Rose-Hulman Institute of Technology Course Catalog

Chemistry - Course Descriptions

CHEM 111 General Chemistry I 3R-0L-3C F,W,S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: CHEM 111L
Topics include stoichiometry, nomenclature, phases, and writing balanced chemical equations. Quantum theory is introduced in relation to chemical applications. Atomic structure is introduced. Bonding principles and molecular structure are discussed in terms of Lewis Dot Structures, Valence Bond Theory, VSEPR Theory, Hybridization, and Molecular Orbital Theory.

CHEM 111L General Chemistry I Laboratory 0R-3L-1C F,W,S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: CHEM 111
Fundamental chemistry laboratory skills are introduced along with data analysis in support of topics presented in CHEM111 recitation.

CHEM 112 Chemistry Honors 4R-3L-5C F
Graduate Studies Eligible: No
Prerequisites: Advanced placement
Corequisites: There are no corequisites for this course.
An accelerated course covering topics in CHEM 111 and CHEM 113. Upon successful completion of this course, an additional 3 credits will be awarded. Enrollment is limited to those students who complete the Rose-Hulman online Chemistry Advanced Placement Examination given prior to the freshman orientation period.

CHEM 113 General Chemistry II 3R-0L-3C W,S
Graduate Studies Eligible: No
Prerequisites: CHEM 111, and CHEM 111L
Corequisites: CHEM 113L
Topics in this course include the fundamentals of thermodynamics and kinetics. The fundamentals of chemical equilibrium are introduced. Definitions of acid and bases are discussed utilizing the Bronsted-Lowry and Lewis models. Nuclear chemistry is also included.

CHEM 113L General Chemistry II Laboratory 0R-3L-1C W,S
Graduate Studies Eligible: No
Prerequisites: CHEM 111, and CHEM 111L
Corequisites: CHEM 113
Fundamental chemistry laboratory skills are introduced along with data analysis in support of topics presented in CHEM113 recitation.

CHEM 115 General Chemistry III 3R-0L-3C W, S
Graduate Studies Eligible: No
Prerequisites: CHEM 113, and CHEM 113L or CHEM 112
Corequisites: CHEM 115L
Topics in this course include acid-base reactions, electrochemistry, and coordination chemistry.

CHEM 115L General Chemistry III Laboratory 0R-3L-1C W,S
Graduate Studies Eligible: No

Prerequisites: CHEM 113, and CHEM 113L or CHEM 112
Corequisites: CHEM 115
Fundamental chemistry laboratory skills are introduced along with data analysis in support of topics presented in CHEM113 recitation.

CHEM 199 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

CHEM 200 Career Preparation 1R-0L-1C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course is for chemistry and biochemistry majors to be taken in the second year. The course addresses career choices, summer opportunities, employment and graduate school preparation, and curriculum vitae and resumes preparation. Cross-listed with MA200, and SV200.

CHEM 210 Chemistry of Poisons and Potions 2R-0L-2C SeeDept
Graduate Studies Eligible: No
Prerequisites: CHEM 111, and CHEM 111L
Corequisites: There are no corequisites for this course.
This course examines chemical agents found in medicinal plants and their use in different contexts. Specifically, we will investigate the chemical characteristics of these agents commonly used by humans through cultural practices.

CHEM 211 Chemistry of Food and Cooking 2R-0L-2C See Dept.
Graduate Studies Eligible: No
Prerequisites: CHEM 111, and CHEM 111L
Corequisites: There are no corequisites for this course.
The course presents students with the basic structural elements of four categories of food molecules and many of the physical and chemical transformations that occur in food preparation. Among anticipated outcomes will be the ability to assess the role of ingredients and processes in specific recipes thereby allowing participants to make informed decisions about recipe modifications.

CHEM 212 Chemistry of Sport 2R-0L-2C SeeDept
Graduate Studies Eligible: No
Prerequisites: CHEM 111, and CHEM 111L
Corequisites: There are no corequisites for this course.
This course will take a molecule-focused look at the overlap of chemistry and sports. The course will look at types of performance-enhancing drugs and their history, mechanisms of action, claims of efficacy, and detection using case studies

CHEM 213 Chemistry of Art 2R-0L-2 SeeDept
Graduate Studies Eligible: No
Prerequisites: CHEM 111, and CHEM 111L
Corequisites: There are no corequisites for this course.
This course will highlight the intersection of the chemical sciences and visual arts. Focus will be given to understanding the chemical nature and behaviors of dyes,

pigments, and paints, pottery and glazes, textiles, and materials used for sculpture. Historical developments of artistic media will be discussed and related to chemical conservation efforts and forgery detection.

CHEM 225 Analytical Chemistry 3R-0L-3C F,S
Graduate Studies Eligible: No
Prerequisites: CHEM 115, and CHEM 115L
Corequisites: CHEM 225L
This laboratory-driven course is an introduction to classical and modern quantitative analysis with emphasis on calculations, separations, and precise and accurate measurements. Theoretical and practical perspectives of chemical analysis are considered. Chemical instrumentation includes recording pH/mV meters, constant rate burets, colorimeters, spectrophotometers, high performance liquid chromatographs and gas-liquid chromatographs.

CHEM 225L Analytical Chemistry Laboratory 0R-3L-1C F,S
Graduate Studies Eligible: No
Prerequisites: CHEM 115, and CHEM 115L
Corequisites: CHEM 225
This course represents the laboratory component of analytical chemistry. Practicums are part of the grade along with reports.

CHEM 251 Organic Chemistry I 3R-0L-3C F,W
Graduate Studies Eligible: No
Prerequisites: CHEM 113, and CHEM 113L or CHEM 112
Corequisites: CHEM 251L
An introduction to the classification of organic compounds, their structural features, including stereochemistry, and concepts related to reaction mechanisms and synthetic methods as it relates to compounds with biochemical relevance.

CHEM 251L Organic Chemistry I Laboratory 0R-3L-1C F,W
Graduate Studies Eligible: No
Prerequisites: CHEM 113, and CHEM 113L or CHEM 112
Corequisites: CHEM 251
Organic Laboratory techniques in running chemical reactions and isolating compounds are developed. Assessment is in part via practicums. Computational chemistry methods and green chemistry approaches are also introduced. Lab will meet 5 times in the term.

CHEM 252 Organic Chemistry II 3R-0L-3C W,S
Graduate Studies Eligible: No
Prerequisites: CHEM 251, and CHEM 251L
Corequisites: CHEM 252L
Continuation of Organic Chemistry I with greater emphasis on reaction mechanisms and an introduction to the methods used to determine structure, including IR and NMR spectroscopy and mass spectrometry.

CHEM 252L Organic Chemistry II Laboratory 0R-3L-1C W,S
Graduate Studies Eligible: No
Prerequisites: CHEM 251, and CHEM 251L
Corequisites: CHEM 252
A continuation of Organic Chemistry I Lab where additional, more complicated synthetic techniques and methods along with additional spectroscopic techniques are introduced.

CHEM 253 Organic Chemistry III 3R-0L-3C S
Graduate Studies Eligible: No
Prerequisites: CHEM 252, and CHEM 252L
Corequisites: CHEM 253L

Continuation of Organic Chemistry II with a focus on carbon-carbon bond-forming reactions, heterocycles, and polyfunctional molecules.

CHEM 253L Organic Chemistry III Laboratory 0R-4L-1C S

Graduate Studies Eligible: No

Prerequisites: CHEM 252, CHEM 252L

Corequisites: CHEM 253

Project based laboratory where techniques and skills developed in the previous organic laboratories are applied to more open-ended problems.

CHEM 270 Special Topics in Chemistry (1-4)R-0L-(1-4)C See Dept

Graduate Studies Eligible: No

Prerequisites: Consent of instructor

Corequisites: There are no corequisites for this course.

Studies in topics of current chemical interest not addressed in other named courses. A maximum of 4 total credit hours of CHEM270 and CHEM276 can be counted towards a chemistry major.

