Graduate Course Descriptions Effective Fall 2021

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 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; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): ACC 4100

ACC 5200 - Financial Statement Analysis
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; 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, advanced capital budgeting, profit center analysis, transfer pricing, and performance evaluation.
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; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ACC 5600 - Taxation for Decision Makers
This course focuses on how taxes impact management decision making. Advanced tax planning techniques are studied to develop 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; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ACC 5700 - Accounting Analytical Methods
Statistical analysis of large datasets. Computer programming will be used to analyze and manipulate the data. Topics include fundamental analysis, fraud detection, default prediction on loans, and other contemporary accounting issues.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Major(s): Accounting; 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; 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

Atmospheric Science

ATM 5100 - Atmospheric Sciences Research Discussion
Credits: 1.0; May be repeated
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2010-2011 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): ATM 5515(C) or ATM 5640(C) or ATM 5680(C) or ENVE 5515 or PH 5640 or PH 5680 or CEE 5515

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 - Offered alternate years beginning with the 2014-2015 academic year
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 - Offered alternate years beginning with the 2010-2011 academic year
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, Spring
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: Fall - Offered alternate years beginning with the 2017-2018 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): MA 3530 and PH 2300

ATM 6999 - Doctoral Research
Independent research conducted in partial fulfillment of the requirements of the Atmospheric Sciences doctoral degree.
Credits: variable to 12.0; May be repeated; Graded Pass/Fail Only
Semesters Offered: On Demand
Restrictions: 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
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 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., Engineering Management, Accounting, Business Administration

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, Summer
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: On Demand
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

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: Summer
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: Summer
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 Globalization
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 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 - Offered alternate years beginning with the 2014-2015 academic year
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 - Offered alternate years beginning with the 2020-2021 academic year
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 - Offered alternate years beginning with the 2014-2015 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

Graduate Course Descriptions Effective Fall 2021, Page 4 of 81
**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 - Offered alternate years beginning with the 2015-2016 academic year
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**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 - Offered alternate years beginning with the 2021-2022 academic year
**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 - Offered alternate years beginning with the 2018-2019 academic year
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

**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
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate
**Pre-Requisite(s):** BL 2020 and BE 3350 and BE 3550

**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
**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 - Offered alternate years beginning with the 2009-2010 academic year
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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

**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 - Offered alternate years beginning with the 2016-2017 academic year
**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 - Offered alternate years beginning with the 2021-2022 academic year
**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 - Offered alternate years beginning with the 2020-2021 academic year
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

Graduate Course Descriptions Effective Fall 2021, Page 5 of 81
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
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 - Offered alternate years beginning with the 2014-2015 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 3400 and BL 3190

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 - Offered alternate years beginning with the 2010-2011 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

BL 5036 - Plant Evolutionary Ecology
Plants, herbivores, and pollinators have played major roles in influencing each others evolutionary diversification. We will examine the ecology and evolution of plant-herbivore- pollinator interactions in basic and applied contexts. A solid foundation of tools in ecology and evolution will be established and class will include lectures and interactive discussions from readings of primary literature. Students will design, conduct, and analyze independent research projects in the lab.
Credits: 3.0
Lec-Rec-Lab: (2-0-2)
Semesters Offered: Summer - Offered alternate years beginning with the 2019-2020 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 3400 and BL 3190
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: Spring - Offered alternate years beginning with the 2021-2022 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 3300 or BL 4030

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 - Offered alternate years beginning with the 2020-2021 academic year
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 - Offered alternate years beginning with the 2011-2012 academic year
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: Summer - Offered alternate years beginning with the 2021-2022 academic year
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 - Offered alternate years beginning with the 2012-2013 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
BL 5153 - Applied Genome Editing
This course offers hands-on training in genome editing design and implementation. Objectives will include knockout, tagging, and targeted mutation of genes in model organisms or cell lines. The history and ethics of genome editing will be discussed. Graduate students will lead a team genome editing project.
Credits: 3.0
Lec-Rec-Lab: (2-0-3)
Semesters Offered: Fall - Offered alternate years beginning with the 2022-2023 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 2200 or FW 3230

BL 5200 - Microbial Physiology
Structure and function of microorganisms, with emphasis on mechanisms for responding to changing environmental and nutritional conditions.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2018-2019 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): BL 3210 or BL 3310

BL 5300 - Applied 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 - Offered alternate years beginning with the 2019-2020 academic year

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 Clinical Laboratory Science
A discussion of recent developments in clinical laboratory science.
Credits: variable to 10.0; Repeatable to a Max of 10
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

BL 5400 - Special Topics in Plant Sciences
A discussion of recent developments in plant science. Topics may include biotechnology, physiology, systematics, phylogenetics, biochemistry, and molecular genetics.
Credits: variable to 10.0; Repeatable to a Max of 10
Semesters Offered: Fall, Spring, Summer
Restrictions: 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 - Offered alternate years beginning with the 2018-2019 academic year  
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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**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:** Summer - Offered alternate years beginning with the 2019-2020 academic year

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**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 - Offered alternate years beginning with the 2022-2023 academic year  
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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**BL 5461 - Ecosystem Ecology**
History, key concepts, and practice of ecosystem ecology in aquatic and terrestrial environments. Emphasizes interconnectedness of energy and nutrient flows globally and in regional case studies.

**Credits:** 3.0  
**Lec-Rec-Lab:** (0-3-0)  
**Semesters Offered:** Spring - Offered alternate years beginning with the 2011-2012 academic year  
**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)

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**BL 5500 - Graduate Seminar in Biological Sciences**
Analysis, evaluation, and synthesis of primary scientific literature on a specific topic in recitation/discussion format.

**Credits:** 1.0; Repeatable to a Max of 4  
**Lec-Rec-Lab:** (0-1-0)  
**Semesters Offered:** Fall, Spring  
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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**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

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**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

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**BL 5572 - 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, apoptosis, 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 - Offered alternate years beginning with the 2022-2023 academic year  
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

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**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, apoptosis, and angiogenesis in cancer initiation, and/or progression. Consideration of current therapies and future directions for treatment.

**Credits:** 3.0  
**Lec-Rec-Lab:** (0-0-3)  
**Semesters Offered:** Spring, Summer  
**Restrictions:** Permission of instructor required; Must be enrolled in one of the following Major(s): Biological Sciences

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**BL 5800 - Molecular Diagnostics**
This course provides the scientific background behind modern molecular techniques applied in the diagnosis of human diseases. Topics to be covered include nucleic acid structure and function as well as introduction to nucleic acid characterization techniques used in disease diagnosis and genetic disorders.

**Credits:** 5.0  
**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 5994 - International Biological Sciences Practicum
Thesis or project work conducted by graduate students enrolled in the Peace Corps Master's International Program in Biological Sciences.
Credits: 1.0; Repeatable to a Max of 18
Lec-Rec-Lab: (0-0-1)
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 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

Biochem & 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 allostery; 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 Engrg

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, plastic analysis of steel structures, and yield analysis of concrete beams and slabs.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2016-2017 academic year
Pre-Requisite(s): CEE 4201

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

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

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

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

CEE 5233 - Advanced Structural Timber Design
Advanced design of timber structures, including arches and traditional timber frames, advanced shear wall design, advanced connection design, including timber connectors, and advanced analysis and behavior of wood, including cumulative damage modeling.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2011-2012 academic year
Pre-Requisite(s): CEE 4233

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)

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 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 Design and Construction
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 - Offered alternate years beginning with the 2020-2021 academic year
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
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 - Offered alternate years beginning with the 2019-2020 academic year
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
Pre-Requisite(s): CEE 3490

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: 4.0
Lec-Rec-Lab: (3-0-2)
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: (0-2-3)
Semesters Offered: Fall, Spring
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

Graduate Course Descriptions Effective Fall 2021, Page 12 of 81
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 - Offered alternate years beginning with the 2015-2016 academic year
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 - Offered alternate years beginning with the 2010-2011 academic year
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/Vis spectroscopy, 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 - Offered alternate years beginning with the 2014-2015 academic year
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 - Offered alternate years beginning with the 2011-2012 academic year
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 - Offered alternate years beginning with the 2014-2015 academic year
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 - Offered alternate years beginning with the 2010-2011 academic year
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

Graduate Course Descriptions Effective Fall 2021, Page 13 of 81
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 - Offered alternate years beginning with the 2019-2020 academic year
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: On Demand
Pre-Requisite(s): CEE 3620 and (CEE 3710 or CEE 3502 or MA 3710)

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 - Offered alternate years beginning with the 2019-2020 academic year
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 5710 - Modeling and Simulation Applications for Decision-Making in Complex Dynamic Systems
Introduces students to the theory and application of modeling techniques and simulations in the analysis of decision alternatives in complex engineering problems. Topics include queuing theory, system dynamics modeling, agent-based modeling, discrete event simulations, etc. Students will be required to conceptualize and implement an appropriate research/engineering problem of choice (this could be a dissertation/thesis problem).

Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2019-2020 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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 5810 - Advanced Soil Mechanics
Provides advanced studies in the topics of soil compressibility and soil strength. Develop advanced procedures for determining stress distribution and stress changes from a fundamental basis. Students are strongly advised to take CE5820 concurrently.

Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Pre-Requisite(s): CEE 3810

CEE 5811 - Fundamentals of Soil Behavior and Engineering Laboratory
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. Laboratory testing will include 1D consolidation, permeability, and monotonic and cyclic triaxial testing.

Credits: 4.0
Lec-Rec-Lab: (3-0-3)
Semesters Offered: Fall, Spring
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 - Offered alternate years beginning with the 2020-2021 academic year
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): Environmental Engineering, Engineering - Environmental, Civil 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): Environmental Engineering, Engineering - Environmental, Civil 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): (ENG 2120 or MEEM 2150) and (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 - Pharmaceutical 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 - Pharmaceutical 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 5210 - Analytical Separations
Covers theory and applications of modern gas chromatography, high performance liquid chromatography, and ion chromatography as well as instrumentation for these techniques. Studies trace organic analysis and environmental problems.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

CH 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 - Offered alternate years beginning with the 2017-2018 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): CH 4212 or CH 4222

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 - Offered alternate years beginning with the 2017-2018 academic year
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 4222

CH 5310 - Advanced Inorganic Chemistry
Covers the organometallic chemistry of the transition elements, beginning with a historical overview of the subject, as well as basic ideas in complex and transition metal chemistry.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Pre-Requisite(s): CH 4320

CH 5410 - Advanced Organic Chemistry: 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, synths, 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 5509 - Transport and Transformation of Organic Pollutants
Assessment of factors controlling environmental fate, distribution, and transformation of organic pollutants. Thermodynamics, equilibrium, and kinetic relationships are used to quantify organic pollutant partitioning and transformations in air, water, and sediments. Use of mass balance equations to quantify pollutant transport.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2005-2006 academic year
Pre-Requisite(s): 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 5516 - Aerosol and Cloud Chemistry
This course is focused on the chemistry of atmospheric aerosols and cloud processes. Students will learn about methods for chemical characterization, the chemical composition of aerosol and the chemical reactions pertinent to secondary aerosol and cloud composition.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2019-2020 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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 - Offered alternate years beginning with the 2011-2012 academic year
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 - Offered alternate years beginning with the 2010-2011 academic year
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: Fall - Offered alternate years beginning with the 2018-2019 academic year
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 - Offered alternate years beginning with the 2010-2011 academic year
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 5640 - Synthesis of Nanoparticles
This hands-on course teaches methods of preparing different types of nanoparticles, and controlling nanoparticle size, structure, and functionalization. Students will analyze selected papers from professional literature to see emerging trends in nanoparticle design and use.
Credits: 3.0
Lec-Rec-Lab: (0-1-4)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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 5730 - Confocal Laser Scanning Microscopy: Foundations, Applications, and Advances
Principles of fluorescence microscopy, confocal microscope design, practical aspects of confocal microscopy, live cell imaging, high speed imaging, fluorescent stains, quantitative fluorescence, immunofluorescence, fluorescent proteins, biosensors. Confocal applications in biology and health related sciences will be covered.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Fall, Summer
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

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
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): 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, Spring

CM 5400 - Adv Reactive Systems Analysis
An analytical study of various aspects of chemical reactor behavior, such as multiple steady-states, dynamics, stability, and control. Also covers transport phenomena in packed beds of solids and mathematical modeling of packed-bed reactors.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

CM 5500 - Theory and Methods of Research
Discusses modern methods of research. Topics could include statistical analysis, presentation of data, modern experimental methods, or oral presentation skills.
Credits: 2.0
Lec-Rec-Lab: (1-0-2)
Semesters Offered: Fall, 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 - Offered alternate years beginning with the 2018-2019 academic year
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, Spring - Offered alternate years beginning with the 2019-2020 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

CM 5720 - Advanced Mineral Processing
Topics in mineral processing of current interest. Will cover grinding, flotation, agglomeration, pollution prevention, surface chemistry, and other areas where rapid advancement is occurring.
Credits: variable to 3.0; Repeatable to a Max of 12
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate

CM 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; Repeatable to a Max of 9
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Fall, Spring
Restrictions: Permission of instructor required

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 - Offered alternate years beginning with the 2014-2015 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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 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: On Demand
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 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: 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)

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 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: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): (CS 3425 or MIS 3100) 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 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 & Engr

CSE 5091 - Computational Science and Engineering Seminar
From time to time, depending on student demand, a seminar will be offered on current topics in computational science and engineering.
Credits: variable to 3.0; May be repeated
Semesters Offered: Fall, Spring
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate
CSE 5311 - 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 5710 - Modeling and Simulation Applications for Decision-Making in Complex Dynamic Domains
Introduces students to the theory and application of modeling techniques and simulations in the analysis of decision alternatives. Topics include queueing theory, system dynamics modeling, agent based modeling, and discrete event simulation. Students conceptualize and implement an appropriate research/engineering problem of choice (this could be a dissertation/thesis problem).
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 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
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: Fall, Spring
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: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EC 3003

EC 5300 - Managerial Economics
Economic analysis of the operation of a business. Topics include optimization, demand theory and forecasting, production/cost analysis, market structure and strategic behavior, risk analysis, antitrust policy and regulation of safety and the environment, and international management.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Business Administration, Applied Natural Resource Econ., Accounting

EC 5400 - Advanced Engineering Economics
Presents and demonstrates procedures and quantitative techniques used in capital budgeting and project evaluation and selection for industry. Topics include cash flow analysis, decision methods, risk and uncertainty, cost of capital, taxes and depreciation, and forecasting market variables. Topics presented with study problems, applying spreadsheet programs.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand - Offered alternate years beginning with the 2002-2003 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): 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: Spring
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: Fall, Spring
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: Fall
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: Fall, Spring, Summer
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:** Spring  
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate  
**Co-Requisite(s):** ED 0510

**ED 5101 - Foundations of Online Teaching**
This course provides an introduction to the planning, design development, and delivery of an online course. Students learn to create measurable learning objectives, engaging online activities, and authentic assessments for use in a future online course. Students will create and deliver an online lesson as their course capstone.

**Credits:** 1.0  
**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

**ED 5110 - Psychological Foundations of Education**
The course examines how human beings grow and learn across the lifespan. Psychological basis of educational procedures and practices are established with special reference to formal schooling, higher and tertiary education, and workplace settings.

**Credits:** 2.0  
**Lec-Rec-Lab:** (0-2-0)  
**Semesters Offered:** On Demand  
**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

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

**ED 5470 - Issues in STEM Education**
This course explores historical and contemporary issues in Science, Technology, Engineering, and Mathematics (STEM) education. Topics include STEM literacy, integrative approaches to STEM education, issues of equity and social justice, STEM education-related policy and legislation, and informal STEM education initiatives.

**Credits:** 2.0  
**Lec-Rec-Lab:** (2-0-0)  
**Semesters Offered:** On Demand  
**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

### ED 5540 - Special Topics in Education**
Group studies of specially selected issues or problems in education.  
**Credits:** variable to 6.0; Repeatable to a Max of 9  
**Semesters Offered:** On Demand  
**Restrictions:** Permission of instructor required

**ED 5560 - Ecology of Isle Royale for Educators**
K-12 teachers participate in a field-based camping experience on Isle Royale National Park, exploring basic ecological concepts regarding the interrelatedness of plants, animals, geology, climate, and human influences on Isle Royale. Prepares teachers to help students understand interrelationships, energy distribution in ecosystems and change over time.

**Credits:** variable to 3.0  
**Semesters Offered:** On Demand  
**Restrictions:** Permission of department required

**ED 5570 - Lesson Study**
Teachers will engage in an intensive method of improving instruction that includes designing a lesson with a group of colleagues, implementing the lesson in one of their classrooms, and collectively examining the lesson's effectiveness in engaging students in meaningful learning.

**Credits:** variable to 3.0; Repeatable to a Max of 3  
**Semesters Offered:** On Demand  
**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

**ED 5590 - Developing Science, Technology, Engineering and Mathematics (STEM) Instruction**
Exploration of foundational theories of STEM education. Students will participate in engineering-integrated learning activities, engage in inquiry-based learning tasks in mathematics and science, and utilize technology to enhance student learning. Students will practice backwards design to develop their own STEM learning activity.

