, and animals, principles of ethical research, and societal expectations for researchers. This course qualifies for credit in Advanced RCR training.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

KIP 5800 - Special Topics in Kinesiology

Selected additional topics in kinesiology for advanced students based on interests of faculty and students. Interested students should contact the Kinesiology and Integrative Physiology 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

KIP 5900 - Graduate Internship in Kinesiology

Practical experience in the field of kinesiology at an approved internship site. Internships must be approved by department chair or graduate director, and work a minimum of 42 hours for each credit earned.
Credits: variable to 6.0
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of department required

KIP 5999 - Master's Research

An original research investigation in kinesiology.
Credits: variable to 9.0; Repeatable to a Max of 20; 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

KIP 6100 - Doctoral Graduate Seminar in Integrative Physiology

The graduate seminar is designed to facilitate critical discussions of peer-reviewed research and student research projects in the field of integrative physiology. The presenter will provide an overview or seminar of the research of interest, which will establish the foundation for the discussion thereafter.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Fall, Spring
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Integrative Physiology

KIP 6800 - Special Topics in Integrative Physiology

Examination of current topics in the field of integrative physiology. Literature and research topics are addressed.
Credits: variable to 9.0; Repeatable to a Max of 9
Semesters Offered: Fall, Spring
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Integrative Physiology, Kinesiology

KIP 6999 - Doctoral Research

An original investigation in theoretical or experimental physiology, or both, and submission of a dissertation.
Credits: variable to 9.0; 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): Integrative Physiology

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, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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, in odd years
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 tournaments.
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: Fall

MA 5280 - Topics in Applied Combinatorics

Topics will vary with instructor but will emphasize real world applications of combinatorial methods. Topics include: cryptography, network reliability, operations research or scheduling, among many other possible choices.
Credits: 3.0; Repeatable to a Max of 48
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in even years
Restrictions: Permission of department required

MA 5301 - Algebra I

Theory of finite groups, their actions and applications. Review of basic group theory (Sylow theorems). Simple groups and group actions (transitivity). Symmetric and alternating groups, linear groups and more general classical groups. Applications: finite fields, designs, finite geometries.
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 - Algebra II

Introduction to polynomial rings, finite fields and field extensions. Review of basic notions concerning rings, polynomials and power series. General theory of finite and algebraic field extensions. The basics of Galois theory (field extensions and their Galois groups).
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): MA 5301

MA 5320 - Commutative Algebra

Introduction to commutative algebra and combinatorial algebra. A first description of research issues is also given. Topics include: commutative rings (quotients, morphisms; prime, maximal ideals); modules, Noetherian, artinian rings; combinatorial algebra (gradings, monomials, Hilbert functions, resolutions, level, Gorenstein algebras).
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in even years
Restrictions: Permission of instructor required
Pre-Requisite(s): MA 4310

MA 5360 - Number Theory

Topics may include, but not limited to, unique factorization, elementary estimates on the distribution of prime numbers, congruences, Chinese remainder theorem, primitive roots, n-th powers modulo an integer, quadratic residues, quadratic reciprocity, quadratic characters, Gauss sums, and finite fields.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in odd years
Restrictions: Permission of instructor required
Pre-Requisite(s): MA 4310

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

MA 5501 - Theoretical Numerical Analysis

Functional analytic basis of modern numerical analysis. Linear spaces, including Sobolev space theory, linear operators, approximation theory, and applications to Fourier analysis, fixed point theorems, iterative methods, finite difference methods, etc.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Pre-Requisite(s): MA 4330 and MA 4450

MA 5510 - Ordinary Differential Equations

Qualitative theory of solutions of ordinary differential equations, including existence, uniqueness, and continuous dependence; theory of linear equations; solution of constant coefficient systems; phase plane analysis; design and analysis of numerical methods.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Pre-Requisite(s): MA 4450 and MA 4330

MA 5565 - Partial Differential Equations

Theory of partial differential equations. Covers classification, appropriate boundary conditions and initial conditions, PDEs of mathematical physics, characteristics, Green`s functions, and variational principles.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MA 5501

MA 5580 - Topics in Applied Mathematics

Topics will vary with instructor, but will cover areas in applied mathematics.
Credits: 3.0; Repeatable to a Max of 48
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand

MA 5627 - Numerical Linear Algebra

Design and analysis of algorithms for problems in linear algebra. Covers floating point arithmetic, condition numbers, error analysis, solution of linear systems (direct and iterative methods), eigenvalue problems, least squares, and singular value decomposition. Includes the use of appropriate software including high performance computational libraries.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): MA 4330 or MA 4630

MA 5629 - Numerical Partial Differential Equations

Analysis and design of algorithms for the numerical solution of partial differential equations.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Pre-Requisite(s): MA 4610 or MA 5627 and MA 5501

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, in even years
Pre-Requisite(s): MA 4330 or MA 4610 or MA 4630 or MA 5627

MA 5631 - Advanced Numerical Linear Algebra

Design and analysis of numerical algorithms for linear algebra. Covers sparse iterative algorithms (including pre-conditioners) for linear solve, eigenvalue, and singular value problems. Includes the use of appropriate high performance computational libraries and applications of linear algebra.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
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, Spring, Summer
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 4770 or MA 4705)

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 5730 - Nonparametric Statistics

Introduces nonparametric techniques that require less restrictive assumptions on the data. Topics include statistical inference concerning location and dispersion parameters as well as the general distributions. Goodness-of-fit tests for count and ordinal data are also discussed.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in odd years
Pre-Requisite(s): MA 2710 or MA 2720 or MA 3710 or MA 3715

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: Fall
Pre-Requisite(s): MA 4710 and MA 4720 and MA 4760 and MA 4330

MA 5732 - Generalized Linear Models

The focus of this course is on generalized linear models (GLM), including the structure of GLM, statistical theory for GLM (maximum-likelihood estimation of GLM and hypothesis tests), and their applications. Also covers generalized linear mixed and random effects models.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in odd years
Pre-Requisite(s): (MA 4710 or MA 5731) and (MA 4770 or MA 5712)

MA 5741 - Multivariate Statistical Methods

Random vectors and matrix algebra. Multivariate Normal distribution. Theory and application of multivariate techniques including discrimination and classification, clustering, principal components, canonical correlation, and factor analysis.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): (MA 4710 or MA 4720) and MA 2320

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: Spring, in odd years

MA 5751 - Statistical Data Mining

Course will cover various topics in statistical data mining, including linear model selection and regularization, regression and smoothing splines, unsupervised learning, resampling methods, tree-based methods, and deep learning. This course will introduce modern statistical data mining techniques and their applications.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in odd years
Pre-Requisite(s): (MA 4700 or MA 4760) and (MA 5701 or MA 4710)

MA 5761 - Computational Statistics

Introduction to computationally intensive statistical methods. Topics include resampling methods, Monte Carlo simulation methods, smoothing technique to estimate functions, and methods to explore data structure. This course will use the statistical software R.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Pre-Requisite(s): MA 4770(C) or (MA 4700 and MA 5701)

MA 5770 - Bayesian Statistics

The theory of Bayesian inference. Topics include prior specifications, basics of decision theory, Markov chain, Monte Carlo, Bayes factor, linear regression, linear random effects model, hierarchical models, Bayesian hypothesis testing, Bayesian model selection.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in even years
Pre-Requisite(s): MA 4330 and MA 4710 and MA 4760

MA 5771 - Applied Generalized Linear Models

Construction, evaluation, and application of generalized linear models to analyze different types of data. Topics include logistic and Poisson regression, multinomial logit models, random effects and mixed effect models, models for repeated measures and longitudinal data. Introduce theory on GLM fitting, hypothesis testing, and diagnostic models.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Pre-Requisite(s): MA 4710 and (MA 4760 or (MA 4700 and MA 5701))

MA 5781 - Time Series Analysis and Forecasting

Statistical modeling and inference for analyzing experimental data that have been observed at different points in time. Topics include models for stationary and non stationary time series, model specification, parametric estimation, model diagnostics and forecasting, seasonal models and time series regression models.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): (MA 2710 or MA 2720 or MA 3710 or MA 3715 or MA 5701) and (MA 3720 or EE 3180 or MA 4700)

MA 5790 - Predictive Modeling

Application, construction, and evaluation of statistical models used for prediction and classification. Topics include data pre-processing, over-fitting and model tuning, linear and nonlinear regression models and linear and nonlinear classification models.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): MA 3740 or MA 4710 or MA 4720 or MA 4780 or (MA 4700 and MA 5701)