CHEM 276 Special Topics in Chemistry with Laboratory (0-3)R-(3-6)L-(1-4)C

Graduate Studies Eligible: No

Prerequisites: Consent of instructor

Corequisites: There are no corequisites for this course.

Studies in topics of current chemical interest not addressed in other named courses. This course will have a laboratory component. A maximum of 4 total credit hours of CHEM270 and CHEM276 can be counted towards a chemistry major.

CHEM 290 Chemical Research 0R-(4-8)L-(1-2)C F, W, S

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Research performed under the direction of a faculty member selected by mutual agreement. This course is designed for research performed before taking CHEM291. Students may register for 1 to 2 credit hours per quarter.

CHEM 291 Introduction to Chemical Research 2R-4L-3C W

Graduate Studies Eligible: No

Prerequisites: CHEM 113, and CHEM 113L or CHEM 112 and declared chemistry or biochemistry major.

Corequisites: There are no corequisites for this course.

Students will be introduced to skills necessary for conducting chemical research. Students will gain proficiency in: (1) literature searching of primary, secondary, and tertiary sources emphasizing the use of online databases; (2) laboratory skills involving synthesis, characterization, analysis, and keeping a notebook; (3) safety practice including MSDS interpretation; and (4) ethical conduct in collecting and reporting data and results. Students will be required to attend all seminars during the quarter. Enrollment is reserved for students who are declared as chemistry or biochemistry majors.

CHEM 326 Bioanalytical Chemistry 3R-4L-4-C W

Graduate Studies Eligible: No

Prerequisites: CHEM 225, and CHEM 225L

Corequisites: There are no corequisites for this course.

Addresses instrumental methods of analysis applicable to biochemistry including instrument design, operating principles, theory and application. Topics include molecular spectroscopic techniques in the infrared, visible and ultraviolet regions,

including luminescence and Raman spectroscopy. Separation techniques including liquid chromatography and capillary electrophoresis are also addressed.

CHEM 327 Advanced Analytical Chemistry 3R-4L-4C S

Graduate Studies Eligible: No

Prerequisites: CHEM 326

Corequisites: There are no corequisites for this course.

Addresses theory, operating principles, and application of instrumental methods for chemical analysis in the areas of atomic spectroscopy, x-ray techniques, gas chromatography and electroanalytical methods.

CHEM 330 Biochemistry I 4R-0L-4C F,S

Graduate Studies Eligible: No

Prerequisites: CHEM 251

Corequisites: There are no corequisites for this course.

Includes the structure and function of biological molecules, enzyme kinetics and mechanisms, and the reactions, strategy, and regulation of carbohydrate metabolism.

CHEM 331 Biochemistry II 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: CHEM 330, and BIO 210

Corequisites: There are no corequisites for this course.

Includes the reactions, strategy, and regulation of the major metabolic pathways in humans and of selected pathways in plants, and the storage, repair, and transmission of genetic information.

CHEM 360 Introduction to Physical Chemistry for Engineers 4R-0L-4C W,S

Graduate Studies Eligible: No

Prerequisites: CHE 303, CHE 304, and CHEM 115

Corequisites: There are no corequisites for this course.

Introduction to quantum chemistry, statistical thermodynamics, electrochemistry, chemical kinetics, surface chemistry and colloid science.

CHEM 361 Physical Chemistry I 4R-2L-4C F

Graduate Studies Eligible: No

Prerequisites: CHEM 115, and CHEM 115L, and MA 113, and MA 223 or MA 381*
See notes below

Corequisites: There are no corequisites for this course.

Covers the laws of thermodynamics, free energy, gases, phase equilibria and solutions. Emphasizes the applications of differential and integral calculus and includes an introduction to statistical thermodynamics and surface chemistry. The laboratory will meet for 4 hours on alternate weeks and will investigate topics associated with thermodynamics and phase equilibrium.

CHEM 362 Physical Chemistry II 3R-2L-4C W

Graduate Studies Eligible: No

Prerequisites: CHEM 361

Corequisites: There are no corequisites for this course.

Covers chemical equilibria, statistical mechanics, kinetics and electrochemistry. The laboratory will meet for 4 hours on alternate weeks.

CHEM 391 Research Proposal 1R-0L-1C F, W, S

Graduate Studies Eligible: No

Prerequisites: CHEM 291

Corequisites: There are no corequisites for this course.

Students will take online lessons related to the generation and communication of research ideas culminating in the production of a research proposal. The research

proposal will be written under the direction of a faculty member of record for the student's CHEM490 or by other faculty member selected by mutual agreement.

CHEM 395 Chemistry Seminar 0R-0L-0C F

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Students will be required to attend and/or present research seminars, the number to be determined by the department. The students will register for the course in the fall of the third year and if all the requirements are met, the students will receive a grade of Satisfactory. Failure to meet the requirements during the fall quarter will result in No Grade and the student must complete the requirements by the end of the third year. If the requirements are not completed by the end of the third year, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 420 Electronics for Scientists 3R-4L-4C See Dept

Graduate Studies Eligible: Yes

Prerequisites: CHEM 326 or CHEM 327 or consent of instructor

Corequisites: There are no corequisites for this course.

A fundamental course on understanding important electronic systems as they pertain to chemical signals and instrumentation. Topics include analog systems (RC circuits, diodes, transistors, and operational amplifiers), digital systems (logic gates, shift registers, and lock-in amplifiers), and signal enhancement and noise reduction modules. The laboratory component will showcase basic circuit design and construction, and will culminate with a student-built chemical instrument.

CHEM 421 Biochemical Mass Spectrometry 1R-0L-1C See Dept

Graduate Studies Eligible: Yes

Prerequisites: CHEM 330

Corequisites: There are no corequisites for this course.

This course will explore the theoretical basis and practical aspects of mass spectrometry, with an emphasis on their use for analysis of biological molecules. Topics include ionization mechanisms and methods for sample preparation and mass spectral analysis, and the course will include a project.

CHEM 422 Fluorescence Spectroscopy 1R-0L-1C See Dept

Graduate Studies Eligible: Yes

Prerequisites: CHEM 330

Corequisites: There are no corequisites for this course.

This course will explore the theoretical basis and practical aspects of fluorescence spectroscopy, with an emphasis on their use for analysis of biological molecules. Topics include mechanisms of fluorescence excitation and emission, quenching processes, anisotropy, and time-resolved fluorescence, and the course will include a project.

CHEM 423 NMR Spectroscopy 1R-0L-1C See Dept

Graduate Studies Eligible: Yes

Prerequisites: CHEM 252

Corequisites: There are no corequisites for this course.

This course is designed to provide the basic training and tools necessary to operate the 300MHz Bruker NMR and the associated ICON software. Additionally, the focus will be on sample preparation, acquisition, analysis, and processing of 1H NMR, 13C NMR, COSY and HETCOR (2D NMR), DEPT-90, DEPT-135, heteronuclear NMR, and applications of NMR to related fields. The course will consist primarily of basic and practical NMR instruction.

CHEM 424 Absorption Spectroscopy 2R-0L-2C See Dept

Graduate Studies Eligible: Yes
Prerequisites: CHEM 326 or CHEM 327
Corequisites: There are no corequisites for this course.
This course looks at absorption spectroscopy from the microwave to x-ray relating spectra to the molecular and/or atomic processes. The course will consist of both instruction and a project of student choice involving absorption process.

CHEM 425 Raman Spectroscopy 1R-0L-1C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 225
Corequisites: There are no corequisites for this course.
This course explores various theoretical and practical aspects of Raman spectroscopy including fundamental vibrational modes of molecules and selection rules, the physicochemical origin of Raman scattering, Raman spectrometers, lasers, resonance Raman spectroscopy, surface-enhanced Raman spectroscopy (SERS), and applications of Raman spectroscopy. The course includes an independent project in which a Raman spectrum is acquired for a sample of interest.

CHEM 426 Microfluidics 1R-0L-1C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 225
Corequisites: There are no corequisites for this course.
This course explores various theoretical and practical aspects of microfluidics. The course addresses the benefits and challenges of microfluidics in chemistry and chemical analysis and the materials and processes available for fabricating microfluidic devices. General characteristics of microfluidic devices including fluid flow regimes, heat transfer and diffusion are addressed as well as practical applications of microfluidic devices and how various functions like valving and detection are performed. The course includes an independent project involving the design and fabrication of a microfluidic device.