**Credits:** 2.0; Repeatable to a Max of 4  
**Lec-Rec-Lab:** (2-0-0)  
**Semesters Offered:** On Demand  
**Restrictions:** Permission of department required; Must be enrolled in one of the following Level(s): Graduate

**ED 5600 - Independent Study in Education**
Through an independent study, gain additional insights to relevant topics in education and research. Students must work directly with select faculty to develop a structured line of study on select educational topics.

**Credits:** variable to 6.0; Repeatable to a Max of 9  
**Semesters Offered:** On Demand  
**Restrictions:** Permission of instructor required

**ED 5601 - Special Content Studies in Education**
Intensive institutes designed to help elementary, middle and high school educators integrate important concepts in math and science into classroom teaching units.

**Credits:** variable to 9.0; Repeatable to a Max of 9  
**Semesters Offered:** On Demand  
**Restrictions:** Permission of department required
ED 5602 - Special Applications in Education
Practical application following special content studies during which elementary, middle and high school teachers implement and evaluate a teaching unit that they designed for their own classroom inspired by the previous content course. A mandatory teachers’ forum provides opportunity to share ideas with other participating teachers.
Credits: variable to 9.0; Repeatable to a Max of 9
Seminars Offered: On Demand
Restrictions: Permission of department required

ED 5620 - Professional Development for Educators: Teaching Earth Science
A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of earth science.
Credits: variable to 4.0; Repeatable to a Max of 12
Seminars Offered: On Demand
Restrictions: Permission of department required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ED 5630 - Professional Development for Educators: Teaching Life Sciences
A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of life science.
Credits: variable to 4.0; Repeatable to a Max of 12
Seminars Offered: On Demand
Restrictions: Permission of department required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ED 5640 - Professional Development for Educators: Teaching Environmental Science
A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of environmental science.
Credits: variable to 4.0; Repeatable to a Max of 12
Seminars Offered: On Demand
Restrictions: Permission of department required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ED 5650 - Professional Development for Educators: Teaching Physical Science
A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of physical science.
Credits: variable to 4.0; Repeatable to a Max of 12
Seminars Offered: On Demand
Restrictions: Permission of department required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ED 5660 - Professional Development for Educators: Teaching Mathematics
A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of mathematics.
Credits: variable to 4.0; Repeatable to a Max of 12
Seminars Offered: On Demand
Restrictions: Permission of department required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ED 5665 - Professional Development for Educators: Teaching Computer Science
A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of computer science.
Credits: variable to 4.0; Repeatable to a Max of 12
Seminars Offered: On Demand
Restrictions: Permission of department required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ED 5670 - Teaching Technologies for Educators
This course guides educators in using technologies to design, implement, and assess learning experiences. Outcomes include the development of strategies to engage students, improve learning, and enrich professional practice through the thoughtful integration of technology.
Credits: variable to 4.0; Repeatable to a Max of 12
Seminars Offered: On Demand
Restrictions: Permission of department required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ED 5680 - Professional Development for Educators: Teaching Social Studies
A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of social studies.
Credits: variable to 4.0; Repeatable to a Max of 12
Seminars Offered: On Demand
Restrictions: Permission of department required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ED 5690 - Professional Development for Educators: Teaching Language Arts
A course for the professional development of professional K-12 educators. Topics address ideas, trends, and applications in the teaching and learning of language arts.
Credits: variable to 4.0; Repeatable to a Max of 12
Seminars Offered: On Demand
Restrictions: Permission of department required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

ED 5700 - Introduction to Education Research
Overview of education research methods to develop an understanding of designing education research, including the relationship between research question, theoretical framework(s), and methods. Focus is placed on developing a literature review to help lay theoretical groundwork for pursuing education research.
Credits: 2.0
Lec-Rec-Lab: (0-2-0)
Seminars Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate
ED 5705 - Action Research Project
Teachers will engage in the systematic study of their own practice by designing an action research study and then collecting and analyzing data to answer a question about their own teaching and/or student learning. Course enrollment is restricted to practicing teachers.
Credits: variable to 4.0; Repeatable to a Max of 8
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

ED 5720 - Inquiry-Based practices for Science and Mathematics Teaching
Examination of science and mathematics inquiry-based teaching practices and learning materials that support student understanding and engagement, and align to state and national standards.
Credits: 2.0
Lec-Rec-Lab: (2-0-0)
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

ED 5730 - Assessment and Evaluation
Methodological perspectives and techniques for assessing and evaluating student learning to inform instructional decision making.
Credits: 2.0
Lec-Rec-Lab: (0-2-0)
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

ED 5740 - Designing Education Research
Course focuses on designing a research project for the MSASE program. Emphasis on motivating a study, developing research questions, conducting a literature review, and selecting appropriate research methodology. Should be taken within one year of beginning research project.
Credits: 2.0
Lec-Rec-Lab: (0-2-0)
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): ED 5700

ED 5750 - Diagnosis and Remediation of Reading Problems
Identification of problems related to reading and language processing; identification and application of diagnostic, remediation and assessment strategies and instruments. Classroom specific experience in diagnosis and remediation of the total communication process.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

ED 5780 - Intro to Qualitative Research
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

ED 5800 - Applied Internship for Educators
Students will work in an industry or on a research project. At the conclusion of the internship, students will write a paper regarding how they will apply what they have learned in their pre-college classroom or in their own research.
Credits: variable to 6.0; Repeatable to a Max of 6
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate
Co-Requisite(s): ENG 5100

ED 5820 - Advanced Methods of Teaching Science
Application of learning and instructional theories to the teaching of science. Emphasizes methods of materials used to teach early adolescents. Taught from the perspective of science teachers. Lab offers opportunities to refine instructional techniques. K-12 science classroom teaching experience required.
Credits: 2.0; Repeatable to a Max of 4
Lec-Rec-Lab: (1-0-2)
Semesters Offered: On Demand
Restrictions: Permission of department required

ED 5860 - STEM Education Practicum
Practical experience in teaching, education research, and/or assessment in a STEM discipline. Students either teach/mentor undergraduate STEM students, work with a faculty member on a STEM education research project or work with STEM assessment activities. A seminar is required.
Credits: variable to 5.0; Repeatable to a Max of 5
Semesters Offered: On Demand
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): ED 5100 and ED 5110 and ED 5700

ED 5900 - Graduate Research in Education
Students will conduct a research project/report as a capstone to an approved plan of study. The student should present a project plan to their education advisor for approval, conduct whatever work is necessary for the project, prepare a final report at the conclusion of the project, and defend the project/report in an oral presentation.
Credits: variable to 6.0; Repeatable to a Max of 6; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor and department required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): ED 5700
**Electrical & Computer Engrg**

**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 - Offered alternate years beginning with the 2007-2008 academic year  
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical Engineering, Electrical Engineering, 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 - Offered alternate years beginning with the 2013-2014 academic year  
**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 - Offered alternate years beginning with the 2008-2009 academic year

**EE 5224 - Power System Protection Lab**
Theory-based application of software and hardware used for power system protection. Fault simulations, protective relay settings and coordination, and test operation of relays under static, dynamic, and transient conditions.

**Credits:** 1.0  
**Lec-Rec-Lab:** (0-0-2)  
**Semesters Offered:** Spring - Offered alternate years beginning with the 2008-2009 academic year  
**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 - Offered alternate years beginning with the 2012-2013 academic year  
**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, vo/t/var optimization, state estimation, feeder reconfiguration.