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, in odd years

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: (0-3-0)
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): Mathematical Sciences, Statistics, Mathematics

MA 5904 - Teaching Online Courses

An introduction to college-level online teaching principles. Based on nationally recognized standards for online course evaluation, the course will focus on course preparation, assessment, instructional strategies to increase student learning and motivation, and the use of instructional technology to optimize an online course.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: On Demand

MA 5980 - Special Topics in Mathematics

Special topics in mathematics.
Credits: variable to 12.0; Repeatable to a Max of 48
Semesters Offered: Fall, Spring, Summer

MA 5999 - Graduate Research in Mathematics

Original investigation in theoretical, or applied mathematics, and submission of a thesis in partial fulfillment of the requirements for the master's degree in mathematics.
Credits: variable to 12.0; 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

MA 6222 - Advanced Topics in Design Theory

Advanced topics in design theory.
Credits: 3.0; Repeatable to a Max of 18
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Permission of department required
Pre-Requisite(s): MA 5222

MA 6231 - Advanced Topics in Coding Theory

Advanced topics in coding theory.
Credits: 3.0; Repeatable to a Max of 18
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Permission of department required
Pre-Requisite(s): MA 5231

MA 6280 - Advanced Topics in Combinatorics, Algebra, or Number Theory

Advanced topics in combinatorics, algebra, or number theory.
Credits: 3.0; Repeatable to a Max of 18
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Permission of department required

MA 6300 - Advanced Topics in Algebra

Advanced topics in algebra.
Credits: 3.0; Repeatable to a Max of 18
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Permission of department required
Pre-Requisite(s): MA 5302

MA 6500 - Advanced Topics in Applied Mathematics

Advanced topics in applied mathematics.
Credits: 3.0; Repeatable to a Max of 18
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Permission of department required

MA 6600 - Advanced Topics in Computational Mathematics

Advanced topics in computational mathematics.
Credits: 3.0; Repeatable to a Max of 18
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

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 18
Semesters Offered: Spring, in even years
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: Fall, in odd years
Pre-Requisite(s): MA 3720 and MA 5401

MA 6980 - Special Topics in Mathematics

Special topics in mathematics.
Credits: variable to 12.0; Repeatable to a Max of 18
Semesters Offered: On Demand

MA 6999 - Mathematical Sciences Doctoral Research

Taken in partial fulfillment of the doctoral thesis requirement.
Credits: variable to 12.0; 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

Mechanical Engineering

ME 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: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5130 - Nanoscale Science and Technology

The course covers fundamentals of nanoscience (synthesis, properties, characterization) and recent technological advances in renewable energy, biotechnology, and nanodevices. This course is appropriate for students with backgrounds in mechanical engineering, materials science, chemistry, chemical engineering, civil engineering, and physics.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5150 - Advanced Mechanics of Matls

A study of incorporating complexities into the classical theories of axial rods, torsion of circular and non-circular shafts, bending of beams and plates. Use of variational principles to obtain boundary value problems of aforementioned structural members.
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 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 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: Must be enrolled in one of the following College(s): College of Engineering; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ME 5170 - Finite Element and Variational Methods in Engineering

Presents fundamental concepts of variational methods including Rayleigh-Ritz technique. Introduces foundations of finite element modeling through direct method, variational method, and weighted residual method. Reviews elements commonly used in static structural analysis and heat transfer problems. Advanced topics such as nonlinearity and time-dependent problems may also be discussed.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 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, in odd years
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5190 - Machine Learning for Engineering Applications

This course introduces students to machine learning algorithms and their applications in engineering. Topics include supervised and unsupervised learning algorithms. Students will apply machine learning techniques to problems in different areas including mechanical, biomedical, and materials design problems.
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 College(s): College of Engineering

ME 5201 - Principles of SI Engine Operations

SI engines are examined through labs, lectures, and dynamometer testing. Focus on applied aspects; performance metrics, thermochemistry, combustion, fuel and air systems, variable valve actuation, and turbocharging. Covers advanced cycles like Miller/Atkinson and prechamber concepts.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Summer, in odd years
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5202 - Principles of Diesel Engine Operations

Diesel engine operation through lectures, labs, and dynamometer testing are studied. Topics include performance metrics, thermochemistry, combustion, fuel injection, air handling, EGR, and aftertreatment. it also addresses the impact of emissions standards on engine design.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Summer, in even years
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5203 - SI Engine Control & Calibration

Spark-ignition engine control and calibration are examined through lectures, labs, and hands-on activities. Examines sensors, actuators, torque, and combustion management. Covers combustion phasing, lambda, valve timing, knock, emissions control, calibration, and OBD.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Summer, in odd years
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5204 - Diesel Engine Control & Calibration

Diesel engine control and calibration are examined through lectures, labs, and hands-on activities. Examines sensors, actuators, torque, combustion, and emissions management. Fuel injection control and air/EGR charge management and their impact on load, combustion, and emissions.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Summer, in even years
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 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; Must be enrolled in one of the following College(s): College of Engineering

ME 5212 - Intermediate Thermodynamics

A graduate-level thermodynamics course with emphasis on chemically reacting mixtures, thermodynamic property relations, entropy production/exergy destruction, and chemical and phase equilibrium.
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): Mechanical Eng-Eng Mechanics, Mechanical Engineering

ME 5215 - Computational Fluids Engineering

This course introduces students into the theoretical and practical aspects of computational methods in fluid mechanics and thermal transport problems. Computer based tools are used to reinforce principles on advanced topics in thermo-fluids science.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering

ME 5220 - Fuel Cell Technology

Fuel cell basics, operation principles and advanced performance analysis. Emphasis on component materials and two-phase transport phenomena on proton exchange membrane fuel cells. Hydrogen production, transportation, and storage. Balance of plant and systems analysis.
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; Must be enrolled in one of the following College(s): College of Engineering

ME 5225 - Advanced Power System and Pollution Control

Course will cover stationary systems for industrial and power applications; will include coal power plants, open-and combined-cycle gas turbines, co-generation, post combustion pollution control, biomass based fuels for power generation, and economic considerations.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5230 - Advanced Heat Transfer

Advanced topics on conduction, convection, radiation, and heat exchangers are covered. Emphasis is on problem formulation, exact solutions, empirical correlations/results, and on computational techniques.
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; Must be enrolled in one of the following College(s): College of Engineering

ME 5235 - Wind Energy

This course introduces students to the underlying principles of wind energy conversion, with an emphasis on the theoretical aspects of wind turbine design, aerodynamics, construction, control, and operation.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering

ME 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, in odd years
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

ME 5250 - Internal Combustion Engines II

Examination of current technology SI and diesel engines through the study of actuators, in-cylinder processes, cylinder pressure analysis, and cycle simulation. Additional topics of interest based on student input.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in odd years
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, Mechanical Engineering
Pre-Requisite(s): (MEEM 4220 or ME 4220) and (MEEM 4201(C) or ME 4201(C) or MEEM 5212(C))

ME 5255 - Advanced Powertrain Instrumentation and Experimental Methods

Experimentation and testing of engines and propulsion systems through instruction and structured labs. Study and application of data acquisition systems. Investigation of transducers, calibration, signal conditioning, and noise for combustion, power, performance, efficiency, and emissions.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): MEEM 4220(C) or ME 4220(C)

ME 5265 - Physical Gasdynamics

Equilibrium gaskinetic theory, chemical thermodynamics, introduction to quantum and statistical mechanics, flow with finite rate (e.g. vibrational energy relaxations, and chemical reactions), nonequilibrium kinetic theory, selected gaskinetic related computational methods.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5270 - Advanced Combustion

The objective is to understand basic combustion processes through detailed chemical reaction step analysis. Introduces both analytical and modern experimental methods. Emphasizes gas liquid fuel combustion, flame propagation, and critical phenomena of ignition and extinction.
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
Pre-Requisite(s): MEEM 4240 or ME 4240 or MEEM 4201 or ME 4201 or MEEM 5212 or ME 5212

ME 5275 - Energy Storage Systems

Designing energy storage solutions for grid, vehicle, and portable/autonomous systems. Quantitative and qualitative analysis of energy storage aging, cost, and performance improvement.
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): Mechanical Eng-Eng Mechanics, Mechanical Engineering

ME 5280 - Phase-Change & Two-Phase Flows

Air-water, condensing, and boiling flows are discussed in the context of interface conditions and instabilities. Wettability conditions and nucleation mechanisms are considered. Two-phase flow predictions are discussed in the context of correlations for: flow-regime maps, heat transfer coefficients, pressure-drop, void-fraction, etc.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5290 - Principles of Energy Conversion