CHEM 427 HPLC 1R-0L-1C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 225
Corequisites: There are no corequisites for this course.
This course will explore various theoretical and practical aspects of HPLC including a review of separation parameters, equilibrium types, retention mechanisms, stationary phases and their performance, mobile phases and their properties and choosing an appropriate separation type.

CHEM 428 Trace Metal Detection 1R-0L-1C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 225
Corequisites: There are no corequisites for this course.
This course aims at providing students with fundamental skills and knowledge in trace metal analysis, for environmental and biological samples. The course will enable students to understand, develop and execute analytical protocols involving recent trace metal analysis methodologies and instrumentation using voltammetry. Students will learn by lectures, class activities, and homework assignments and how to optimize conditions to obtain sufficient analytical performance parameters in terms of selectivity, detection limit, cost, and analysis time.

CHEM 429 Capillary Electrophoresis 1R-0L-1C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 225

Corequisites: There are no corequisites for this course.
This course will explore various theoretical principles and chemical/biochemical applications of capillary electrophoresis. Main emphasis will focus on the choice of CE as an alternative form for separations for biochemical samples. Students will learn by lectures, class activities, homework assignments and how to optimize experimental conditions to achieve a good separation.

CHEM 430 Advanced Biochemistry 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CHEM 330
Corequisites: There are no corequisites for this course.
An in-depth exploration of selected topics from the current biochemistry scientific literature, including molecular mechanisms of infectious diseases and genetic disorders, methods for rational drug design, and relationships between structure and function for biological molecules.

CHEM 433 Biochemistry Laboratory 0R-3L-1C S
Graduate Studies Eligible: Yes
Prerequisites: CHEM 330
Corequisites: There are no corequisites for this course.
Fundamental techniques employed in isolation, characterization and study of biomolecules, and enzyme kinetics. Techniques used may include homogenization, solvent extraction, centrifugation, salt fractionation, chromatography, and electrophoresis.

CHEM 441 Inorganic Chemistry I 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: CHEM 252, CHEM 362, CHEM 360
Corequisites: There are no corequisites for this course.
The chemistry of non-metals. This course consists of a systematic study of the properties and reactions of the elements and their compounds based upon modern theories of the chemical bond, as well as from the viewpoint of atomic structure and the periodic law.

CHEM 442 Inorganic Chemistry II 3R-4L-4C W
Graduate Studies Eligible: Yes
Prerequisites: CHEM 441
Corequisites: There are no corequisites for this course.
The chemistry of metals. Modern theories such as valence bond, molecular orbital, electrostatic and ligand field are used to explain the properties of complex ions. Synthesis and characterization of complexes are done in the lab.

CHEM 451 Organic Structure Determination 2R-8L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 253 or instructor consent
Corequisites: There are no corequisites for this course.
Chemical and spectroscopic identification of organic compounds. Study of nuclear magnetic resonance and mass spectrometry, infrared spectroscopy and other techniques applied to structure elucidation and stereochemistry.

CHEM 463 Quantum Chemistry & Molecular Spectroscopy 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CHEM 111, CHEM 111L, PH 112, and MA 221
Corequisites: There are no corequisites for this course.
Covers elementary quantum mechanics with emphasis on applications in molecular structure.

CHEM 470 Special Topics in Chemistry (1-4)R-0L-(1-4)C See Dept
Graduate Studies Eligible: Yes
Prerequisites: or instructor consent
Corequisites: There are no corequisites for this course.
Studies in advanced topics of current chemical interest not addressed in other named courses.

CHEM 476 Special Topics in Chemistry with Laboratory (0-3)R-(3-6)L-(1-4)C See Dept
Graduate Studies Eligible: Yes
Prerequisites: To be taken concurrently with the appropriate elective not accompanied by an identified laboratory component.
Corequisites: There are no corequisites for this course.
Studies in advanced topics of current chemical interest not addressed in other named courses. This course will have a laboratory component.

CHEM 477 Directed Study in Chemistry (1-4)R-0L-(1-4)C F, W, S
Graduate Studies Eligible: No
Prerequisites: or instructor consent
Corequisites: There are no corequisites for this course.
Allows individual study in a topic not usually offered. A student may take 1 to 4 credits. A maximum of 4 credits is permitted.

CHEM 490 Chemical Research Rotation 1R-4L-2C F, W, S
Graduate Studies Eligible: No
Prerequisites: CHEM 291
Corequisites: There are no corequisites for this course.
Open-ended research projects performed as part of a research group. The students will gain proficiency in advanced lab techniques, the scientific method, data management and communication.

CHEM 491 Senior Thesis 1R-0L-1C F, W, S
Graduate Studies Eligible: No
Prerequisites: CHEM 490
Corequisites: There are no corequisites for this course.
Students will publish a thesis on their undergraduate research or a literature review of an advanced topic mutually agreed upon with the instructor.

CHEM 495 Chemistry Seminar 0R-0L-0C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 496 Chemistry Seminar 0R-0L-0C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 497 Senior Presentation 1R-0L-1C F, W, S
Graduate Studies Eligible: No
Prerequisites: CHEM 490

Corequisites: There are no corequisites for this course.
Students will deliver a professional seminar on their undergraduate research or a review of an advanced topic mutually agreed upon with the instructor.

CHEM 499 Independent Chemical Research 0R-(4-8)L-(1-2)C F, W, S
Graduate Studies Eligible: No
Prerequisites: CHEM 291
Corequisites: There are no corequisites for this course.
Research performed under the direction of a faculty member selected by mutual agreement. Students may register for 1 or 2 credit hours per quarter.

CHEM 520 Electronics for Scientists 3R-4L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 326 or CHEM 327 or consent of instructor
Corequisites: There are no corequisites for this course.
A fundamental course on understanding important electronic systems as they pertain to chemical signals and instrumentation. Topics include analog systems (RC circuits, diodes, transistors, and operational amplifiers), digital systems (logic gates, shift registers, and lock-in amplifiers), and signal enhancement and noise reduction modules. The laboratory component will showcase basic circuit design and construction, and will culminate with a student-built chemical instrument. For graduate credit there will be an additional project beyond the requirements for CHEM420. A student may not take both CHEM420 and CHEM520 for credit.

CHEM 530 Advanced Biochemistry 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CHEM 330
Corequisites: There are no corequisites for this course.
An in-depth exploration of selected topics from the current biochemistry scientific literature, including molecular mechanisms of infectious diseases and genetic disorders, methods for rational drug design, and relationships between structure and function for biological molecules. Students enrolled in CHEM 530 must complete a project not covered in CHEM 430. A student may not receive credit for both CHEM 430 and CHEM 530.

CHEM 531 Biochemical Instrumentation 3R-4L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: BIO 210, and CHEM 330
Corequisites: There are no corequisites for this course.
This project-based course includes approaches for the analysis of biochemical experimental problems, experimental design for molecular biology and biochemistry, and the theoretical basis and practical aspects of operating instruments used in biochemical research.

CHEM 532 Biochemical Pharmacology 4R-0L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 330
Corequisites: There are no corequisites for this course.
Topics include medicinal chemistry and molecular pharmacology. The topics will also include a survey of potential drug targets, the molecular interactions between drugs and their targets, the drug discovery and development process and case studies of drugs treating diseases such as cancer, bacterial and viral infection, and neurological disorders.

CHEM 534 Biochemical Physiology 4R-0L-4C SeeDept
Graduate Studies Eligible: Yes

Prerequisites: CHEM 330
Corequisites: There are no corequisites for this course.
An application of the principles of biochemistry to understanding the chemical aspects of the functioning of living organisms. This course covers topics related to the molecular mechanisms involved in the maintenance of physiological homeostasis, and when appropriate examines current research in the relevant systems. These mechanisms will be organized by the chemical signaling systems responsible for integrating and communicating the response to internal changes and external stimuli.