**Credits:** 3.0  
**Lec-Rec-Lab:** (3-0-0)  
**Semesters Offered:** Spring - Offered alternate years beginning with the 2017-2018 academic year  
**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 - Offered alternate years beginning with the 2008-2009 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): 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 - Offered alternate years beginning with the 2007-2008 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 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 EE 4295

EE 5296 - Powertrain Integration in HEV
This hands-on course examines challenges with powertrain integration in Hybrid Vehicles. Topics include Vehicle Development Process, Thermal Management, Vehicle Controls, Safety, Calibration, and Vehicle Simulation Models. The course project includes optimizing performance of a configurable HEV using 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 computar 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 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: Spring - Offered alternate years beginning with the 2020-2021 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical & 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: 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
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: Spring, Summer - Offered alternate years beginning with the 2007-2008 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EE 5500(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 - Offered alternate years beginning with the 2013-2014 academic year
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 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 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 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 - Offered alternate years beginning with the 2020-2021 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Electrical & 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 - Offered alternate years beginning with the 2016-2017 academic year

Graduate Course Descriptions Effective Fall 2021, Page 33 of 81
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 College(s): Electrical Engineering, Electrical & Computer Engineering
Pre-Requisite(s): EE 3261 or MEEM 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 College(s): College of Engineering; Must be enrolled in one of the following Major(s): Electrical Engineering, Mechatronics, Electrical & Computer Engineer
Pre-Requisite(s): MEEM 4700 or MEEM 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
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

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 4700 or MEEM 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 approved 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 5990 - Thesis Research in Electrical Engineering
Study of some acceptable electrical engineering problem and preparation of a thesis.
Credits: variable to 10.0; May be repeated; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required

EE 5991 - Project Research in Electrical Engineering
Study of some acceptable electrical engineering problem and preparation of a report.
Credits: variable to 6.0; May be repeated; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required

EE 5992 - Practical Experience in Electrical Engineering
A collaboration with industry on some acceptable electrical engineering task and preparation of a report.
Credits: variable to 4.0; May be repeated; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of department required

EE 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

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 Engr Technology

EET 5000 - Independent Study in Electrical Engineering Technology
Independent study in an approved topic under the guidance of an Electrical Engineering Technology staff member. Course of study may either be research or academic to be 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 Level(s): Graduate

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.
Credits: 4.0
Lec-Rec-Lab: (0-3-3)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EET 1411 or EET 2220 or PH 2230 or EE 2110 or EE 3010

EET 5147 - Industrial Robotic Vision System and Advanced Teach Pendant Programming
Courses 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.
Credits: 4.0
Lec-Rec-Lab: (0-3-3)
Semesters Offered: Fall, 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, cascade, feedforward, multivariable and model based methods. Graduate students are expected to demonstrate ability in modeling/simulation techniques of linear systems.
Credits: 4.0
Lec-Rec-Lab: (0-3-3)
Semesters Offered: Fall, Summer
Pre-Requisite(s): EET 3131 or EET 4253

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, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): EET 3373

EET 5990 - Special Topics in Electrical Engineering Technology
Electrical Engineering Technology topic 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

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

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
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 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: 3.0
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 5655 - Introduction to Lean Manufacturing
Lean manufacturing is emerging globally as a paradigm by which business units function to be globally competitive. Quality, cost, and delivery have become critical measures that impact profits, and, in turn, the success of an organization. Significant improvements in these measures come from the continuous elimination of waste, or non-value added activities, in manufacturing. This course is intended to familiarize students with this new philosophy of lean manufacturing and arm them with a basic toolset that enables the identification, measurement, and elimination of non-value added activities.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: 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

ENG 5670 - Experimental Design in Engineering
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: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering

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 & Env Science

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

FW 5020 - 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, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5021 - Forest Certification
Reviews the history and application of the four major certification programs applicable to forests in the United States: Forest Stewardship Council (FSC); Sustainable Forestry Initiative (SFI); American Tree Farm System (ATFS); and Programme for the Endorsement of Forest Certification (PEFC). Prior knowledge of forest ecology is helpful.
Credits: 1.0
Lec-Rec-Lab: (1-0-0)
Semesters Offered: Summer
Restrictions: Permission of instructor required; May not be enrolled in one of the following Major(s): Environmental Science, Engineering - Environmental, Applied Ecology; For Molec Genetics & Biotech, Forestry, Forest Science, Geographic Information Science, Forestry, Environmental Engineering, Forest Ecology & Mgmt; May not be enrolled in one of the following Class(es): Freshman, Sophomore

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.
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

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 - Offered alternate years beginning with the 2018-2019 academic year
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 - Offered alternate years beginning with the 2017-2018 academic year
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 - Offered alternate years beginning with the 2020-2021 academic year
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 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 - Offered alternate years beginning with the 2019-2020 academic year
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, successional, carbon exchange, productivity, and nutrient cycling.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2020-2021 academic year
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 - Offered alternate years beginning with the 2017-2018 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5130 - Forest Vegetation Dynamics
Investigation of how trees grow and interact in a variety of stand structures from a functional standpoint at both the tree- and stand-level. These principles will be used to test the use of silvicultural management tools for meeting a variety of objectives. Linkages will be made between stand development patterns and management options, with an emphasis on disturbance ecology.
Credits: 3.0
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2020-2021 academic year
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 5133 - Intensive Silviculture
Applied forest ecology practices involving interventions to produce high levels of ecosystem services. Covers a full range of ecosystem goods and services, including carbon sequestration and biomaterials. Emphasizes quantitative metrics and methods for assessing and evaluating outcomes, including growth and yield.
Credits: 3.0
Lec-Rec-Lab: (1-2-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2017-2018 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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 - Offered alternate years beginning with the 2017-2018 academic year
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
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 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 - Offered alternate years beginning with the 2017-2018 academic year

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 - Offered alternate years beginning with the 2016-2017 academic year
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 - Offered alternate years beginning with the 2017-2018 academic year
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 - Offered alternate years beginning with the 2018-2019 academic year
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: (0-1-0)
Semesters Offered: Fall, Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

FW 5377 - Advanced Forest & Environmental Resource Management II
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: 2.0; May be repeated
Lec-Rec-Lab: (0-2-0)
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 Regression Analysis
Regression as a tool for the analysis of forest and environmental science data. Topics include multiple linear, curvilinear and non-linear regression, hierarchical and grouped data and mixed-effects models. Emphasis is placed on application of tools to real-world data using R.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2018-2019 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Co-Requisite(s): FW 5412

FW 5412 - Regression in R
Use of R for basic data manipulation, statistical summary and regression. Topics include installing R, data import and export, basic statistics, graphics and fitting of linear, non-linear and mixed-effects models.
Credits: 1.0
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2018-2019 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Co-Requisite(s): FW 5411

FW 5421 - Climate Change and Management in Great Lakes Forested Systems
Provides an overview of climate change science, effects and adaptation for natural resource management in the Great Lakes region. Students develop climate change adaptation plans 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: (2-1-0)
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 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 - Offered alternate years beginning with the 2017-2018 academic year
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 land use, biodiversity, nutrient supply, plant stressors, and climate change are discussed.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring - Offered alternate years beginning with the 2016-2017 academic year
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
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 ArcMap 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
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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
Prepares the theory and quantitative procedures of digital image processing using remotely sensed data. Emphasizes image acquisition, preprocessing, enhancement, transformation classification techniques, accuracy assessment, and outputs. Discusses linkages to GIS. Also covers evaluating applications of the technology to current resource management problems via peer-reviewed literature.
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Spring - Offered alternate years beginning with the 2019-2020 academic year
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
Credits: 3.0
Lec-Rec-Lab: (2-0-1)
Semesters Offered: Fall
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): MA 1032 and (FW 5540 or FW 4540)

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: (0-0-3)
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 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

FW 5701 - Graduate Field Applied Ecology
Field skills in mapping/GPS work, forest diseases and insects, wildlife, vegetation geomorphology, natural resource inventory and silviculture for graduate students without an undergraduate degree in environmental science or a closely related degree.
Credits: 8.0
Lec-Rec-Lab: (3-0-15)
Semesters Offered: Fall, Summer

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
Overview of science and scientific research. The process of graduate education including choosing an advisor, selecting a research problem, writing a thesis proposal, scientific hypothesis testing, analyzing data, and communicating results through various media.
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 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 5812 - Public Relations for Natural Resource Professionals
Explores current methods to effectively communicate natural resource concepts to the public. Students will develop a public relations plan for their organization and will gain skills in crafting a message, writing promotional materials, sourcing compelling imagery, managing digital media, organizing outreach events, and engaging 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 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

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

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

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
Pre-Requisite(s): (MA 1160 or MA 1161 or MA 1121 or MA 1135) and GE 2000 and PH 2100

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

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

FW 6999 - Forest Resources and Environmental Science Doctoral Research
An original investigation in theoretical or experimental natural resources and submission of a dissertation in partial fulfillment of the requirements of the PhD degree.
Credits: variable to 15.0; May be repeated; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate

GE 5515 - Advanced Geoinformatics
This course covers the concepts and theories in geospatial science, GIS analysis techniques (network analysis, cost distance analysis, multi-layer raster data analysis), and remote sensing theories and applications across different spectra. Basic concepts and techniques associated with geostatistics, and analysis of spatial relationships are also introduced using examples in geophysical and environmental research.
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 2010

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 - Offered alternate years beginning with the 2015-2016 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): GE 3050 and PH 2100 and MA 3160

Geolog. & Mining Engrg & Sci.