Introduces fundamentals of energy conversion and storage. Topics include fossil and nuclear fuels, thermodynamic power cycles, solar energy, photovoltaics, and energy storage. Students will apply energy economics and complete semester-long project.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering

ME 5295 - Advanced Propulsion Systems for Hybrid Electric Vehicles

Hybrid electric vehicles (HEV) will be studied and simulated using advanced powertrain component analysis and modeling. An in-depth analysis and study of power flows, losses and energy usage are examined for isolated powertrain components and HEV configurations. Simulation tools will be developed and applied to specify powertrain and vehicle components and to develop control and calibration for a constrained optimization to vehicle technical specifications.
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; Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 4295 or ME 4295

ME 5296 - Powertrain Integration for Vehicle Electrification

This hands-on course examines challenges with powertrain integration in vehicle electrification. Topics include Vehicle Development Process, Thermal Management, Vehicle Controls, Safety, Calibration, and Vehicle Simulation Models. The course project includes optimizing performance of an electrified vehicle through modeling and experimentation.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: 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
Pre-Requisite(s): MEEM 4296(C) or EE 4296(C)

ME 5300 - Cybersecurity of Industrial Control Systems

General introduction to cybersecurity of industrial control systems and critical infrastructures. Topics include NIST and DHS publications, threat analysis, vulnerability analysis, red teaming, intrusion detection systems, industrial networks, industrial malware, and selected case studies.
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): Mechatronics, Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or Graduate Status >= 1

ME 5315 - Cyber Security of Automotive Systems I

Modern automotive control and communications systems from a cyber security perspective. Topics include: V2X communications, vehicle attack surfaces and vulnerabilities, in-vehicle networks, threat analysis and vulnerabilities, security mechanisms and architectures, security requirements analysis, hardware security modules, and standards.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Computer Science, Mechatronics, Mechanical Eng-Eng Mechanics, Computer Engineering, Mechanical Engineering
Pre-Requisite(s): MEEM 5300 or ME 5300 or EE 5455

ME 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, Spring
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5430 - Human Factors - Transportation

This course aims to provide an understanding of drivers as a system component in the operation of vehicles and other transportation systems. Topics covered include human factors, driver-vehicle interaction, intelligent transportation systems, connected vehicle technology, and user interface.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5440 - Advanced Vehicle Dynamics

This course will develop advanced nonlinear models to predict vehicle dynamic response of road vehicles by means of Matlab Simulink environment. Topics covered by this course include advanced tire modeling, powertrain modeling, lateral dynamics and vertical dynamics.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, 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, Mechanical Engineering, Computer Engineering, Electrical Engineering

ME 5500 - Supervised Practicum

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 MS degree. For online students only.
Credits: variable to 9.0; 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): Mechanical Engineering; Must be enrolled in one of the following Campus(s): Off Campus MTU On-Line

ME 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: 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

ME 5640 - Micromanufacturing Processes

Introduction, analysis and reporting of 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.
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; Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics, Mechanical Engineering

ME 5645 - Analysis of Manufacturing Processes

Computational analysis of manufacturing processes, selection analysis considering manufacturability and process economics, subtractive manufacturing, additive manufacturing, polymer/composite processing, bulk forming processes, sheet forming processes, casting processes, assembly processes.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5650 - Advanced Quality Engineering

Introduction to the concepts and methods of 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; multi-variate situations; and computer-based workshops.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
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

ME 5655 - Introduction to Lean Manufacturing

Introduces lean manufacturing tools, techniques, and practices. Topics include Muda, 5S, visual factory, VSM, theory of constraints, standardized work, pull system, SMED, TPM, and lean assessment. Additional case studies and manufacturing process simulation-based projects are also used for assessing and improving processes.
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; Must be enrolled in one of the following College(s): College of Engineering, College of Business

ME 5656 - Advanced Production Planning

Covers fundamental production planning topics as capacity management, facility layout, process design and analysis, forecasting, inventory management, MRP, scheduling, and theory of constraints. Introduces basic lean concepts, lean production, and value stream mapping. Advanced topics include case studies and exploring the influence of machine learning, artificial intelligence, data analytics, and augmented/virtual reality fields on production planning.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics

ME 5670 - Experimental Design in Engineering

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: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 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
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5695 - Additive Manufacturing

Background, principles, process chain, software aspects, post-processing, open-source tools, applications, and future directions of AM technologies are discussed. Advanced topics include process modeling and selection, DFAM, and opportunities and challenges of AM processes.
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; Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics, Mechanical Engineering

ME 5700 - Dynamic Measurement/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, Summer
Restrictions: Must be enrolled in one of the following College(s): College of Engineering, College of Computing
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5701 - Engineering Vibrations

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: Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5702 - Engineering Vibrations

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: Spring
Restrictions: Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): ME 4702(C) or Graduate Status >= 1

ME 5703 - Exp Methods for Eng Vibrations

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: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): (MEEM 5700 or ME 5700(C)) and (MEEM 4701 or ME 4701)

ME 5705 - 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.
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; Must be enrolled in one of the following Major(s): Mechatronics, Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 3750 or ME 3750

ME 5715 - Linear Systems Theory and Design

Overview of linear algebra, modern control; state-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,
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): Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 3750 or ME 3750 or EE 3261

ME 5730 - Dynamic System Simulation

Methods for simulating dynamic systems described by ordinary differential equations using numerical integration are developed including error quantification and simulation verification. MATLAB, Simulink and Simscape are used to illustrate key concepts.
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): Mechanical Engineering, Mechanical Eng-Eng Mechanics, Vehicle Dynamics

ME 5750 - Model-Based Embedded Control System Design

This course introduces embedded control system design using model-based approach. Course topics include model-based embedded control system design, discrete-event control, sensors, actuators, electronic control unit, digital controller design, and communications protocols. Prior knowledge of hybrid electric vehicles are highly recommended.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
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): Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 4775 or ME 4775 or EE 4261 or EE 3261

ME 5800 - Advanced Engineering Mathematics with Applications

This course is for engineering graduate students to learn about in-depth ordinary differential equations (ODEs) and partial differential equations (PDEs) widely employed in the field of Mechanical Engineering. 'Vector Calculus' will also be covered. The students will be asked to demonstrate their knowledge of the material covered in this Advanced Engineering Mathematics course.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Summer
Restrictions: Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 4901(C) or ME 4901(C) or ENT 4950(C) or Graduate Status >= 1

ME 5811 - Automotive Systems

Automotive systems for light duty vehicles are examined from the perspectives of requirements, design, technical, and economic analysis for advanced mobility needs. This course links the content for the automotive systems graduate certificate in controls, powertrain, vehicle dynamics, connected and autonomous vehicles.
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): Mechanical Eng-Eng Mechanics, Automotive Systems & Controls, Hybrid Elec. Drive Vehicle Eng, Mechanical Engineering

ME 5812 - Automotive Control Systems

Introduction to automotive control systems. Modeling and control methods are presented for: air-fuel ratio, transient fuel, spark timing, idle speed, transmission, cruise speed, anti-lock brakes, traction, active suspension systems, and hybrid electric vehicles, Advanced control methodologies are introduced for appropriate applications.
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): Mechanical Eng-Eng Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 4775 or ME 4775

ME 5990 - Special Topics

Study of selected subjects related to mechanical engineering or engineering mechanics.
Credits: variable to 4.0; May be repeated
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

ME 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; 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): Mechanical Eng-Eng Mechanics, Mechanical Engineering

ME 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

ME 6010 - Engineering Research Communications

Guides students through the process of preparing proposals, publishing research, and presenting at conferences and other venues, with a focus on practical application of rhetorical concepts. Students will prepare proposals, papers, and presentations related to their own research.
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, College of Computing

ME 6110 - Advanced Continuum Mechanics

Presents fundamental concepts in hyperelasticity, damage mechanics, linear viscoelasticity, quasi-linear viscoelasticity, poroelasticity, continuum jump conditions, plasticity, and viscoplasticity. These theories are applied to describe the mechanical behavior of a wide range of engineering materials and biomaterials such as polymers, metals, soil, collagen, muscle tissue, bone tissue, and cartilage.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in even years
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 5110 or ME 5110

ME 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: Spring, in even years
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, Mechanical Engineering

ME 6212 - Advanced Thermodynamics

This course includes classical (equilibrium) thermodynamics and non-equilibrium thermodynamics. Topics include thermodynamic potentials, state relations, stability, chemical equilibrium and reaction kinetics, phase equilibrium, and non-equilibrium phase change. Objectives are to develop a deeper understanding of thermodynamic methods.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): MEEM 5212 or ME 5212