CHEM 535 Toxicology for Chemists 4R-0L-4C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 251
Corequisites: There are no corequisites for this course.
A fundamental course on the interaction of chemical agents with the human body. Topics include toxic thresholds and dose-response relationships, toxicological mechanisms of action, and models for physical and aquatic toxicities. Students engage in quantitative structure-activity relationship (QSAR) modeling and hazard assessment.

CHEM 545 Organometallic Chemistry 4R-0L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 115, and CHEM 252
Corequisites: There are no corequisites for this course.
A survey of the chemistry of main group organometallic compounds and organo-transition metal complexes. Reaction mechanisms and uses in organic synthesis and catalysis are studied.

CHEM 552 Synthetic Organic Chemistry 4R-0L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 253
Corequisites: There are no corequisites for this course.
A survey of contemporary methodology in organic synthesis. Retrosynthetic analysis, functional group transformations, condensation chemistry, and organometallic reagents will be stressed. Includes computer assisted synthesis.

CHEM 554 Theoretical Organic Chemistry 4R-0L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 253, and CHEM 361 or CHEM 360 or permission of instructor
Corequisites: There are no corequisites for this course.
Study of physical and chemical methods used to investigate organic reaction mechanisms; the chemistry of carbenes; organic photochemistry.

CHEM 556 Green Chemistry 4R-0L-4C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 252
Corequisites: There are no corequisites for this course.
Advanced topics in green chemistry including industrial applications, atom economy, safer solvent substitutions, alternatives assessment, green metrics (PMI, E-factor), and a brief introduction to chemical toxicology.

CHEM 561 Advanced Physical Chemistry 4R-0L-4C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 463, and CHEM 360 or CHEM 362
Corequisites: There are no corequisites for this course.
The course covers advanced topics in quantum mechanics, statistical thermodynamics, and kinetics.

CHEM 570 Special Topics in Chemistry (1-4)R-0L-(1-4)C See Dept

Graduate Studies Eligible: Yes
Prerequisites: permission of instructor
Corequisites: There are no corequisites for this course.
Studies in advanced topics of current chemical interest not addressed in other named courses. If cross-listed with CHEM470, students in CHEM570 will need to complete an additional project.

CHEM 581 Polymer Chemistry 3R-4L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 252 Junior class standing
Corequisites: There are no corequisites for this course.
Polymer synthesis, reactions, and characterization techniques. Structure/property relationships and morphology will be discussed, both for industrially relevant polymers as current topics of from the recent literature. Laboratory sequence consists of polymer synthesis and characterization.

CHEM 582 Physical Properties of Polymeric Materials 4R-0L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 361 or CHEM 360
Corequisites: There are no corequisites for this course.
In this course the physical properties of polymeric systems will be defined in terms of the models that have been used to characterize them. The behavior of isolated polymers and polymers in solution will be mapped to macroscopic properties of bulk polymeric systems using theories such as Rotational Isomeric State and Flory's Lattice model. Methods of molecular weight determination will be fully developed. Phase transitions will be characterized and related to polymeric and monomeric structural features. Theories of elasticity and viscoelastic behavior will be used to explain macroscopic behaviors of polymeric materials.

CHEM 595 Chemistry Seminar 0R-0L-0C F
Graduate Studies Eligible: Yes
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Chemistry graduate students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 596 Chemistry Seminar 0R-0L-0C W
Graduate Studies Eligible: Yes
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Chemistry graduate students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 597 Chemistry Seminar 0R-0L-0C S
Graduate Studies Eligible: Yes
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Chemistry graduate students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 599 Thesis Research As assigned F, W, S
Graduate Studies Eligible: Yes
Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.
Graduate students only. Credits as assigned; however, not more than 12 credits will be applied toward the requirements of the M.S. degree.

CHEM 699 Professional Experience 1R-0L-1C See Dept
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The work experiences should be informative or integral to the advancement or completion of the student's program requirements. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

Biology - Course Descriptions

BIO 101 Essential Biology 3R-3L-4C F, W, S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys basic concepts in the biological sciences and describes how new advances related to these concepts affect contemporary society. Students who have completed BIO110, BIO120 or BIO130 cannot receive credit for taking BIO101.

BIO 102 Nutrition 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course surveys essential concepts in the nutritional sciences, including food composition, diet construction and analysis, physiological processes, and special nutritional needs for certain groups. This course counts as a free elective, not a BIO elective, for BIO and BE majors.

BIO 103 Core Biology Advances and Applications 04R-0L-4C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course promotes comprehension of core biological concepts and systems to enable a more sophisticated understanding of advances in biology and applications of biological sciences. Current advances in our understanding of living systems and the application of biotechnologies to various challenges in medicine, forensics, agriculture, and energy are also discussed. This course counts as a free elective, not a BIO elective, for BIO and BE majors.

BIO 104 Science in Practice 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course explores the dispositions and applications of science relevant to understanding a broad range of popular scientific topics. Major concepts include distinguishing science from pseudoscience, information flow and use in science, misinformation tactics used to advance dubious science, and the influence of

perspective on interpretation of both science and non-science information. This course counts as a free elective, not a BIO elective, for BIO and BE majors.

BIO 105 Human Health and Disease 4R-0L-4C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course examines the human body in states of health and disease. Various diseases such as infections, cancer, heart disease, genetic conditions, and autoimmunity and the mechanisms leading to these diseases are studied. This course counts as a free elective, not a BIO elective, for BIO and BE majors.

BIO 107 Introduction to Environmental Science 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course examines major themes that cut across environmental topics (e.g. human influence) and uses a variety of specific environmental scenarios like food production, water resources, and energy systems to explore those themes. This course counts as a free elective, not a BIO elective, for BIO majors.

BIO 110 Cell Structure and Function 3R-3L-4C F,W

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course explores cellular and molecular biology structures, mechanisms, and laboratory techniques with respect to five core concepts: (1) evolution, (2) structure/ function interdependence, (3) information flow, (4) bioenergetics and (5) systems perspective and interdependence.

BIO 120 Comparative Anatomy & Physiology 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course surveys animal tissues and organ systems and laboratory techniques (including dissections and recordings from biological specimens/living tissues) with respect to five core concepts: (1) evolution, (2) structure/function interdependence, (3) information flow, (4) bioenergetics, and (5) systems perspective and interdependence.

BIO 130 Evolution and Diversity 3R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course explores ecological and evolutionary patterns and processes, including field and laboratory approaches to develop knowledge with respect to five core concepts: (1) evolution, (2) structure/functio interdependence, (3) information flow, (4) bioenergetics, and (5) systems perspective and interdependence.

BIO 191 Special Topics in Biology XR-0L-XC

Graduate Studies Eligible: No

Prerequisites: Arranged prerequsite by consent of instructor

Corequisites: There are no corequisites for this course.

Introduces structures, mechanisms, and laboratory techniques in cellular and molecular biology. Discusses biomolecules, bioenergetics, biosynthesis, enzymatic function, genetics, and cellular regulatory systems.

BIO 199 Professional Experience 1R-0L-1C

Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

BIO 205 Cellular Physiology 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: BIO 110
Corequisites: There are no corequisites for this course.
The flow of information in biological systems provides a framework for detailed discussion of cell structure and function, with particular attention paid to the physiology of excitable cells. Cellular communication and the interactions of cells in tissues and the immune system are also examined. Reproduction and organismal development will also be addressed at the cellular level. A student who earns credit for BIO205 cannot earn credit for BIO230 without approval of the department head.

BIO 210 Mendelian & Molecular Genetics 3R-3L-4C F
Graduate Studies Eligible: No
Prerequisites: BIO 110 or instructor consent
Corequisites: There are no corequisites for this course.
A discussion of Mendelian genetics including the molecular mechanisms of nuclear and cytoplasmic inheritance. Information flow and control of gene expression are addressed at the molecular level. Basic genetic techniques are covered in both lecture and laboratory.