GE 5115 - Advanced Environmental 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 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 5850 - Advanced Groundwater Engineering and Remediation
Computer modeling and other advanced topics in the analysis hydrological systems, contaminant transport and fate, and subsurface remediation systems.
Credits: 3.0
Lec-Rec-Lab: (0-2-3)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Class(es): Graduate

GE 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: Fall, Spring
Pre-Requisite(s): GE 3250

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 5970 - Special Topics in Global Environment Change
Course will focus on emerging topics on global environment change including changes in atmospheric composition and air quality, air pollution meteorology, extreme meteorological events, and ocean chemistry. Anthropogenic contributions to these changes will be presented and analyzed. Students will work on course projects based on historical records from multiple datasets to evaluate and appreciate the long-term changes in the global environment and better understand the perturbations due to human activities.
Credits: 3.0; Repeatable to a Max of 6
Lec-Rec-Lab: (2-1-0)
Semesters Offered: Fall, Spring

GE 5994 - International Geological Practicum
Geological field work outside of the U.S. used by Peace Corps Master International students during their field assignments. May be used repeatedly up to 12 credits.
Credits: 1.0; Repeatable to a Max of 12
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required; Must be enrolled in one of the following Major(s): Geology, Geophysics, Geological Engineering

GE 5995 - Domestic Geological Practicum
Project course for students serving in a U.S. based service activity for one or more semesters. The service activities pertain to community development in the context of geological resource development, restoration, or protection or geological hazard mitigation.
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

GE 5998 - International Geology Master's Research
An original investigation in theoretical or experimental natural geological hazard mitigation and submission of a thesis or report in partial fulfillment of the MS degree conducted while in the Peace Corps Program.
Credits: variable to 9.0; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of instructor required; Must be enrolled in one of the following College(s): College of Engineering

GE 5999 - Master's Graduate Research
Research of an acceptable geological engineering, mining engineering, geology, or geophysics problem and preparation of a thesis.
Credits: variable to 15.0; May be repeated; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate
GE 6999 - Doctoral Graduate Research
Original research of an acceptable geological engineering, mining engineering, geology, or geophysics problem and preparation of a PhD dissertation.
Credits: variable to 15.0; May be repeated; Graded Pass/Fail
Semesters Offered: Fall, Spring, Summer
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: 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

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 - Cultural Studies
Introduction to the theoretical history, methods, and practice of cultural studies. Includes the influence of literary humanism, Marxism, structuralism, subcultural studies, feminism, postmodernism, articulation theory, Deleuze and Guattari.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s):
Graduate

HU 5114 - 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 - Offered alternate years beginning with the 2018-2019 academic year
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 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: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): HU 5931

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: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): HU 5931

HU 5935 - Practicum in Writing Center Administration
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 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 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 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 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 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
Pre-Requisite(s): HU 6115

HU 6159 - Directed Reading
Directed reading in a focused area 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 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 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 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
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: Fall, Spring
Restrictions: Permission of department required

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 - Offered alternate years beginning with the 2018-2019 academic year
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 - Offered alternate years beginning with the 2018-2019 academic year
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 - Offered alternate years beginning with the 2010-2011 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MA 5301 or MA 4209

MA 5221 - Graph Theory
Review of basic graph theory followed by one or more advanced topics which may include topological graph theory, algebraic graph theory, graph decomposition or graph coloring.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2003-2004 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MA 5301 or MA 4209

MA 5222 - Design Theory
Methods for the construction of different combinatorial structures such as difference sets, symmetric designs, projective geometries, orthogonal latin squares, transversal designs, steiner systems and tournaments.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Pre-Requisite(s): 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 - Offered alternate years beginning with the 2010-2011 academic year
**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 - Offered alternate years beginning with the 2010-2011 academic year
**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 - Offered alternate years beginning with the 2011-2012 academic year
**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 I
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 the numerical solution of systems of linear algebraic equations, least-square problems, and eigenvalue problems. Direct and iterative methods will be covered.
**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 - Offered alternate years beginning with the 2002-2003 academic year
Pre-Requisite(s): MA 4330 or MA 4610 or MA 4630 or MA 5627

MA 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 4710 or MA 5731) and (MA 4710 or MA 4720) and MA 4760 and MA 5501

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 - Offered alternate years beginning with the 2019-2020 academic year
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 - Offered alternate years beginning with the 2017-2018 academic year
Pre-Requisite(s): (MA 4710 or MA 5731) and (MA 4770 or MA 5712)

MA 5741 - Multivariate Statistical Methods
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 - Offered alternate years beginning with the 2015-2016 academic year

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 - Offered alternate years beginning with the 2021-2022 academic year
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, Spring
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 - Offered alternate years beginning with the 2016-2017 academic year
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 preprocessing, 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
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
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2005-2006 academic year

MA 5901 - Teaching College Mathematics I
Survey key issues in undergraduate mathematics education, including course preparation, assessment, student learning, developing assignments, instructional strategies, technology, motivating students and institutional resources. The lab involves practical training in the computer algebra system used in the mathematics lab.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following Major(s): Mathematical Sciences, Statistics, Mathematics; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

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: Summer

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 48
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2011-2012 academic year
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 48
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2010-2011 academic year
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 48
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2010-2011 academic year
Restrictions: Permission of department required
Pre-Requisite(s): MA 5302

MA 6300 - Advanced Topics in Algebra
Advanced topics in algebra.
Credits: 3.0; Repeatable to a Max of 48
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2011-2012 academic year
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 48
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2011-2012 academic year
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 48
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2010-2011 academic year
Restrictions: Permission of department required

MA 6700 - Advanced Topics in Statistics
Topics may include but are not limited to experimental designs, methods of quality improvement, discrete data analysis, regression analysis, sampling theory, multivariate methods, resampling methods, statistical computing, integral and measure theory, stochastic processes, asymptotic methods, optimization, modeling, nonparametric and parametric statistics.
Credits: variable to 12.0; Repeatable to a Max of 48
Semesters Offered: Spring - Offered alternate years beginning with the 2010-2011 academic year
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 - Offered alternate years beginning with the 2011-2012 academic year
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 48
Semesters Offered: Fall, Spring, Summer

MA 6999 - Mathematical Sciences Doctoral Research
Taken in partial fulfillment of the doctoral thesis requirement.
Credits: variable to 12.0; 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


MEEM 5010 - Professional Engineering Communication
Course introduces graduate students to conventions of professional engineering communication such as composing technical documents and working effectively in teams. Students will practice creating effective visuals for reports and slides and develop and deliver presentations.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring, Summer
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 5110 - Continuum Mechanics/Elasticity
Covers development of Cartesian tensors and indicial notation applied to vector analysis; analysis of stress, principal stresses, invariants, strain tensors, material derivatives, and continuity equations; basic conservation laws and constitutive relationships; the theory of elasticity, including 2-D problems in plane stress/strain, stress functions, and 3-D problems with polar symmetry.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1
MEEM 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 ENT 4950(C) or Graduate Status >= 1

MEEM 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 ENT 4950(C) or Graduate Status >= 1

MEEM 5160 - Experimental Stress Analysis
Review of elastic stress-strain relationships. Covers theory and use of resistive strain gages, strain gage circuits, rosette analysis, static and dynamic strain measurement; discusses other current strain measuring techniques; introduces photoelasticity, Moire, and other optical techniques.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Fall
Restrictions: 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

MEEM 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 ENT 4950(C) or Graduate Status >= 1

MEEM 5180 - Mechanics of Composite Matls
Introduces engineering properties and advantages of fibrous composites, the governing equations of mechanics of anisotropic, laminated materials. Develops micromechanics methods for predicting the elastic properties of the composite and classical lamination theory, including hygrothermal effects, and applies them to stress and failure analysis of composite structures.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2009-2010 academic year
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 5201 - Fundamentals of SI Engines
A combination of lab lecture and hands-on activities. Operation fundamentals, performance metrics, thermochemistry, combustion, Miller & Atkinson cycle, fuel & air system, supercharging & turbocharging, exhaust systems, energy balance, variable valve actuation, simulation, and advanced concepts & trends.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Summer - Offered alternate years beginning with the 2017-2018 academic year
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 5202 - Fundamentals of Diesel Engines
A combination of lab lecture and hands-on activities. Fundamentals of operation, performance metrics, thermochemistry, combustion, fuel injection and spray, air systems and turbocharging, EGR, energy balance, heat transfer, diesel engine simulation, and advanced concepts and trends in diesel engines.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Summer - Offered alternate years beginning with the 2018-2019 academic year
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 5203 - SI Engine Control Systems
A combination lab lecture and hands-on activities. Review engine operation, regulations, intro to engine control, sensors & actuators, causality effects, combustion phasing, lambda, valve timing, load, control of, throttle, knock, turbo, fuel, emissions control, algorithm & calibration, OBD, controller communications.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Summer - Offered alternate years beginning with the 2017-2018 academic year
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 5204 - Diesel Engine Control Systems
A combination of lab lecture and hands-on activities. Review diesel operation, regulations, intro to engine control, diesel engine actuators, load control, Start of Injection, Rail Pressure, Turbo Control, EGR & Engine Out Emissions, after treatment, algorithm & calibration, OBD, controller communications.
Credits: 1.0
Lec-Rec-Lab: (0-0-2)
Semesters Offered: Summer - Offered alternate years beginning with the 2018-2019 academic year
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1
MEEM 5210 - Advanced Fluid Mechanics
Develops control volume forms of balance laws governing fluid motion and applies to problems involving rockets, pumps, sprinklers, etc. Derives and studies differential forms of governing equations for incompressible viscous flows. Some analytical solutions are obtained and students are exposed to rationale behind computational solution in conjunction with CFD software demonstration. Also covers qualitative aspects of lift and drag, loss of stability of laminar flows, turbulence, and vortex shedding.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering

MEEM 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics

MEEM 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

MEEM 5220 - Fuel Cell Technology
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

MEEM 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics
Pre-Requisite(s): MEEM 4901(C) or ENTR 4950(C) or Graduate Status >= 1

MEEM 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

MEEM 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

MEEM 5240 - Comp Fluid Dynamics for Engg
Introduces finite-difference and finite-volume methods used in solving fluid dynamics and heat transfer problems. Covers numerical grid generation, turbulence modeling, and application to some selected problems.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2001-2002 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering
MEEM 5250 - Internal Combustion Engines II
Advanced topics in internal combustion engines with emphasis on CI operation, modeling of engines, modeling of combustion processes, tribology, second law applications, and other topics of current interest.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2001-2002 academic year
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
Pre-Requisite(s): MEEM 4220 and (MEEM 4201(C) or MEEM 5212(C))

MEEM 5255 - Advanced Powertrain Instrumentation and Experimental Methods
Course is for those interested in experimentation, engines, and powertrain. Objective is to prepare to acquire quality data, and efficient experiments. Investigate transducers, calibration, data acquisition, signal conditioning, noise, and specific applications; engine combustion and emissions. Hands-on homework and structured lab activities.
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)

MEEM 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 ENT 4950(C) or Graduate Status >= 1

MEEM 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 MEEM 4201 or MEEM 5212

MEEM 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics

MEEM 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 ENT 4950(C) or Graduate Status >= 1

MEEM 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

MEEM 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics
Pre-Requisite(s): MEEM 4295
MEEM 5296 - Powertrain Integration in HEV
This hands-on course examines challenges with powertrain integration in Hybrid Vehicles. Topics include Vehicle Development Process, Thermal Management, Vehicle Controls, Safety, Calibration, and Vehicle Simulation Models. The course project includes optimizing performance of a configurable HEV using 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 Major(s): MEEM or ENT 4950(C) or Graduate Status >= 1
Pre-Requisite(s): MEEM 4296(C) or EE 4296(C)

MEEM 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): Mechanical Eng-Eng Mechanics, Mechatronics, Engineering Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 4901(C) or Graduate Status >= 1

MEEM 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 EE 5455

MEEM 5401 - Design for Reliability
Emphasizes the importance of reliability in design, covering basic concepts of series, parallel, standby and mixed systems. Uses conditional probability and multimodefunctions as methods for problem solution. Considers derating and reliability testing.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 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 Engineering, Mechanical Engineering, Engineering Mechanics
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 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, Engineering Mechanics, Mechanical Engineering, Computer Engineering, Electrical Engineering

MEEM 5610 - Advanced Machining Processes
Covers mechanics of 2-D and 3-D cutting and their extension to commonly used processes such as turning, boring, milling, and drilling. Topics include force modeling, surface generation, heat transfer, tool life and dynamics.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering

MEEM 5615 - Advanced Metal Forming
Introduces fundamentals of plasticity theory and applies to the analysis of deformation processes. Processes considered are forging, extrusion, wire drawing, bending, deep drawing, and stretch forming. Emphasizes sheet metal formability.
Credits: 4.0
Lec-Rec-Lab: (0-3-2)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1
MEEM 5625 - Precision Manuf and Metrology
Presents theory and practice involved in the manufacturing and measuring of precision components. Topics include precision machining processes, precision machine/mechanism design, and dimensional metrology. Addresses current manufacturing challenges in the bearings, optics, and microelectronics industries.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Fall, 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, Engineering Mechanics

MEEM 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics

MEEM 5645 - Numerical Analy Manuf Proc
Nonlinear FEM and BEM analyses, modeling of bulk forming processes, sheet forming processes, machining processes, casting processes, grinding of ceramics.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 5650 - Advanced Quality Engineering
Stresses the concepts and methods for quality and productivity improvement. Topics include principles of Shewhart, Deming, Taguchi; meaning of quality; control charts for variables, individuals, and attributes; process capability analysis; variation of assemblies; Monte Carlo simulation, multi-variate situations; and computer-based workshops. No credit for both MEEM4650 and MEEM5650.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, 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

MEEM 5655 - Introduction to Lean Manufacturing
Lean manufacturing is emerging globally as a paradigm by which business units function to be globally competitive. Quality, cost, and delivery have become critical measures that impact profits, and, in turn, the success of an organization. Significant improvements in these measures come from the continuous elimination of waste, or non-value-added activities, in manufacturing. This course is intended to familiarize students with this new philosophy of lean manufacturing and arm them with a basic toolset that enables the identification, measurement, and elimination of non-value added activities.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following College(s): College of Engineering, College of Business
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 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

MEEM 5670 - Experimental Design in Engineering
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 ENT 4950(C) or Graduate Status >= 1

MEEM 5680 - Optimization I
Provides introductory concepts to optimization methods and theory. Covers the fundamentals of optimization, which is central to any problem involving engineering decision making. Provides the tools to select the best alternative for specific objectives.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1
MEEM 5685 - Environmentally Responsible Design and Manufacturing
Examines impact of engineering and, in particular, design/manufacturing decisions on the environment. Topics include sustainability; energy/material flows; risk assessment, life cycles, manufacturing process waste streams, product design issues, including disassembly/post-use product handling; techniques for pollution prevention. Requires course project. Credit may not be received for both MEEM4685 and MEEM5685.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring - Offered alternate years beginning with the 2001-2002 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MEEM 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

MEEM 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 ENT 4950(C) or Graduate Status >= 1

MEEM 5701 - Intermediate Dynamics
Intermediate study of several topics in engineering dynamics, including three-dimensional kinematics and kinetics, generalized coordinates, Lagrange's equation, and Hamilton's principle. Uses computer-aided dynamic simulation tools for analyzing dynamic systems.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Major(s): Mechanical Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 5702 - Analytical Vibroacoustics
First in a series of two courses on vibro-acoustics to provide a unified approach to study noise and vibration. Emphasizes interaction between sound waves and structures. Presents advanced vibration concepts with computational tools. Discusses wave-modal duality.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Major(s): Mechanical Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics
Pre-Requisite(s): MEEM 4901(C) or ENT 4950(C) or Graduate Status >= 1

MEEM 5703 - Exp Methods Vibro-Acoustics
Covers operating data measurement and analysis, including multisource ODS. Includes signature analysis and order tracking; modal theory, modal scaling, FRF estimators; multiple input excitation techniques; parameter estimation methods; sound measurements and acoustic intensity; sound quality; field data acquisition, DAT; binaural recording and playback with equalization.
Credits: 4.0
Lec-Rec-Lab: (0-3-3)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MEEM 5700 and MEEM 5702

MEEM 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. Cannot receive credit for both MEEM4705 and MEEM5705.
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): Mechanical Eng-Eng Mechanics, Mechatronics, Engineering Mechanics, Mechanical Engineering
Pre-Requisite(s): MEEM 3750

MEEM 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics
Pre-Requisite(s): MEEM 3750 or EE 3261
MEEM 5720 - Advanced Space Mechanics
This course presents the vector-based solution of the two-body problem and the solution for Kepler's equations. The course will also cover basic orbit determination techniques, impulsive orbit transfer maneuvers, interplanetary trajectories, ground tracks, and rendezvous problems.  
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

MEEM 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 College(s): College of Engineering; Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics, Mechatronics, Engineering Mechanics, Mechanical Engineering  
Pre-Requisite(s): (MEEM 4700 or MEEM 4775 or EE 4261 or EE 3261)

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

MEEM 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, Engineering Mechanics, Mechanical Engineering

MEEM 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics  
Pre-Requisite(s): MEEM 4700 or MEEM 4775

MEEM 5990 - Special Topics  
Study of selected subjects related to mechanical engineering or engineering mechanics.  
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