ME 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 and compares them with software based numerical solutions.
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 or ME 5230

ME 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 or ME 5230

ME 6245 - Advanced Computational Fluid Dynamics

An advanced graduate CDF course based on finite difference/ volume methods. Topics are selected from the following list: numerical grid generation, turbulence modeling, multi-phase flows, chemically reacting flows, lattice Boltzmann method, gas kinetic scheme, molecular dynamics method, Monte Carlo Method, particle-in-cell method, etc.
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 5240 or ME 5240

ME 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 or ME 5230

ME 6320 - Cyber Security of Automotive Systems II

This course covers advanced topics in cyber security of automotive systems. Topics covered include modeling and simulation of cyber attacks on vehicle subsystems, communications, security for V2X systems, vulnerabilities in cooperative vehicle infrastructures, threat analysis, and cyber security of SAE level 2, 3, and 4 autonomous driving 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; Must be enrolled in one of the following Major(s): Computer Science, Mechanical Engineering, Mechanical Eng-Eng Mechanics, Computer Engineering, Electrical Engineering
Pre-Requisite(s): MEEM 5310 or EE 5310 or ME 5310

ME 6500 - Supervised Practicum

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. Online students only.
Credits: variable to 9.0; 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): Mechanical Eng-Eng Mechanics; Must be enrolled in one of the following Campus(s): Off Campus MTU On-Line

ME 6701 - Advanced Acoustics

Advanced concepts in acoustics with emphasis on modeling of sound sources, sound interaction with solid structures, transmission and radiation of sound. Discusses numerical acoustics, statistical energy analysis, and sound quality concepts. Provides beneficial background in basic vibrations and noise control.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MEEM 4704 or ME 4704

ME 6702 - Nonlinear Systems Analysis & Control

Studies nonlinear systems from perspective of analysis/control system design. Explores fundamental properties for 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 and sliding mode control.
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 5715 or ME 5715

ME 6703 - Advanced Vibrations

Discuss continuous systems with applications to strings, shafts, beams, plates, and membranes. Modeling piezoceramics augmented structures as actuators and sensors for control applications. Problems are formulated using Hamilton's principle and Lagrange's equations.
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): Mechanical Eng-Eng Mechanics, Mechanical Engineering

ME 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

ME 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; May be repeated; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

Mechanical Engineering Technology

MET 5000 - Independent Study in Mechanical Engineering Technology

Independent study in an approved topic under the guidance of a Mechanical Engineering Technology faculty member. Course of study may either be research or academic determined by student 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 Class(es): Senior

MET 5377 - Applied Fluid Power

An introduction to fluid power components and systems. The course includes component selection, circuit design, electrical interfaces, and system troubleshooting and maintenance. A laboratory exposes students to system hardware and circuit simulation techniques for mobile and industrial applications.
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): MET 3400 or MEEM 3201 or MET 3130

MET 5378 - Advanced Hydraulics: Electro-hydraulic Components & Systems

This course covers electro-hydraulic components including solenoid operated valves, proportional valves, and servo valves. Also covered are hydraulic systems including open-loop and closed-loop.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Spring
Pre-Requisite(s): MET 4377

MET 5400 - Key Factors of Holistic Safety Programs

Students learn best industry safety practices with respect to; risk management, lockout/energy isolation, fluid power and electrical symbols, basic circuit design and machine design, and sequence of operation involved with automation controls and mechanical motion.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Spring
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): (EET 3373 or EET 5373) and (MET 4377 or MET 5378)

MET 5800 - Dynamics and Kinematics of Robotics Platforms

This course covers the dynamics and kinematics of rigid bodies as the foundation for analyzing the motion of robots. Robotic kinematics is reviewed by analyzing the motion of the robot. The dynamics is reviewed by analyzing the relation between the joint actuator torques and resulting motion.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Spring
Pre-Requisite(s): MET 2130 or MET 3130

MET 5802 - Vibrations of Mechanical Systems

This course deals with the modeling and analysis of mixed physical systems. Introduction to modeling and oscillatory response analysis for discrete and continuous mechanical and structural systems. Time and frequency domain analysis of linear system vibrations. Vibration of multi-degree-of-freedom systems. Free vibration eigenvalue problems.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Pre-Requisite(s): MET 2130

MET 5990 - Special Topics in Mechanical Engineering Technology

Mechanical Engineering Technology topics of interest to faculty and student.
Credits: variable to 3.0; Repeatable to a Max of 12
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

Manufacturing Engineering

MFGE 5000 - Organizational Leadership

Team building, ethical decision making, enhanced communication skills, critical thinking, and people skills are discussed. Students learn the practice of leadership, as it relates to organizational effectiveness.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 5010 - Professional Engineering Communication

This course introduces graduate students to professional engineering communication such as composing technical memos and a variety of reports (test, design, progress, etc.). Students learn and practice creating compelling visuals for reports and slides, and also develop and deliver presentations individually and in groups.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 5100 - Tolerance Analysis with Geometric Dimensioning & Tolerancing

GD&T is the universal manufacturing language. This course will focus on the ASME Y14.5-2018 standard and cover the concepts of GD&T needed to communicate effectively in the manufacturing sector. Includes: assembly tolerance stack-up, applying and interpreting geometric symbols, datum reference frames, and calculating position and profile tolerance.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 5200 - Industry 4.0 Concepts

An examination of industry 4.0 as it relates to manufacturing. Topics include smart factories, cyber physical systems, proactive maintenance, computer simulation, horizontal and vertical integration, and barriers to implementation.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 5300 - Design for Additive Manufacturing

This course looks into the challenges of Additive. Pros and cons of the seven ASTM AM categories are discussed with the view of product purpose: form, fit, and function. Effects of build orientation, layer height, particle size, and slicing software have on part integrity are also discussed.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 5400 - Additive Manufacturing Lab

A hands-on approach is used to investigate Additive Manufacturing technologies. Key concepts are demonstrated by implementing the generic eight-step AM process. Students will design and print parts using various AM machines.
Credits: 3.0
Lec-Rec-Lab: (0-1-3)
Semesters Offered: Fall, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 5500 - Industrial Safety

In this course, students will be introduced to the principles of industrial safety. In detail, this course will cover best practices of safety in the workplace as well as OSHA regulations. After completing this course, students should be able to demonstrate their knowledge of maintaining a safe working environment as well as OSHA compliance.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 5990 - Special Topics in Manufacturing Engineering

Select additional topics of interest in Manufacturing Engineering based on student and faculty demand and interest. May be a tutorial, seminar, workshop, project, or class study.
Credits: variable to 3.0; May be repeated
Semesters Offered: On Demand
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

MFGE 5999 - Graduate Research

Research/investigation on a topic related to manufacturing engineering leading to the submission of a thesis or report in partial fulfillment of the requirements for the master's degree.
Credits: variable to 10.0; Repeatable to a Max of 10; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 6010 - Engineering Research Communications

Guides students through the process of preparing proposals, publishing research, and presenting at conferences and other venues, with a focus on practical application of rhetorical concepts. Students will prepare proposals, papers, and presentations related to their own research.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 6500 - Supervised Practicum

Research/investigation on a topic related to manufacturing engineering leading to the submission of a dissertation in partial fulfillment of the requirements for the PhD degree. Online students only.
Credits: variable to 9.0; 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): Manufacturing Engineering; Must be enrolled in one of the following Campus(s): Off Campus MTU On-Line

MFGE 6999 - Dissertation Research

Research/investigation on a topic related to manufacturing engineering leading to the submission of a dissertation in partial fulfillment of the requirement of the PhD degree.
Credits: variable to 9.0; 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): Manufacturing Engineering

Management Info Systems

MIS 5000 - Emerging Technologies

Focuses on understanding IT for competitive advantage and as an agent of transformation. Topics include managing IT infrastructure and architecture, facilitating information distribution throughout the enterprise, business applications for machine learning and artificial intelligence, and other emerging trends and technologies.
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): (MIS 2100 and MIS 3200(C)) or (CS 2321 and CS 3141) or BA 5200 or UN 5550

MIS 5100 - Information Systems Projects

MIS capstone course. Applies IS practices and artifacts as solutions to business problems using student-led project teams under faculty supervision. Students develop a working prototype of a business solution using good design and management practices.
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): (MIS 2100 and MIS 3100 and MIS 3200) or (CS 2321 and CS 3141 and CS 3425) or (MIS 2100 and MIS 3100 and MA 3720) or BA 5200 or UN 5550