BIO 220 Microbiology 3R-3L-4C W
Graduate Studies Eligible: No
Prerequisites: BIO 110 or instructor consent.
Corequisites: There are no corequisites for this course.
Discusses the essential properties of eubacteria and archea. Bacterial nutrition, growth, genetics and structural and metabolic diversity are discussed in detail. The basics of virology are also addressed. Fundamental laboratory methodologies are also covered.

BIO 230 Cell Biology 3R-3L-4C S
Graduate Studies Eligible: No
Prerequisites: BIO 110 or instructor consent
Corequisites: There are no corequisites for this course.
Examines the structure and function of various eukaryotic cells. Biomembranes, organelles, the cytoskeleton, energetics, protein sorting, signal transduction and cell interactions are discussed in detail. Essential methods in cell biology are addressed in both lectures and laboratories.

BIO 310 Plant Structure & Function 3R-3L-4C S (alternate years)
Graduate Studies Eligible: No
Prerequisites: BIO 130 or instructor consent.
Corequisites: There are no corequisites for this course.
Surveys the structure, physiology, diversity, evolution, and ecological importance of plants and related groups of organisms.

BIO 320 Ecology 3R-3L-4C F (alternate years)
Graduate Studies Eligible: No
Prerequisites: BIO 130 or instructor consent

Corequisites: There are no corequisites for this course.
Surveys adaptations of organisms, population dynamics, species interactions, and the structure and function of natural communities and ecosystems.

BIO 330 Evolutionary Biology 4R-0L-4C W (alternate years)
Graduate Studies Eligible: No
Prerequisites: BIO 130 or instructor consent
Corequisites: There are no corequisites for this course.
Surveys three major themes of evolutionary biology: adaptation, diversity of life, and the shared characteristics of life. Mechanisms of evolution, speciation, phylogeny, and macroevolutionary processes are discussed.

BIO 340 Introduction to Biomedical Research: Clinical Methodology 1R-1L-1C
Graduate Studies Eligible: No
Prerequisites: BIO 120 and Jr/Sr standing or consent of instructor.
Corequisites: There are no corequisites for this course.
Designed to introduce biology/bioengineering students to the basics of biomedical research using the clinical methodology typical of patient sample analysis. Students will learn to relate testing procedures with specific diseases and to use data obtained from laboratory testing to understand more about specific patient health problems.

BIO 350 Principles of Synthetic Biology 2R-0L-2C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course provides an introduction to feedback control systems. These systems will be characterized with respect to their time response, stability, and steady-state error. Design compensation will be used to improve the performance of a system. When possible, examples of biological control systems will be considered.

BIO 351 Synthetic Biology Design 2R-0L-2C S
Graduate Studies Eligible: No
Prerequisites: BIO 350
Corequisites: There are no corequisites for this course.
Open to all majors. This course focuses on the design of novel biological parts, devices and systems, and their use in engineering cell function. Bioengineering principles and the design of genetic logic circuits, memory modules, biosensors and other cellular devices will be addressed. For the final project, students will design a novel biological system that meets the standards and goals of the International Genetically Engineered Machine Competition.

BIO 352 Synthetic Biology Laboratory 4C (studio format, 4 days x 3 hrs) Su1
Graduate Studies Eligible: No
Prerequisites: Instructor Consent
Corequisites: There are no corequisites for this course.
Open to all majors. This project-based studio laboratory course focuses on the fundamental laboratory techniques employed in the synthetic biology laboratory. Relevant background and theory will be discussed and applied in the hands-on learning of core laboratory techniques. In practice, students will build and test novel genetic devices designed to advance the current International Genetically Engineered Machine Competition (iGEM) Team project. Significant contribution to the project will earn students membership on the Rose-Hulman iGEM team and attribution in iGEM competition materials.

BIO 399 Practice of Science 4R-0L-4C
Graduate Studies Eligible: No

Prerequisites: ENGL H290, and MA 223 or consent of instructor
Corequisites: There are no corequisites for this course.
This course focuses on skills required for implementing scientific research, including reading the primary literature, experimental design, scientific writing, oral presentations, research proposal writing, poster presentations, and investigation of research programs (through seminars or individual meetings). Each student chooses a project and research mentor by the end of the course.

BIO 410 Infection and Immunity 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: BIO 110 or instructor consent
Corequisites: There are no corequisites for this course.
Discussion of various pathogens, how they cause disease, and how they elicit the innate and adaptive immune responses employed to combat them. Cellular and molecular mechanisms of immunity are addressed, as is the epidemiology of various human diseases.

BIO 411 Genetic Engineering 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: BIO 205 or BIO 210 or consent of instructor
Corequisites: There are no corequisites for this course.
Discusses the basics of molecular biology and the genetic and molecular techniques used to engineer prokaryotic and eukaryotic cells, plants, and animals for the production of useful traits or compounds. The application of DNA technology to the diagnosis and treatment of disease is also addressed.

BIO 421 Applied Microbiology 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: BIO 110 *Arranged prerequisite or instructor consent
Corequisites: There are no corequisites for this course.
Discusses the fundamental biology of microprobes and the processes underlying their use in the production of chemicals, therapeutics and foods. The basics of microbial ecology and the environmental applications of microbial biotechnology are also discussed.

BIO 431 Genomics and Proteomics 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: BIO 205 or BIO 210 or consent of instructor
Corequisites: There are no corequisites for this course.
Exploration of the methodologies used to generate systems-level sets of genetic and protein data, and the tools used to access and analyze the prodigious amounts of data emerging from such projects. The application of these technologies to investigate biological questions and model complex biological systems is also discussed.

BIO 441 Virology 3R-3L-4C
Graduate Studies Eligible: Yes
Prerequisites: BIO 110 or instructor consent
Corequisites: There are no corequisites for this course.
Virology focuses on the study of viruses as well as non-viral entities such as prions and viroids. In this course, students will learn about the structures, genomes, replication strategies, and pathogenic mechanisms of various viruses. Viruses causing diseases of medical and economic importance will be emphasized. In addition, the techniques used to study viruses and the uses of viruses in the treatment of disease will be addressed.

BIO 451 Cancer Biology 4R-0L-4C
Graduate Studies Eligible: Yes

Prerequisites: BIO 205 or BIO 210 or consent of instructor
Corequisites: There are no corequisites for this course.
This course focuses on cancer at the molecular and cellular level. Specific cellular molecules and the changes to these cellular molecules that contribute to transformational and immortalization of cells and tumor progression will be studied. The mechanisms behind these molecular changes, cancer promotion and initiation events, and cancer molecule-specific treatment options will be addressed. In addition, students will study a variety of specific cancer types.

BIO 461 Evolutionary Medicine 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: BIO 130*, and BIO 205* or BIO 210* *Arranged prerequisite or instructor consent.
Corequisites: There are no corequisites for this course.
This course examines medicine and medical practice from the perspective of evolutionary constraints, challenges, and diversity. Topics include theoretical foundations of the field, cancer patterns, mental health, genetic disease, evolutionary health promotion, and others.

BIO 471 Genetic & Molecular Analysis of Inherited Human Disease 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: BIO 205* or BIO 210* *Arranged prerequisite or consent of instructor
Corequisites: There are no corequisites for this course.
Strategies and methods used to identify and understand the genetic and molecular bases of inherited human disease are addressed. Topics include, human population genetics, pedigrees, genetic and physical mapping of human genes, linkage analysis, and diagnostic testing. Primary literature is routinely utilized.

BIO 491 Special Topics in Biology XR-0L-XC
Graduate Studies Eligible: No
Prerequisites: Arranged prerequisite or instructor consent
Corequisites: There are no corequisites for this course.
Covers upper level material of mutual interest to student and instructor which cannot be acquired in any other listed BIO course.

BIO 492 Directed Study in Biology XR-XL-XC
Graduate Studies Eligible: No
Prerequisites: Arranged prerequisite or instructor consent
Corequisites: There are no corequisites for this course.
Covers biology material of mutual interest to the student and instructor which cannot be experienced in any other listed BIO course. A student may take between 1-4 credits in any given term, and a maximum of 8 credits of this course are permitted. Prior approval of the BBE department is required to use this course to fulfill BIO elective credit requirements.