MEEM 5995 - Graduate Research (Online/Off Campus)  
Research/investigation on a topic related to mechanical engineering or engineering mechanics leading to the submission of a thesis or report in a partial fulfillment or 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics

MEEM 5999 - Graduate Research  
Research/investigation on a topic related to mechanical engineering or engineering mechanics leading to the submission of a thesis or report in partial fulfillment of the requirements for the master's degree.  
Credits: variable to 15.0; 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics

MEEM 6000 - Graduate Seminar  
Presentations/seminars on issues related to mechanical engineering and engineering mechanics. May include invited speakers from industry, government labs, and academe.  
Credits: 1.0; Repeatable to a Max of 2  
Lec-Rec-Lab: (0-1-0)  
Semesters Offered: Fall, Spring  
Restrictions: Must be enrolled in one of the following Level(s): Graduate

Graduate Course Descriptions Effective Fall 2021, Page 62 of 81
MEEM 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

MEEM 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 - Offered alternate years beginning with the 2008-2009 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following College(s): College of Engineering
Pre-Requisite(s): MEEM 5110

MEEM 6130 - Engineering Fracture Mechanics
Development of the stress and deformation fields present near the tips of cracks. Uses elasticity solutions, plasticity corrections, and numerical methods in modeling these fields. Introduces fracture criteria and explains the various parameters used to develop these criteria.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, Summer - Offered alternate years beginning with the 2008-2009 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate; Must be enrolled in one of the following Major(s): Mechanical Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics

MEEM 6120 - 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

MEEM 6230 - Conduction
Fundamental aspects of conductive heat transfer applied to steady-state and transient conditions. Studies multidimensional conduction problems with exact and approximate solutions techniques.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MEEM 5230

MEEM 6240 - Convective Heat Transfer
An introduction to flow and boundary layer theory for forced and natural convection heat and mass transfer. Includes derivation and application of the equations for conservation of mass, energy, and momentum; dimensional analysis and correlation of experimental results.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MEEM 5230

MEEM 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
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MEEM 5240

MEEM 6250 - Radiative Heat Transfer
Fundamentals of thermal radiation for black, gray, nongray, diffuse, and specular surfaces. Includes radiation combined with conduction and convection at boundaries; properties for radiation in absorbing, emitting, and scattering media; and the engineering treatment of gas radiation in enclosures.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MEEM 5230
MEEM 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

MEEM 6701 - Advanced Acoustics
Advanced concepts in acoustics with emphasis on modeling of sound sources, sound interaction with solid structures, transmission and radiation of sound. Discusses numerical acoustics, statistical energy analysis, and sound quality concepts. Provides beneficial background in basic vibrations and noise control.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): MEEM 4704

MEEM 6702 - Nonlinear Sys Analy & 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

MEEM 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 Engineering, Mechanical Eng-Eng Mechanics, Engineering Mechanics

MEEM 6990 - Special Topics
Study of selected subjects related to mechanical engineering or engineering mechanics.
Credits: variable to 6.0; May be repeated
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

MEEM 6995 - Graduate Research (Online/Off Campus)
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; Must be enrolled in one of the following Major(s): Mechanical Eng-Eng Mechanics

MEEM 6999 - Doctoral Research
Research/investigation on a topic related to mechanical engineering or engineering mechanics leading to the submission of a dissertation in partial fulfillment of the requirements for the PhD degree.
Credits: variable to 15.0; 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 Engng 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 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: (0-3-0)
Semesters Offered: Fall
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 5801 - Controls of Dynamics Systems
This course covers the modeling, analysis, and control of dynamic systems. It used the controlling equations for the control of mechanical and electrical systems. Theory is verified with simulation and lab testing. Included is a major project with a report and presentation on the subject.
Credits: 3.0
Lec-Rec-Lab: (0-2-2)
Semesters Offered: Fall
Pre-Requisite(s): MET 4800 or MET 5800

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

Materials Sci. & Engineering

MSE 5100 - Introduction to Materials Science and Engineering with Advanced Topics
A survey of the processing structure property relationships including metals, ceramics, and polymers. The course will cover the same material as in MY2100 plus advanced topics on materials structure, characterization, processing, and properties.
Credits: 4.0
Lec-Rec-Lab: (4-0-0)
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): Materials Science and Engrg
MSE 5110 - Thermodynamics and Kinetics I
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
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 - Offered alternate years beginning with the 2020-2021 academic year

MSE 5190 - Advanced Materials Processing for Mechanical, Energy, and Biomedical Applications
Advanced materials processing technologies will be instructed with examples of various applications in mechanical, energy, and biomedical areas. Powder production, surface chemistry, separation, agglomeration, composites, forming, shaping, conventional and microwave heating, and nano materials and structures will be introduced.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand
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

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 5480 - Advanced MEMS
This course will cover advanced topics dealing with MEIXIS instrumentation, models and experimental techniques used to examine the physical principles and evolution of solid-state devices. Laboratory practice of various techniques.
Credits: 4.0
Lec-Rec-Lab: (3-1-0)
Semesters Offered: On Demand
Restrictions: Permission of instructor required; Must 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 5510 - Advanced Contact Mechanics and Nanoindentation
The application of elastic and plastic contact mechanics in relation to nanoindentation with emphasis on the application of instrumentation, models and experimental techniques used to examine the small-scale mechanical behavior of metals, ceramics, polymers, composites, biomaterials, hydrogels, and structured devices.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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, Spring
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 5560 - Powder Processing
Processing of metal and ceramic powders into bulk products. Powder manufacture and characterization, compaction, sintering, pressure-assisted consolidation to full density. Emphasis on principles underlying consolidation practices.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand - Offered alternate years beginning with the 2005-2006 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior
Pre-Requisite(s): MY 2100 or MSE 2100

MSE 5562 - Open Source Scientific Hardware
This course provides an introduction to the use of distributed digital manufacturing of open source hardware for scientific and engineering applications. The course outcome will be a design of an open hardware tool.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall

MSE 55622 - Advanced Open Source Scientific Hardware
This course provides an introduction to the use of distributed digital manufacturing of open source hardware for scientific and engineering applications. The course outcome will be a design of an open hardware tool.
Credits: 3.0
Lec-Rec-Lab: (1-0-2)
Semesters Offered: Spring
Restrictions: Permission of instructor required

MSE 5565 - 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 - Offered alternate years beginning with the 2010-2011 academic year
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 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
Graduate student presentations at departmental seminars.
Credits: 1.0; May be repeated
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Fall, Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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 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: Fall, Spring - Offered alternate years beginning with the 2002-2003 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PH 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 - Offered alternate years beginning with the 2020-2021 academic year
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, Lorentz 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 - Offered alternate years beginning with the 2008-2009 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): PH 5210

PH 5310 - Statistical Mechanics
Ensembles, partition functions and distributions, thermodynamic potentials, quantum statistics, ideal and nonideal gases, interacting systems. Applications may include classical and quantum liquids, phase transitions and critical phenomena, correlation functions, linear response and transport theory, or other topics.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2007-2008 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PH 5320 - Mathematical Physics
Partial differential equations of physics, separation of variables, boundary value problems, Sturm-Liouville theory, Legendre and Bessel functions, inhomogeneous partial differential equations, Green's functions, Fourier series, Fourier and Laplace transforms, complex variables, evaluation of integrals by contour integration, linear algebra, matrix methods with emphasis on numerical applications.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PH 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

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
Co-Requisite(s): PH 4395
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 - Offered alternate years beginning with the 2000-2001 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): PH 5320 and PH 5410

PH 5520 - Materials Physics
Materials classification and structures; phase diagrams; lattice imperfections; quasiparticles; boundaries and interfaces; mechanical, electronic, optical, magnetic and superconducting properties of materials.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2001-2002 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PH 5530 - Selected Topics in Nanoscale Science and Technology
Presentation and discussion of selected topics in nanoscale science and engineering. Topics include growth, properties, applications, and societal implication of nanoscale materials. Evaluation: attendance and assignment.
Credits: 2.0
Lec-Rec-Lab: (2-0-0)
Semesters Offered: On Demand
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

PH 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: Fall - Offered alternate years beginning with the 2017-2018 academic year
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. Attendance is required in the physics department colloquium series.
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. Attendance is required in the physics department colloquium series.
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: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

PSY 5015 - Cognitive Task Analysis Methods
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 walk, and critical decision method.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
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: On Demand
Restrictions: Must be enrolled in one of the following Level(s): Graduate
PSY 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

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 - Offered alternate years beginning with the 2017-2018 academic year
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: On Demand
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: Spring - Offered alternate years beginning with the 2019-2020 academic year
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 - Offered alternate years beginning with the 2018-2019 academic year
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 - Offered alternate years beginning with the 2018-2019 academic year
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
Pre-Requisite(s): PSY 5210