Materials Science & Engineering

MSE 5110 - 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

MSE 5120 - 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 or MSE 5110

MSE 5130 - Crystallography & Diffraction

Crystallographic concepts and diffraction analyses in materials science.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MSE 5140 - Mechanical Behavior of Materials

Deformation-related physical behaviors of materials in the mathematical framework of tensor analysis. Material symmetry and tensor property. Stress, strain, and elastic constitutive relation. Non-elastic strain, thermomechanical, electromechanical, and magnetomechanical behaviors.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MSE 5151 - Quantum Field Theory for Photonics and Materials

This course will review the basics of quantum mechanics and second quantization, and cover quantum field theoretical methods, including Wick's theorem and Feynman diagram techniques, for absolute zero and non-zero temperatures (Matsubara frequencies) and their application in photonics, properties of materials and condensed matter physics.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years

MSE 5400 - Statistical Quality Control in Materials Manufacturing

This course examines the application of statistical quality control concepts to materials manufacturing, utilizing statistical inference relating processing, structure and properties. The concepts of uni- and multivariable and attribute control charts, process design and optimization are examined using various processing routes.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Summer
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

MSE 5410 - Materials for Energy Applications

Advanced solid materials for hydrogen energy will be introduced, including hydrogen storage materials, hydrogen production catalysts, and proton exchange membranes with emphasis on structures and properties. Silicon semiconductors, compound semiconductors, and nanostructured semiconductors will be discussed for solar energy applications.
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

MSE 5430 - Electronic Materials

A study of the physical principles of electronic materials, their applications in solid-state devices, and future trends in their development.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MSE 5440 - 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: On Demand
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

MSE 5460 - Solid State Devices

A study of the physical principles and evolution of solid-state devices, such as transistors: from conventional to novel types utilizing hetero-junctions and quantum effects; light emitting devices, semiconductor lasers; and displays of various types.
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

MSE 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

MSE 5480 - Advanced MEMS

This course will cover advanced topics dealing with MEIXIS technologies, transduction mechanisms, and microfabricated sensors and actuators.
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 or MSE 4240

MSE 5490 - Solar Photovoltaic Science and Engineering

Solar photovoltaic materials, the device physics of photovoltaic cells and practical applications of solar electric systems engineering.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

MSE 5540 - Advanced Computational Materials Science: Theory, Modeling, Simulation, and Practice

Theories of materials science from list principles to constitutive laws. Materials modeling and computer simulation at multiple length and time scales. Laboratory practice of various computational methods.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MSE 5550 - 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

MSE 5665 - Surface and Interface Science for Chemical and Materials Analysis

Coursework and hands-on laboratory experiences explore physical and chemical properties governing surface processes and the appropriate analysis techniques used to study interfaces and surface chemical reactions. Topics include principles of physical chemistry and materials science for understanding and applying modern surface analysis.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: On Demand
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

MSE 5760 - Vehicle Battery Cells and Systems

The behavior and application of batteries will be examined by introducing concepts from thermodynamics, materials science, transport processes and equivalent circuits. The non-ideal power source behavior of rechargeable batteries in applications will be treated using electrolyte: electrode transport and electrode materials chemistry. Prior exposure to freshman chemistry, elementary electrical circuits, and elementary transport theory is assumed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following College(s): College of Engineering; Must be enrolled in one of the following Major(s): Biomedical Engineering, Engineering, Civil Engineering, Chemical Engineering, Computer Engineering, Electrical & Computer Engineer, Electrical Engineering, Engineering Mechanics, Environmental Engineering, Geological Engineering, Geology, Engineering, Mechanical Engineering, Materials Science and Engrg, Applied Physics, Chemistry, Physics, Applied Geophysics; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

MSE 5777 - Advanced Open-Source 3-D Printing

An introduction to distributed additive manufacturing using open-source 3-D printing. Design, use, and maintenance of open-source electronics and self-replicating rapid prototypers (RepRap). Graduate students will be expected to complete coursework and an in-depth project.
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 College(s): College of Engineering

MSE 5900 - Graduate Professional Preparation

A weekly seminar covering topics relevant to professional development, such as technical seminars, effective communication techniques, intellectual property, engineering ethics, global and social issues in engineering, and diversity, equity and inclusion.
Credits: 1.0; May be repeated
Lec-Rec-Lab: (0-1-0)
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): Materials Science and Engrg

MSE 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

MSE 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

MSE 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

MSE 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

MSE 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

MSE 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

Physics

PH 5001 - Independent Study of Physics

Graduate level special topics to be decided by the instructor depending on the disciplinary needs of the students. All students must attend the physics colloquium and present their progress when requested.
Credits: variable to 3.0; Repeatable to a Max of 15
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

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. Attendance is required in the physics department colloquium series.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PH 5090 - Special Topics in Physics

The subject matter may vary from term to term and year to year depending on the needs of advanced students.
Credits: variable to 3.0; May be repeated
Semesters Offered: Fall, Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PH 5110 - Classical Mechanics

Lagrangian methods, symmetries and conservation laws, variational formulation, small oscillations, Hamilton's equations, contact transformations, Poisson brackets, Hamilton-Jacobi theory, Lorentz-invariant formulation.
Credits: 2.0
Lec-Rec-Lab: (2-0-0)
Semesters Offered: Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PH 5151 - Quantum Field Theory for Photonics and Materials

This course will review the basics of quantum mechanics and second quantization, and cover quantum field theoretical methods, including Wick's theorem and Feynman diagram techniques, for absolute zero and non-zero temperatures (Matsubara frequencies) and their application in photonics, properties of materials and condensed matter physics.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
Pre-Requisite(s): PH 3410 and PH 3411(C)

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: On Demand
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, in even years
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 5395 - Computer Simulation in Physics

Role of computer simulation in physics with emphasis on methodologies, data and error analysis, approximations, and potential pitfalls. Methodologies may include Monte Carlo simulation, molecular dynamics, and first-principles calculations for materials, astrophysics simulation, and biophysics simulations.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Spring, in odd years

PH 5396 - Statistics, Data Mining and Machine Learning in Astronomy

The course focuses on modern problem solving in Astronomy and Astrophysics through statistical inference, machine learning algorithms and data mining techniques. Students will be presented with data sets and research problems in astrophysics and will learn how to formulate solutions.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Spring, in even years
Pre-Requisite(s): PH 4390

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: On Demand
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, in even years
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, in odd years
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 5640 - Atmospheric Physics

Essential elements of atmospheric physics, including thermodynamics, aerosol and cloud physics, radiative transfer, and atmospheric fluid dynamics.
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 2300 and (MA 3520 or MA 3521 or MA 3530 or MA 3560)

PH 5680 - Geophysical Fluid Dynamics

Fundamental forces and conservation laws that govern fluid flow; applications to the atmosphere and ocean, 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: Spring, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): PH 2300 and (MA 3520 or MA 3521 or MA 3530 or MA 3560)

PH 5999 - Master's Research

Master's-level research conducted under the direction of a graduate faculty advisor. All students must attend the physics colloquium and present their progress when requested.
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; Must be enrolled in one of the following Major(s): Physics, Applied Physics

PH 6999 - Doctoral Research

Independent research conducted in partial fulfillment of the requirements for the PhD degree. Scheduled by arrangement. All students must attend the physics colloquium and present their progress when requested.
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; Must be enrolled in one of the following Major(s): Physics, Applied Physics

Psychology

PSY 5010 - Cognitive Psychology

A systematic survey of classical and contemporary research topics in human cognition, including perception, attention, mental representation and processing, memory, knowledge, visual imagery, problem solving, reasoning, and decision making. Students will read original research papers and develop a research proposal.
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

PSY 5020 - Research Methods

This course provides a foundation in research methods in cognitive science and human factors, with an emphasis on experimental design, research ethics, and scientific communication. Course meets Michigan Tech's Advanced Responsible Conduct of Research (RCR) requirements.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PSY 5100 - Applied Cognitive Science

Survey of applied human information processing literature, detailed review of recent developments in applied cognitive science, and examination of the purposes, role and scope of cognitive systems engineering.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PSY 5160 - Sensation and Perception

This course will investigate sensory mechanisms and perceptual interpretations of the sensory stimuli. In addition to the basic five senses, proprioception, pain perception, and time perception will also be covered. Students will also write a research proposal.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PSY 5170 - Human Attention

This course will examine theories and empirical findings from the study of human attention and consider their implications for human performance in real-world contexts.
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

PSY 5210 - Advanced Statistical Analysis and Design I

An overview of data analysis methods including visualization, data programming, and univariate statistics such as t-test and ANOVA.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PSY 5220 - Advanced Statistical Analysis and Design II