BIO 496 Senior Thesis Research I 0R-6L-2C F,W,S
Graduate Studies Eligible: No
Prerequisites: BIO 399 and consent of instructor
Corequisites: There are no corequisites for this course.
Initiation of senior thesis under the direction of an BBE faculty mentor. Major tasks include creation and submission of a research proposal and piloting procedures. Additional requirements for adequate progress determined by each faculty mentor.

BIO 497 Senior Thesis Research II 0R-12L-4C F,W,S
Graduate Studies Eligible: No
Prerequisites: BIO 399 and consent of instructor

Corequisites: There are no corequisites for this course.
Continuation of research under the direction of an BBE faculty mentor. Major tasks include data acquisition and methodological refinement. Additional requirements for adequate progess determined by each faculty mentor.

BIO 498 Senior Thesis Research III 0R-12L-4C F,W,S
Graduate Studies Eligible: No
Prerequisites: BIO 399 and consent of instructor
Corequisites: There are no corequisites for this course.
Continuation of research under the direction of an BBE faculty mentor. Major tasks include data acquisition and preliminary analysis. Additional requirements for adequate progress determined by each faculty mentor.

BIO 499 Senior Thesis Research IV 0R-6L-2C W
Graduate Studies Eligible: No
Prerequisites: BIO 399 and consent of instructor
Corequisites: There are no corequisites for this course.
Completion of senior thesis under the direction of an BBE faculty mentor. Major tasks include final analysis, public presentation of results, and submission of the written thesis. Additional requirements for adequate progress determined by each faculty mentor.

Biomathematics - Course Descriptions

BMTH 199 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

BMTH 295 Research Seminar in Biomathematics 1R-0L-1C Arranged
Graduate Studies Eligible: No
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
A seminar-style course that introduces novel problems in biomathematics. Problems will be drawn from the modern literature in biomathematics, computational biology, bioinformatics, systems biology, and biostatistics. This course may be taken at most twice for credit.

BMTH 301 Introduction to Biomathematics: Continuous Models 4R-0L-4C (even years) S
Graduate Studies Eligible: No
Prerequisites: MA 222
Corequisites: There are no corequisites for this course.
This course requires no previous knowledge of biology. The application of differential equations and probability to modeling and analyzing dynamic biological systems. Mathematical topics include ordinary and partial differential equations, dynamical systems, bifurcations, limit cycles, chaos, and probabilistic and stochastic modeling. Biological applications may include biochemistry, cell biology, epidemiology, neuroscience, ecology, biofluids, biomaterials, diffusion, and pattern formation.

BMTH 302 Introduction to Biomathematics: Discrete Models 4R-0L-4C (odd years) S

Graduate Studies Eligible: No

Prerequisites: MA 113

Corequisites: There are no corequisites for this course.

This course requires no previous knowledge of biology. The application of discrete mathematics and computational algebra for modelling biological phenomena. Topics may include: gene regulatory networks, genomics, RNA folding, neuronal networks, infectious disease modeling, phylogenetics, and/or ecological networks. Students will also use software currently used in mathematical biology research for visualization, simulation, and analysis.

BMTH 311 Systems Biology 4R-0L-4C F (even years)

Graduate Studies Eligible: No

Prerequisites: MA 222

Corequisites: There are no corequisites for this course.

The study of how to combine detailed biological information to build models of entire systems. Nearly any biological scale can be considered. For example, at the biochemistry level the course will consider topics such as gene regulatory networks, protein interaction networks, and metabolisms. Moving toward larger scales, systems biology can be used to study the growth of cancerous tumors, and on an even larger scale, the mating and social structure of populations. The course's focus is on how to use relational information to perform model based inquiries of an entire system.

BMTH 312 Bioinformatics 4R-0L-4C W (even years)

Graduate Studies Eligible: No

Prerequisites: CSSE 120, and MA 381

Corequisites: There are no corequisites for this course.

This course will study how to combine mathematical, statistical, probabilistic, and computational methods to analyze biological data. Example topics are sequence alignment, locating genes, structural alignment, microarray analysis, and drug design. The course emphasizes how to search and compare biological datasets to make scientific inferences.

BMTH 413 Computational Biology 4R-0L-4C W (odd years)

Graduate Studies Eligible: Yes

Prerequisites: MA 332, and either BMTH 301 or BMTH 302 or BMTH 311 or BMTH 312

Corequisites: There are no corequisites for this course.

The study of how to build and validate computational models to conduct biological studies. Ex-emplary topics include molecular dynamics, haplotyping, phylogenetics, neuroscience, and population dynamics. The course will consider the implementation and analysis of algorithms that are specifically germane to the life sciences.

BMTH 490 Topics in Biomathematics Variable Credit

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Varies

BMTH 496 Capstone Experience I 2C F

Graduate Studies Eligible: No

Prerequisites: Senior standing or permission of instructor.

Corequisites: There are no corequisites for this course.

Independent study in a thesis project to be directed by a faculty member. The project and faculty adviser are to be identified prior to starting BMTH 496, and a plan of study is to be agreed upon by the student and adviser prior to the initiation of the thesis sequence. The thesis will culminate in a written report and a public presentation/ defense that will be evaluated by a thesis committee consisting of at least the adviser and two other members of the faculty. BMTH 496/497/498 must be taken in consecutive quarters.

BMTH 497 Capstone Experience II 4C W

Graduate Studies Eligible: No

Prerequisites: BMTH 496

Corequisites: There are no corequisites for this course.

Independent study in a thesis project to be directed by a faculty member. The project and faculty adviser are to be identified prior to starting BMTH 496, and a plan of study is to be agreed upon by the student and adviser prior to the initiation of the thesis sequence. The thesis will culminate in a written report and a public presentation/ defense that will be evaluated by a thesis committee consisting of at least the adviser and two other members of the faculty. BMTH 496/497/498 must be taken in consecutive quarters.

BMTH 498 Capstone Experience III 2C S

Graduate Studies Eligible: No

Prerequisites: BMTH 497

Corequisites: There are no corequisites for this course.

Independent study in a thesis project to be directed by a faculty member. The project and faculty adviser are to be identified prior to starting BMTH 496, and a plan of study is to be agreed upon by the student and adviser prior to the initiation of the thesis sequence. The thesis will culminate in a written report and a public presentation/ defense that will be evaluated by a thesis committee consisting of at least the adviser and two other members of the faculty. BMTH 496/497/498 must be taken in consecutive quarters.

FOCUS AREAS

Students earning a major in Biomathematics are encouraged to gain depth in a particular mathematical or scientific area. By pursuing focused coursework in the following suggested areas, students will advance their preparation for graduate studies or careers in mathematical life sciences. Gaining depth through advanced electives also provides biomathematics students with an opportunity to apply knowledge gained through BMTH coursework. The following focus areas are illustrative examples to consider.

Applied Mathematics		
	BE 350	Biocontrol Systems
	MA 275/375	Discrete and Combinatorial Algebra I/II
	MA 332	Intro. to Computational Science [required for major]
	MA 330	Vector Calculus
	MA 342	Computational Modelings
	MA 366	Real Analysis

	MA 367	Functions of a Complex Variable
	MA 436	Introduction to Partial Differential Equations
	MA 472	Graph Theory
	MA 491	Introduction to Mathematical Modeling
Biochemistry		
	BMTH 312	Bioinformatics
	BMTH 310	Mathematical Biology
	CHEM 251/252/253	Organic Chemistry I/II/III
	CHEM 326	Bioanalytical Chemistry
	CHEM 330/331	Biochemistry I/II
	CHEM 430	Advanced Biochemistry
Bioinformatics & Biostatistics		
	BMTH 312	Bioinformatics
	MA 381	Intro. to Probability with Statistics [required for major]
	MA 382	Intro. to Statistics with Probability
	MA 382	Engineering Statistics II
	MA 386	Statistical Programming
	MA 482	Bioengineering Statistics
Biomechanics		
	BE 361	Biomaterials
	BE 525	Biomedical Fluid Mechanics
	BE 534	Soft Tissue Mechanics
	BE 539	Multiscale Biomechanics
	BE 545	Orthopedic Biomechanics
Biophysics		
	PH 302	Biophysics
	BE 525	Biomedical Fluid Mechanics
Cellular and Molecular Biology		
	BIO 220/230	Prokaryotic/Eukaryotic Cell and Molecular Biology [required for major]