PSY 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

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 - Offered alternate years beginning with the 2018-2019 academic year
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; 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 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: On Demand
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 - Offered alternate years beginning with the 2018-2019 academic year
**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 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:** Fall - Offered alternate years beginning with the 2019-2020 academic year
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate

PSY 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 - Offered alternate years beginning with the 2018-2019 academic year
**Restrictions:** Must be enrolled in one of the following Level(s): Graduate
**Pre-Requisite(s):** PSY 5850

PSY 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

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 6991 - 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

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 Admin. 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, translational research informatics and homecare. Students will see medical informatics from diverse perspectives. 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. Analyzes the roles of people maintaining health information security and explains elements of these roles within the organization.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SAT 5114 - Artificial Intelligence in Healthcare
This course introduces students to clinical data and artificial intelligence (AI) methods in healthcare. Health AI topics such as risk prediction, imaging, natural language processing of clinical text, and the integration of AI into the clinical environment are covered.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall, Spring - Offered alternate years beginning with the 2019-2020 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SAT 5131 - System Analysis and Design
Provides knowledge of tools available to perform systems analysis, examines key factors in systems design, emphasizes importance of communication, and an understanding of 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

SAT 5141 - Clinical Support Modeling
Course addresses complex medical decisions, evidence-based medicine, disease management and comprehensive laboratory informatics. Topics include improving physical order entry and healthcare, using medical literature, clinical case discussions, meaningful use of medical data, enhancing patient and care-giver education, disease prevention, and public health and environmental health informatics.
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): SAT 5114

SAT 5151 - Application Integration and Interoperability
Defines and explains the role of interoperability in the development of a functioning EHR. Analyzes predominant standardization in the healthcare field such as ASTM and HL7. Examines the challenges to the development of interoperability in healthcare.
Credits: 3.0
Lec-Rec-Lab: (0-2-1)
Semesters Offered: Fall
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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

SAT 5241 - Designing Security Systems
Provides an overview of techniques used in the design of secure systems with a primary focus on real-world case studies. Students will examine attacks on deployed systems and investigate how these vulnerabilities have been addressed. Practical advantages and shortcomings of several notions of provable security will also be examined. Students will be expected to read, understand, and present recent research papers.
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 5111

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 5255 - Medical Imaging I
Introduction to the underlying physics, image formation theories and application of imaging methods used in medicine. This course is not a comprehensive presentation of imaging science but is an overview of the characteristics of each modality and their use.
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): SAT 5255

SAT 5256 - Medical Imaging II
Continuation of Medical Imaging I presenting more advanced imaging methods and their use in medicine. Topics such as MRI and Ultrasound will be covered in depth.
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): SAT 5255
SAT 5261 - Medical Image Analysis
Overview of medical image analysis techniques. Topics will include: fundamentals of medical imaging; image enhancement; image compression; image segmentation; noise reduction; image registration; content-based medical image retrieval, feature extraction and image recognition; and computer-aided diagnosis and detection systems.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring, Summer
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): CS 1111 or SAT 1200

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 - Offered alternate years beginning with the 2021-2022 academic year
Restrictions: Must be enrolled in one of the following College(s): College of Computing, College of Engineering, College of Business

SAT 5314 - Applied Machine Learning in Healthcare
This course provides an overview of designing and implementing practical applications of artificial intelligence (AI) in healthcare. As a research and project-based course, students will have opportunities to learn and specialize in particular AI methods, medical applications, and relevant tools.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): SAT 5114

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: (0-2-2)
Semesters Offered: Spring, Summer
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): SAT 5001 and SAT 5114

SAT 5761 - Introduction to Hadoop and Applications
This course will introduce the basic concepts of the Hadoop system. Topics include: programming languages for Hadoop, Hadoop Architecture, MapReduce, administration of Hadoop clusters, Hadoop input and output; basic concepts of Yarn, Spark, Pig, HBase, and Hive, and the applications of Hadoop for data analysis.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Summer

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 - Offered alternate years beginning with the 2020-2021 academic year
Restrictions: Must be enrolled in one of the following Major(s): Health Informatics, Integrated Geospatial Tech, Cybersecurity

SAT 5890 - Special Topics in Medical 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
The study of an acceptable medical informatics research problem and the preparation of a report.
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

SAT 5999 - Thesis Research in Health Informatics
The study of an acceptable medical informatics 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

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 - Offered alternate years beginning with the 2018-2019 academic year
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 - Offered alternate years beginning with the 2019-2020 academic year
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore

SS 5005 - Introduction to Agent Based Modeling
An introduction to computational methods for the social sciences. The course provides an introduction to complexity theory and Agent-Based Modeling. Students will apply what they have learned in this course to develop a pilot simulation to understand any social phenomena of their choosing.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2022-2023 academic year
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: Spring - Offered alternate years beginning with the 2018-2019 academic year
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 - Offered alternate years beginning with the 2019-2020 academic year
Restrictions: Permission of instructor required; Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): SS 5049

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 qualitative and quantitative analytical methods.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: On Demand

SS 5300 - Environmental and Natural Resources 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 - Offered alternate years beginning with the 2019-2020 academic year
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 5318 - Public Sector 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: Spring
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 5325 - Water Policy, History, and Governance
This seminar will explore the global history, politics, and governance of freshwater resources. Topics will include the effects of forestry, mining, watershed management, sanitation systems, privatization, climate change, fisheries, emerging contaminants, and agriculture on water systems and policies.

Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2020-2021 academic year

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 - Environmental 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 - Offered alternate years beginning with the 2018-2019 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
Pre-Requisite(s): SS 5300 and EC 2001

SS 5420 - Memory and Heritage
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 - Offered alternate years beginning with the 2021-2022 academic year

SS 5500 - History of Technology
Provides a basic introduction to work in the history of technology.

Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2013-2014 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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.

Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2022-2023 academic year
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: Spring - Offered alternate years beginning with the 2019-2020 academic year
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 - Offered alternate years beginning with the 2019-2020 academic year
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 - Offered alternate years beginning with the 2019-2020 academic year

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 - Offered alternate years beginning with the 2018-2019 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate
SS 5600 - Industrial Archaeology
Directed readings and lectures in industrial archaeology using wide range of material from the historical engineering and archaeology literature. Central focus is on regional case studies. Students complete a substantial directed research project.

Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2018-2019 academic year
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, Summer - Offered alternate years beginning with the 2012-2013 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

SS 5820 - Advanced, Ethical, Legal and Societal Implications (ELSI) of Nanotechnology
Advanced exploration of the implications of molecularism as brought about by emergent nanotechnology and nanoscience. Involves comparative investigations, extended reading and writing assignments in seminar setting.

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 5900 - Heritage Management
Introduces the current field of heritage management; the legislation that underwrites its practice; the articulation of federal, state, and local governmental activity; the evolving philosophies of archaeologists and historic preservationists operating in the public interest; parallels on the international scene; and the impacts of heritage tourism.

Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2021-2022 academic year
Restrictions: Must be enrolled in one of the following Level(s): Graduate

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: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring, Summer
Restrictions: Must not be enrolled in one of the following Level(s): 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: 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 in environmental and energy policy.

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 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 - Offered alternate years beginning with the 2012-2013 academic year
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, Summer
Restrictions: 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 - Data Analysis and Adjustments
Course explores fundamentals of mathematical error propagation theory including various observation equations, least squares adjustment, and Kalman filter methods. Blunder detection, decorrelation, and inversion of patterned large matrices processes are considered. Involves analysis of position estimation deploying geospatial measurements.
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)

Graduate Course Descriptions Effective Fall 2021, Page 78 of 81
SU 5022 - Positioning with GNSS
In-depth study of GPS, GLONASS, Galileo, COMPASS satellite systems, theory, and processing of global positioning measurements. Strongly recommended for geospatial practitioners.

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

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 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: (0-2-1)
Semesters Offered: On Demand
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 5501 - 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 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
UN 5000 - 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; May be repeated
Semesters Offered: Fall, Spring, Summer
Restrictions: Permission of department required; Must be enrolled in one of the following Level(s): Graduate

UN 5001 - 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 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 5000

UN 5003 - 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
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 IV
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 5000 - 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 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 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 5000

UN 5003 - 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
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 IV
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 5100 - Water and Society Colloquium
Seminar based class covers current topics in water resources. Objectives: build towards a common literacy on water resources issues; identify areas of common interest among students and faculty in water resources topics.
Credits: 1.0; Repeatable to a Max of 2
Lec-Rec-Lab: (0-1-0)
Semesters Offered: Spring
Restrictions: Permission of instructor required
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