Course covers multivariate statistics such as ANCOVA, Multiple Regression, factor analysis, clustering, machine learning, and mixture modeling.
Credits: 3.0; Repeatable to a Max of 12
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): PSY 5110

PSY 5390 - Testing and Measurement Advanced Psychometrics

Provides an advanced foundation in concepts, theories, and methods of psychological testing and measurement. Topics include: validity and reliability, cognitive process-tracing, test construction, survey construction, and evaluation, data analysis and interpretation, applications in human factors, workplace, neuropsychological, and educational contexts, test administration, ethics, laws, and standards. Satisfies some requirements for professional administration of psychological and educational assessments.
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): PSY 5210

PSY 5450 - Aging, Cognition, and Motor Behavior

Seminar on current research on age-related changes in cognitive function, motor behavior, and the interaction between cognitive decline and motor performance. Topics include the impact of aging on memory, attention, cognitive control, gait, balance, and motor learning.
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

PSY 5500 - Supervised Teaching Practicum

An experiential course in which student gain practical experience with course design and instruction.
Credits: variable to 3.0; Repeatable to a Max of 9
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

PSY 5510 - Memory and Learning: Review, Synthesis, and Applications

Review of literature on human memory and learning from behavioral, neural, and applied perspectives. Readings and discussion will focus on foundational research studies that have formed the basis for our knowledge about human memory and learning, with a focus on the implications for applied work in learning, training, and human factors.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PSY 5750 - Judgment and Decision Making

Decision making is a skill. To improve that skill and design better decision support systems, we examine how people make decisions, sources of power, common biases, and errors. This interdisciplinary approach includes three levels of analysis: descriptive, normative, and prescriptive.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PSY 5780 - Introduction to Qualitative Research Methods and Analysis

An introduction to the use of qualitative research methods in social science contexts. Emphasis is placed on understanding the underpinnings of qualitative research, research traditions, and theoretical orientations. Students will be introduced to specific qualitative analysis techniques, ways to interpret data, and writing strategies.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

PSY 5910 - Independent Research

Research experience, preparation, and data collection for projects that will not result in a thesis or dissertation.
Credits: variable to 12.0; Repeatable to a Max of 21; Graded Pass/Fail Only
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

PSY 5999 - Graduate Research

Fundamental and applied research in cognitive science and/or human factors leading to the submission of a thesis or report in partial fulfillment of the requirements for the master's degree.
Credits: variable to 12.0; 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

PSY 6990 - Special Topics in Cognitive Science

Study of special topics in cognitive science as designed by section title.
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

PSY 6999 - Doctoral Research

Fundamental and applied research in cognitive science and/or human factors. Leading to the 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: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

Systems Administration Technology

SAT 5001 - Introduction to Health Informatics

Course covers fundamental subjects such as medical decision support systems, telemedicine, medical ethics and biostatistics. Topics include consumer health informatics, international health care systems, global health informatics, and translational research informatics. Students will see medical informatics from a diverse scope of healthcare industry organizations. Scientific writing and communication will be encouraged.
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

SAT 5111 - Security and Privacy

Examines key health information security, policy, and procedures. Investigates how to distinguish elements of a security audit and key security policies. Students will conduct offensive and defensive cybersecurity methods to understand the security and privacy landscape of healthcare and its sensitive information, Analyzes roles of people maintaining health information security.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SAT 5114 - Artificial Intelligence in Healthcare

This course introduces students to clinical data and artificial intelligence (A1) methods in healthcare. Health AI topics such as machine learning, deep learning, risk prediction, medical image analysis, natural language processing of clinical text, computer vision, and the integration of AI, bias in algorithm development, bioethics, and regulation into the clinical environment are covered.
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): SAT 4650

SAT 5131 - Systems Analysis and Design

Provides knowledge of tools available to perform healthcare systems analysis, examines key factors in systems design, emphasizes importance of communication, and an understanding or the primary factors in systems implementation. Course will examine strategies, risks, and key factors in purchasing 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; Must be enrolled in one of the following Major(s): Health Informatics

SAT 5141 - Clinical Decision Support and AI Modeling

Course addresses complex medical decisions, evidence-based medicine, disease management and comprehensive laboratory informatics. Topics include correlation, differential diagnosis, disease progression, precision medicine, telemedicine, machine learning, deep learning, computer vision, WLP, data preprocessing, AI modeling to improve patient outcomes, and safety.
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): SAT 4650

SAT 5165 - Introduction to Big Data Analytics

Course will cover concepts and techniques used to analyze big data. We will cover the most important big data processing frameworks (e.g. Hadoop, spark) and GPU techniques. The students will acquire the knowledge of Hadoop architecture, MapReduce, Spark and the capability of programming to analyze big data.
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): SAT 4650

SAT 5251 - Advanced Topics in Network Security

Focuses on advanced research topics in communications security. The course is structured as a research seminar where students present research papers. Topics include protocol analysis, security in inter-domain routing, broadcast authentication protocols, covert channels and anonymous communication, key management, advanced trace-back schemes, and attack propagation modeling. A course project is required.
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): SAT 5231 or SAT 5241

SAT 5283 - Information Governance and Risk Management

Course will consist of the legal and regulatory requirements and security privacy concept principles regarding data management. Best practices of how organizations manage information risk through risk assessment practices and procedures will be conducted.
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 College(s): College of Computing, College of Engineering, College of Business

SAT 5317 - Internet of Medical Things (IoMT) and Remote Patient Monitoring (RPM)

The course will cover various aspects (including new research developments) of remote patient monitoring (RPM) and internet of medical things (IoMT) from embedded devices, low-power wireless, edge and cloud computing, to data analytics and machine learning. Students will perform conceptual and hands-on assignments.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Security & Privacy in Healthcr, Biomedical Engineering, Cybersecurity, Computational Science & Engrg, Data Science, Computer Science, Health Informatics, Electrical & Computer Engineer
Pre-Requisite(s): SAT 4650

SAT 5424 - Population Health Informatics

This course explores the foundations of population health informatics, including information architecture, data standards and confidentiality. We will examine key concepts related to registries, electronic health records, epidemiological databases, biosurveillance, health promotion, and quality reporting in population health management.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SAT 5520 - Machine Learning in Security

Study of artificial intelligence and machine learning in cybersecurity. Topics include fundamentals of common machine learning and deep learning algorithms, intelligent threat detection and analysis, user behavior analytics, machine learning in hacking, and automated cybersecurity systems.
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): SAT 3812 and SAT 4310

SAT 5555 - Blockchain Fundamentals and Applications

Introduction to basic concepts of blockchain and smart contracts, and applications based on blockchain and distributed ledger technology.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Permission of department required; Must be enrolled in one of the following Major(s): Applied Computer Science, Cybersecurity, Cybersecurity, Computer Engineering, Electrical & Computer Engineer, Computer Science, Management Information Systems, Information Technology; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): SAT 2711 or SAT 3812

SAT 5816 - Digital Forensics

Introduction of the basic principles and technology of digital forensics, including acquisition, preservation, and recovery and investigation of the evidence stored in digital devices.
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): SAT 2511 and (SAT 2711 or SAT 5111)

SAT 5817 - Security Penetration Testing and Audit

To provide knowledge and demonstrated methods to help prevent security breaches and develop safeguards to protect sensitive information and confidential data. Student learn offensive and defensive security concepts, audit best-practices.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): SAT 5111

SAT 5980 - Special Topics in Cybersecurity

Cybersecurity topic of interest to the faculty and student.
Credits: variable to 3.0; Repeatable to a Max of 3
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

SAT 5988 - Practical Experience in Cybersecurity

Independent study of a practical problem, design project, or emerging technology in cybersecurity. Preparation of a written report and/or oral presentation.
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

SAT 5989 - Graduate Research in Cybersecurity

The study of an acceptable cybersecurity research problem and the preparation of a thesis or report.
Credits: variable to 10.0; Repeatable to a Max of 10; Graded Pass/Fail Only
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

SAT 5990 - Special Topics in Health Informatics

Medical informatics topic of interest to the faculty and student.
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

SAT 5998 - Practical Experience in Health Informatics

Independent study of a practical problem, design project, or emerging technology in health informatics. Preparation of a written report and/or oral presentation.
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

SAT 5999 - Graduate Research in Health Informatics

The study of an acceptable medical informatics research problem and the preparation of a thesis or report.
Credits: variable to 10.0; Repeatable to a Max of 10; Graded Pass/Fail Only
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