	BIO 205	Cellular Physiology
	BIO 411	Genetic Engineering
	BIO 421	Applied Microbiology
	BIO 431	Genomics and Proteomics
	BMTH 310	Mathematical Biology
	CHEM 455	Natural Products [offered irregularly]
Computational Biology		
	BMTH 310	Mathematical Biology
	BMTH 413	Computational Biology
	CSSE 220	Object Oriented Software Development
	CSSE 333	Database Systems
	CSSE 403	Programming Language Paradigms
	CSSE 431	Artificial Intelligence
	MA/CS 335	Introduction to Parallel Computing
	MA 342	Computational Modeling
	MA 433	Numerical Analysis
	MA 435	Finite Difference Methods
	MA/CS 473	Design and Analysis of Algorithms
Ecology		
	BIO 130	Evolution and Diversity
	BIO 264	Introduction to Environmental Science
	BIO 320	Ecology
	BMTH 310	Mathematical Biology
	CHEM 371	Environmental Analytical Chemistry
Epidemiology & Pathology		
	BE 310/320	Analysis of Physiological Systems I/II
	BIO 410	Infection and Immunity
	BIO 441	Virology
	BIO 451	Cancer Biology
	BIO 461	Evolutionary Medicine

	BIO 471	Genetic and Molecular Analysis of Inherited Human Disease
	BMTH 310	Mathematical Biology
Evolution		
	BIO 130	Evolution and Diversity
	BIO 330	Evolutionary Biology
	BIO 461	Evolutionary Medicine
	SV 386	Human Evolution
Imaging and Optics		
	BE 435	Biomedical Optics
	ECE 480	Introduction to Image Processing
	BE 541	Medical Imaging Systems
	MA 429	Mathematical Methods of Image Processing
	PH 302	Biophysics
Medicine		
	BIO 120	Comparative Anatomy and Physiology
	BIO 410	Infection and Immunity
	BIO 441	Virology
	BIO 451	Cancer Biology
	BIO 461	Evolutionary Medicine
	BIO 471	Genetic and Molecular Analysis of Inherited Human Disease
	BE 541	Medical Imaging Systems
	CHEM 251/252/253	Organic Chemistry I/II/III
	CHEM 330/331	Biochemistry I/II
	CHEM 420	Advanced Biochemistry
Physiology		
	BIO 120	Comparative Anatomy and Physiology
	BIO 205	Cellular Physiology
	BE 310/320	Analysis of Physiological Systems I & II
	BE 520	Introduction to Brain Machine Interfaces

Biomedical Engineering - Course Descriptions

BE 100 Problem Solving in the Biological Sciences & Engineering 3R-3L-4C F
Graduate Studies Eligible: No
Prerequisites: BE 1st year standing or permission of instructor
Corequisites: There are no corequisites for this course.
This course introduces students to computational tools for solving problems in biology and biomedical engineering. The primary thrust of the course is structured programming in MatLab. In addition, we will explore data description, the proper presentation of data, effective use of spreadsheet tools in data analysis, and structured programming.

BE 118 Design Thinking and Communication 1R-3L-2C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Engineers must be able to communicate their design ideas to others. This course focuses on the improvement of communication skills, including written and oral presentation, sketching, and solid modeling. Student groups work on projects with the goal of recognizing and developing behaviors associated with consensus decision-making and cooperative teamwork. Students also learn the steps of the engineering design process and fundamental machining techniques.

BE 121 DC Circuits 1R-3L-2C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course introduces the fundamentals of DC circuit design and analysis. DC circuit analysis tools such as Kirchhoff's laws, mesh and nodal analysis, superposition, and source transformations are introduced. In conjunction with BE128, students will complete projects that utilize microcontrollers and resistive sensors to interact with their environments.

BE 122 Systems Accounting and Modeling I 3R-0L-3C W
Graduate Studies Eligible: No
Prerequisites: MA 111
Corequisites: There are no corequisites for this course.
BE122 introduces the systems accounting and modeling approach to solving problems. Conservation of mass, linear and angular momentum, and energy will be introduced and reinforced with examples. Same as ENGD205.

BE 128 Design Thinking and Realization 2R-3L-3C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: BE 121
This course explores elements of the engineering design process as a means of enhancing students' abilities to define problems, develop and evaluate creative alternatives, and effectively present technical information.

BE 131 AC Circuits 1R-3L-2C S
Graduate Studies Eligible: No
Prerequisites: BE 121 or ENGD 110
Corequisites: There are no corequisites for this course.
This course introduces the fundamentals of AC circuit design and analysis. Topics include RLC circuits, equivalent impedance, phasor domain analysis (nodal analysis,

mesh current, source superposition, source transformation), and Thevenin and Norton theorems. The concept of linear systems and the use of electronic components (op-amps, capacitors, inductors) for biosignal processing applications will also be introduced. Students may not receive credit towards graduation for both BE131 and ES213.

BE 132 Systems Accounting and Modeling II 3R-0L-3C S

Graduate Studies Eligible: No

Prerequisites: BE 122 or EM 121 or ENGD 205

Corequisites: BE 131

A common framework for engineering analysis is extended using the concepts of a system, accounting and conservation of extensive properties, constitutive relations, constraints, and modeling assumptions. Stress, strain, and deformation under axial loading are defined. Equilibrium is defined. Conservation equations for mass, charge, momentum and energy are developed. Applications are developed from multiple engineering disciplines. Students may not receive credit towards graduation for both BE132 and ES201. Same as ENGD215.

BE 138 Design Thinking and Human-Centered Products 2R-3L-3C S

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: BE 131

This project-based design course focuses on ensuring that products meet the needs of their users. The course incorporates observational methods, brainstorming, prototyping, user testing, business models, and the social, marketing, and engineering constraints that impinge upon products.

BE 199 Professional Experience 1R-0L-1C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

BE 211 Circuits, Sensors, and Measurements 2R-3L-3C F

Graduate Studies Eligible: No

Prerequisites: BE 131, and MA 112

Corequisites: There are no corequisites for this course.

This course introduces the concepts of biomedical signal measurement and conditioning. Topics include amplifiers, filters and A/D converters, digital logic, biomedical sensors and uncertainty analysis. Matlab is used in the context of biosignal acquisition and visualization.

BE 218 Design Methodologies 2R-3L-3C F

Graduate Studies Eligible: No

Prerequisites: BE 138

Corequisites: There are no corequisites for this course.

Introduction to the philosophy and goals of various design and research processes. Hands-on projects will serve as vehicles for design thinking, visualization, and methodology.

BE 222 Mechanics of Materials 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: BE 132 or EM 121 or ENGD 215
Corequisites: There are no corequisites for this course.
Description: Strength and elastic deflection of engineering materials due to loads applied in torsion, in bending, and in shear. Shear diagrams, bending moment diagrams, and area moments of inertia. Combined stresses and principal stresses. Applications to design of beams and shafts.

BE 228 Design Leadership & Teamwork 1R-3L-2C W
Graduate Studies Eligible: No
Prerequisites: BE 218
Corequisites: There are no corequisites for this course.
This project-based course will help students develop skills in decision-making, leadership, and management of complex design projects.

BE 232 Biomechanics 3R-0L-3C S
Graduate Studies Eligible: No
Prerequisites: BE 211, and either BE 222 or EM 204
Corequisites: There are no corequisites for this course.
This course introduces students to the various interdisciplinary fields in biomechanics - such as orthopaedic biomechanics, biofluid mechanics, soft tissue mechanics, and the biomechanics of human movement. Specific topics include: statics/dynamics of the human body, kinematics during activity; the analysis of forces and stresses/strains in biological structures under loading; constitutive models for biological materials (e.g. bone, cartilage, tendon/ligament); and the relationship between structure and function in tissues and organs. Non-majors interested in taking this course should see the instructor.