Social Sciences

SS 5003 - Survey Methods

A general introduction to survey methods. Students will learn the basics of survey design from questionnaire construction to the measurement of complex social science concepts. Students will also demonstrate their ability to conduct an original survey through a class project.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

SS 5004 - Statistics for the Social Sciences

A general introduction to quantitative analysis for the social sciences. The course uses common statistical software tools, such as SPSS, to aid in the analysis of data. Students apply their data analysis techniques to social science problems of their choosing in a semester-long project.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

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 5015 - Cultural/Environmental Office of Surface Mining VISTA Field Service Internship

Students enroll in this course during a supervised field experience dealing with natural and cultural heritage, natural or cultural resources, and/or community development. This course allows progress toward MS degrees in Industrial Archaeology and Environmental and Energy Policy while serving as an intern through OSM VISTA.
Credits: 1.0; May be repeated
Lec-Rec-Lab: (0-0-3)
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 Major(s): Industrial Archaeology, Environmental Policy

SS 5049 - GIS Applications for the Graduate Researcher

Applications of Geographic Information Science and Technologies for research problem identification, analysis, and dissemination. Students learn how to use GIS as a tool to collect and analyze qualitative and quantitative data for graduate research. Hands-on experience in data collection, analysis, and problem solving.
Credits: 3.0
Lec-Rec-Lab: (1-0-2)
Semesters Offered: Fall, in even years, Spring, in even years
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

SS 5050 - Advanced GIS Methods and Projects

Advanced application of Geographic Information Systems in social sciences as a tool to collect and analyze qualitative and quantitative data. Students gain hands-on experience in data collection, advanced spatial analysis, and scripting.
Credits: 3.0
Lec-Rec-Lab: (1-0-2)
Semesters Offered: Fall, in odd years
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): SS 5049

SS 5101 - Energy and Climate Policy

This course will review the complex process of energy policy making in the U.S. focusing on political, economic, social, organizational, and technological dimensions. Students will examine the prospects for policy change in the light of global climate change.
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

SS 5201 - Cultural Dimensions of International Immersion and Research

Students reflect on their culture and assumptions about the world; discuss conducting research responsibly; consider structural, material, and historical dimensions of social problems and social change; and explore how to live and work effectively with people from other cultural groups.
Credits: variable to 3.0; Repeatable to a Max of 6
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SS 5220 - Archaeological Thought in Society

This course explores themes concerned with the intellectual development of archaeology, including research methods, theoretical concepts, and problems that have characterized the history of the discipline. Particular emphasis is placed on the broader social contexts in which archaeology has developed.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SS 5230 - Archaeological Analysis and Interpretation

Course focuses on how archaeologists mobilize material data to understand everyday life in the past. Discussion, exercises, and lab time are used to cover the goals of archaeology, nature of archaeological data, research design, sampling, typology, classification, database management, and quantitative and qualitative analytical methods.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand

SS 5300 - Environmental and Energy Policy

An overview of environmental and natural resource policies in the U.S. and internationally. Emphasizes policies regarding forests, wildlife, public lands, pollution, and climate change. Discussion of policy administration by the USDA Forest Service and National Park Service.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years, Spring, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SS 5301 - The Policy Process

This course introduces key concepts in the policy making process (agenda, setting, formulation, decision-making, implementation, and evaluation). Theories of policy change are also introduced.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand

SS 5313 - Sustainability Science

This course covers the fundamental scientific concepts (dynamic systems and catastrophe theory) as they are applied to socioecological systems and the use of indicators and indices to track progress towards sustainability goals. Review of local, national, and global sustainability policies to avoid catastrophes and guide sustainable development.
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 5318 - Public Management

The main theories, philosophies, current themes, and critical issues in public sector management are examined.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required

SS 5320 - Special Topics in Environmental Policy

An intensive, student-led seminar focused on environmental and sustainability policy issues at local, regional, or global scales. Topics may include climate change, pollution, sustainable agriculture or development, environmental justice, globalization, or other current topics. May be repeated if topic differs.
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

SS 5330 - Advanced Topics in Energy Policy

An intensive student-led seminar focused on energy policy issues at local, regional, or global scales. Topics may include climate change, renewable energy, energy efficiency, nuclear wastes, and government mandates. May be repeated if topic differs.
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

SS 5350 - Policy Analysis

An overview of the policy process, including a detailed review of the major instruments that are used by federal, state, regional, and local governments.
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

SS 5420 - Critical Heritage and Memory

Provides a broad and deep overview into the prevalent debates, cases, and methods within the transdisciplinary fields of memory and heritage studies; students apply these processes in collaborative and individualized cases. Memory work in post-violence and post-industrialization communities, politics, and performances will be framed globally.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in odd years

SS 5501 - Industrial Communities

A graduate seminar covering studies of industrial communities. Introduces the methods and approaches of this field through reading and discussion of selected articles and case studies. Students will acquire skills in oral history, work with archival materials, and conduct field and community-based research.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SS 5502 - Historical Archaeology

Graduate seminar covering the essential elements of historical archaeology through reading and discussion of selected articles and case studies.
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

SS 5503 - Material Culture Studies

Graduate seminar covering the basic elements of material culture studies through readings, discussion, and projects.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SS 5530 - Deindustrialization and the Urban Environment

This course examines economic, environmental, and social problems associated with deindustrialization in postwar North American cities and the strategies adopted to ameliorate them. Major topics include segregation and housing, environmental regulation, environmental justice, industrial heritage, and economic and urban development policy.
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

SS 5550 - Global Environmental History

Examines changes in human interactions with earth systems over time, starting with the development of agriculture and continuing to the present--with flows of material through economies and ecologies now intertwined in complex ways. Places the notion of sustainability in historical perspective.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in odd years

SS 5551 - Global Industrial History

Graduate seminar examining the interlinked processes of industrialization and globalization ca. 1700-present. The course covers key theoretical debates and explores different methodological approaches through case studies of selected topics and themes.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SS 5600 - Industrial and Historical Archaeology

Directed readings and lectures in industrial and historical 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: 3.0
Lec-Rec-Lab: (0-0-3)
Semesters Offered: Spring, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SS 5626 - Program and Policy Evaluation

Provides students with an overview of the tools and methodologies commonly used to assess public programs and policy. Students learn how the effectiveness of public programs are evaluated and how evaluation is crucial to sustainable policy making across a range of sectors, including healthcare, social welfare, and environmental policy.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years, Spring, Summer, in odd years
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 5720 - Social Thought and Contemporary Issues

This course reviews the ways social scientists understand the nature of social organization, how these ideas have changed over time in concert with particular socio-historic transformations, and how, specifically, these ideas relate to understanding interactions between industrial society and the environment.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall

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: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in even years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SS 5900 - Cultural Resource Management

Introduces the field of cultural resource management (CRM) archaeology; the legal structure that underwrites its practice; the real-world implications for the CRM process; practical problems faced by archaeologists in preservation fields, and the legal, political, and ethical obligations they have to various constituents and communities.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall, in odd years
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SS 5920 - Internship Experience

Internships, on or off campus, providing appropriate practical, professional experience in an area related directly to a student's course of study. Students work under professional supervision. Requires a written evaluation of the work.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Summer
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

SS 5950 - Professional Development

This course will prepare graduate students in the social sciences department for the expectations for success in graduate school and future careers. The course will provide a foundation in understanding academic and professional development, including research, presentations and conference attendance, and professional preparation.
Credits: variable to 3.0
Semesters Offered: On Demand
Restrictions: Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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; 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 6002 - Research Design

This objective of this course is to explore the fundamentals of research design and analysis, particularly as these are applied to identifying, initiating, carrying out, and completing a thesis or dissertation research.
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 6005 - Mentoring Experiences for Graduate Students (MEG)

Team research and mentoring experience for graduate students where they serve as a research mentor to an undergraduate on a research project (e.g., UPERSS) creative work, or community-based research.
Credits: variable to 3.0; Repeatable to a Max of 6; Graded Pass/Fail Only
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Indust Heritage & Archaeology, Environmental & Energy Policy
Pre-Requisite(s): SS 6002 and (FW 5811(C) or UN 5001(C) or UN 0500(C))

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 6100 - Advanced Seminar in Energy and Climate Policy

This course will review the complex process of energy policy making in the U.S. focusing on political, economic, social, organizational, and technological dimensions. Students will examine the prospects for policy change in the light of global climate change.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, in even years
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
Semesters Offered: Fall, Spring
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, history of technology, and in environmental and energy policy. 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

Surveying

SU 5004 - Introduction to Geospatial Image Processing

Introduction to the basic concepts of Image Processing and Understanding. Applications focus on preprocessing of satellite and aerial images, remote sensing, and image/video enhancement. This course will provide mathematical foundations and explore modern practical algorithms and 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

SU 5010 - Geospatial Concepts, Technologies, and Data

High-level review of geospatial data acquisition systems, sensors and associated processing technologies. Course considers geospatial metadata generation principles, interoperability, and major tools for manipulation with geospatial data. Course may help in transition of non-geospatial majors to geospatial field.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Major(s): Integrated Geospatial Tech, Surveying Engineering, Geospatial Engineering

SU 5011 - Cadastre and Land Information Systems

Topics include: an introduction to land rights, land ownership, lease, and traditional rights, mortgaging and land as capital, description of land rights, boundary description, land information systems, examples of cadastre types over the globe, and modern technical aspects.
Credits: 3.0
Lec-Rec-Lab: (0-2-1)
Semesters Offered: Fall

SU 5012 - Geospatial Data Mining and Crowdsourcing

This course comprises theory and applications of geospatial data mining. Typical application scenarios are covered. Attention is given to open-source data and systems crowdsourcing, as well as social media. Special focus on imaging and visual analytics.
Credits: 3.0
Lec-Rec-Lab: (0-2-1)
Semesters Offered: Spring

SU 5013 - Hydrographic Mapping and Surveying

This course comprises theory and applications of hydrographic mapping technologies. Typical application scenarios are covered. An intensive lab component provides hands-on experience in hydrographic data processing and visualization.
Credits: 3.0
Lec-Rec-Lab: (0-2-1)
Semesters Offered: Spring

SU 5020 - Surveying Computations and Adjustments

Basic computations and analysis of surveying measurements by adjustment theory are introduced. Students will gain the ability to use computer software to perform the computations Analysis of measurements and errors based on statistical principles and least squares principles will be discussed.
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

SU 5021 - Geodetic Models

Course provides solid geospatial background in geodetic reference frames: datums; geoids; and reference ellipsoids. 2D and 3D geodetic network adjustments are considered based on 3D spherical models.
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): SU 5020(C)

SU 5022 - Geodetic Positioning

Introduces the theory and practice of global positioning systems, primarily global navigation satellite systems (GNSS). Examines data collection, quality assessment, analysis and adjustment.
Credits: 3.0
Lec-Rec-Lab: (0-2-3)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): SU 5020

SU 5023 - Geospatial Positioning

High-level summary of GPS-GAP courses. This course is intended for interdisciplinary graduate students who seek just ONE combination course in adjustments, geodesy and GPS (with emphasis on GPS/GNSS). Not available to students who have taken SU5020, SU5021, SU5022.
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

SU 5060 - Geodesy

Introduction to geometrical and physical geodesy. Examines computations on the ellipsoid, elements of datums, map projections, and state plane coordinate systems.
Credits: 3.0
Lec-Rec-Lab: (0-2-1)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SU 5140 - Photogrammetry & UAV Mapping

Basic principles of photogrammetry and its role as a technology for spatial data collection. Use of photogrammetry in the fields of surveying, engineering, and geographic information management will be discussed.
Credits: 4.0
Lec-Rec-Lab: (0-3-2)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SU 5142 - 3D Surveying and Modeling with Laser Scanner Data

Theory and application of terrestrial LIDAR scanning. Typical application scenarios are also included. Intensive lab component provides hands-on experience in LIDAR point cloud processing and visualization.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SU 5300 - Geospatial Monitoring of Engineering Structures and Geodynamic Processes

Course comprises methods and applications of geospatial monitoring technologies. Typical application scenarios are presented in this course. Course has a number of labs which allow students to get a hands-on experience in processing and modeling monitoring data.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Major(s): Integrated Geospatial Tech, Surveying Engineering, Geospatial Engineering
Pre-Requisite(s): SU 2000 or SU 2050

SU 5540 - Advanced Photogrammetry - Satellite Photogrammetry

Fundamentals of spaceborne imaging systems relevant to topographic mapping. Imagery products: preprocessing levels and metadata. Specific methods of space photogrammetry. Review of contemporary spaceborne imaging systems and imagery products available. Airborne non-frame sensors and photogrammetric processing of the imagery.
Credits: 3.0
Lec-Rec-Lab: (0-2-3)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): SU 4140

SU 5541 - Close-range Photogrammetry

The main topics that will be covered are: math fundamentals; imaging technology; the photogrammetric process; image acquisition planning; interior orientation; bundle block adjustment; 3D plotting; orthoprojection; image-matching techniques; and close range photogrammetry applications.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): SU 4140

SU 5601 - R for Geosciences in Applied and Fundamental Tasks and Research

R for Geosciences is intended to build up modern engineers and scientists and to get them acquainted with a powerful tool for the solution of miscellaneous applied statistical tasks in geosciences.
Credits: 3.0
Lec-Rec-Lab: (0-1-2)
Semesters Offered: On Demand

SU 5640 - Introduction to Remote Sensing

Introduction to the principles of image formation, electromagnetic spectrum, imaging systems, photo interpretation and image classification using image analysis software.
Credits: 3.0
Lec-Rec-Lab: (0-2-1)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SU 5800 - Geospatial Master's Graduate Seminar

Student presentations of geospatial related research. Graduate committee organization assistance, presentation skills training and guidance for final Master's research presentation.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SU 5990 - Special Topics in Integrated Geospatial Technology

Integrated Geospatial Technology topic of interest to the faculty and student.
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

SU 5998 - Practical Experience in Integrated Geospatial Technology

The study of an acceptable geospatial related research problem and the preparation of a report.
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

SU 5999 - Thesis Research in Integrated Geospatial Technology

The study of an acceptable geospatial related research problem and the preparation of a thesis.
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

University Wide

UN 5001 - Advanced Responsible Conduct of Research

Three, 4 hour workshops on advanced responsible conduct of research. Covers topics necessary for this training, including ethical standards, publication practices, peer review process, conflict of interest and societal expectations.
Credits: 1.0
Lec-Rec-Lab: (1-0-0)
Semesters Offered: Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

UN 5002 - Graduate Cooperative Education I

Credits may count as free or technical electives based on academic department. Requires advisor approval, good conduct and academic standing, registration with Career Services, and an official offer letter from the employer.
Credits: variable to 2.0
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

UN 5003 - Graduate Cooperative Education II

Credits may count as free or technical electives based on academic department. Requires advisor approval, good conduct and academic standing, registration with Career Services, and an official offer letter from the employer.
Credits: variable to 2.0
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): UN 5002

UN 5004 - Graduate Cooperative Education III

Credits may count as free or technical electives based on academic department. Requires advisor approval, good conduct and academic standing, registration with Career Services, and an official offer letter from the employer.
Credits: variable to 2.0; May be repeated
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): UN 5003

UN 5005 - Graduate Short Cooperative Education

Credits may count as free or technical electives based on academic department. Requires advisor approval, good conduct and academic standing, registration with Career Services, and an official offer letter from the employer.
Credits: variable to 2.0; May be repeated
Semesters Offered: Summer
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

UN 5200 - Interdisciplinary Colloquium

An interdisciplinary discussion-focused course covering special topics as specified by section title.
Credits: variable to 3.0; May be repeated
Semesters Offered: On Demand
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

UN 5390 - Scientific Computing

Set in a Linux environment, students will learn to design computational workflows, translate problems into programs, understand sources of errors, and debug, profile and parallelize the code. Successful completion of FOSS101 and earning its Digital Badge are required prior to registration
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

UN 5500 - Advanced Research Integrity

Three 4-hour workshops introduce students to the principles, practices, and regulations of responsible conduct research. Topics might include: societal expectations; professional and ethical standards; conflicts of interest; peer review; collaboration; publication and authorship; research misconduct; violations and sanctions.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate

UN 5550 - Introduction to Data Science

Introduces concepts and skills fundamental to Data Science including: getting data, data wrangling, exploratory data analysis, basic statistics, data visualization, data modeling, and learning. The course introduces data science from different perspectives: computer science, mathematics, business, engineering, and more.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
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): Data Science

UN 5951 - Graduate Status - Maintenance of Continuous Enrollment

Meets continuous enrollment requirement for graduate students needing "time out" for special circumstances (such as active military duty) and for online programs with inactive terms.
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 5953 - Graduate Status - Maintenance of Continuous Enrollment

Course can be used to meet the minimum one credit enrollment requirement for graduate students. Students enrolled in research-oriented degree programs must instead register in one credit of research with the appropriate faculty member. Not available to students who need to be enrolled fulltime with 9 credits.
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