BE 233 Biomaterials 3R-0L-3C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Structure-property relationships for metallic, polymeric, and ceramic biomaterials. Study of the interactions of these materials with the body and factors affecting the selection and design of materials for medical implants and devices.

BE 238 Regulatory Affairs & Product Design 3R-3L-4C S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students will build a fundamental understanding of how the FDA regulates medical devices in the United States, with an emphasis on pathways to market. Project is in conjunction with BE232 and BE233. Includes the submission and review process of a student's AIMS for BE majors (peer, career services, faculty, advisory board approval).

BE 314 Musculoskeletal Systems Physiology with Applications 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: BIO 110 , and BE 232, and BE 233
Corequisites: BE 315
An analysis of muscle, bone, and soft tissue physiology/mechanics from a quantitative, system-based approach with an emphasis on clinical applications.

BE 315 Biomedical Engineering Lab I 1R-3L-2C F
Graduate Studies Eligible: No
Prerequisites: BE 232, and BE 233
Corequisites: BE 314

This course emphasizes the fundamental concepts in biomechanics and biomaterials with an emphasis on musculoskeletal applications. Hands-on laboratory projects will be assigned which will require the student to use standard testing equipment and basic instrumentation to execute effective test methods. Written communication of experimental results is emphasized. Non-majors interested in taking this course should see the instructor.

BE 318 Medical Device Research & Design 2R-3L-3C F

Graduate Studies Eligible: No

Prerequisites: BE 238

Corequisites: There are no corequisites for this course.

In this course students collaborate with clinicians, industry partners, and/or community partners to identify unmet clinical or research needs. Based on voice of the customer feedback, stakeholder analysis, market analysis, and evaluation of the regulatory and technical landscape, teams will refine observed needs and present them to reviewers. Projects identified to have a significant impact, a committed team, and a viable market can be continued in BE328.

BE 321 Biosignal Processing 3R-3L-4C W

Graduate Studies Eligible: No

Prerequisites: BE 211 and

Corequisites: BE 324

This course introduces the fundamentals of biomedical signal processing strategies. Topics include data acquisition, A/D and D/A conversion, FIR and IIR digital filter design, time-frequency analysis, and I/O interfaces. Multichannel data processing and high dimensional data analysis techniques are also introduced. Laboratories provide practical experience on the analysis of electrophysiological data, with special emphasis on neurological signals.

BE 324 Neural and Endocrine Systems Physiology with Applications 3R-3L-4C W

Graduate Studies Eligible: No

Prerequisites: BIO 110 , and BE 211, and BE 314

Corequisites: There are no corequisites for this course.

An analysis of neural and endocrine physiology from a quantitative, systems-based approach.

BE 328 Capstone Design I: Designing Products for the Real World 3R-3L-4C W

Graduate Studies Eligible: No

Prerequisites: BE 118, and BE 128, and BE 211, and BE 228, and BE 232, and BE 233, and BE 318

Corequisites: There are no corequisites for this course.

This course begins the capstone design sequence in biomedical engineering. Student teams develop design solutions from a set of client-specified needs, establish specifications, plan the project, schedule and efficiently use resources, examine the ethics and safety in engineering design, and work within explicit (or implicit) constraints, such as social, economic, manufacturing, etc. The course culminates with the presentation of the preliminary proposal for the capstone design project in biomedical engineering.

BE 334 Cardiovascular, Respiratory, and Renal Systems Physiology with Applications 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: BIO 110 , and BE 314, and BE 315

Corequisites: There are no corequisites for this course.

An analysis of cardiovascular, pulmonary, and renal physiology from a quantitative, systems-based approach with an emphasis on biomedical applications.

BE 335 Biomedical Engineering Lab II 1R-3L-2C S

Graduate Studies Eligible: No

Prerequisites: BE 315

Corequisites: There are no corequisites for this course.

This course emphasizes experimental design and execution in biomechanics, biomaterials, and fluid mechanics with an emphasis on cardiovascular applications. Laboratory experiences will require the student to use standard testing equipment and basic instrumentation to execute effective test methods. Written communication as well as experimental design and execution is emphasized. Non-majors interested in taking this course should see the instructor.

BE 338 Capstone Design II: Product Design & Prototyping 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: BE 328

Corequisites: There are no corequisites for this course.

This course is a continuation of BE328. The student teams develop prototype solutions through implementation of the design plan from the previous course. This includes development of a test plan, modifications to the design project as needed, risk assessment, and evaluation of design performance relative to initial specifications. This course culminates in the submission of a functional prototype and updated design history files.

BE 350 Biocontrol Systems 4R-0L-4C

Graduate Studies Eligible: No

Prerequisites: BE 211

Corequisites: There are no corequisites for this course.

This course provides an introduction to feedback control systems. These systems will be characterized with respect to their time response, stability, and steady-state error. Design compensation will be used to improve the performance of a system. When possible, examples of biological control systems will be considered.

BE 418 Capstone Design III: Product Verification and Validation 3R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: BE 338

Corequisites: There are no corequisites for this course.

This course is a continuation of BE338. The student teams iterate on the initial functional prototype based on client feedback, complete testing of the prototype solutions, and transfer the project results to their client. The course culminates with the submission of a critical design document.

BE 428 Capstone Design IV: Integrated Product Design & Practice 1R-3L-2C W

Graduate Studies Eligible: No

Prerequisites: BE 418

Corequisites: There are no corequisites for this course.

This course is a continuation of BE418. Student teams finalize design prototypes, reflect on future product development opportunities, and complete documentation requirements to established standards and specifications. Students participate in a mentorship program with students enrolled in BE328 and begin development of a professional design portfolio.

BE 435 Biomedical Optics 3.5R-1.5L-4C

Graduate Studies Eligible: Yes

Prerequisites: PH 113, and MA 221 or Senior/Graduate standing or consent of instructor
Corequisites: There are no corequisites for this course.
Optical techniques for biomedical applications and health care; laser fundamentals, laser interaction with biological cells, organelles and nanostructures; laser diagnostics and therapy, laser surgery; microscopes; optics-based clinical applications; imaging and spectroscopy, biophotonics laboratories. For graduate credit, students must do additional project work on a topic selected by the instructor. Cross-listed with OE 435.

BE 438 Engineering Portfolio Development 1R-3L-2C S
Graduate Studies Eligible: No
Prerequisites: BE 428
Corequisites: There are no corequisites for this course.
Students complete a portfolio showcasing their engineering design work to further a specific professional goal. Examples of professional goals include developing a career plan, pursuing patent opportunities, or establishing a business plan for a start-up. Students participate in a mentorship program with students enrolled in BE338.

BE 482 Biostatistics 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: MA 223 or MA 382 and consent of instructor (cross listed with MA 482)
Corequisites: There are no corequisites for this course.
Hypothesis testing and confidence intervals for two means, two proportions, and two variances. Introduction to analysis of variance to include one factor and two factors (with interaction) designs. Presentation of simple linear and multiple linear regression modeling; development of analysis of contingency table to include logistic regression. Presentation of Log odds ratio as well as several non-parametric techniques of hypothesis testing and construction of non-parametric confidence intervals and correlation coefficients. Review of fundamental prerequisite statistics will be included as necessary.

BE 491 Special Topics in Biomedical Engineering XR-0L-XC
Graduate Studies Eligible: No
Prerequisites: Arranged prerequisite consent of instructor
Corequisites: There are no corequisites for this course.
Covers upper-level, undergraduate material of mutual interest to student and instructor which cannot be acquired in any other listed undergraduate BE course.

BE 492 Directed Study in Biomedical Engineering XR-XL-XC
Graduate Studies Eligible: No
Prerequisites: Arranged prerequisite consent of instructor
Corequisites: There are no corequisites for this course.
Covers biomedical engineering material of mutual interest to the student and instructor which cannot be experienced in any other listed BE course. A student may take between 1-4 credits in any given term.

BE 499 Thesis Research 0R-6L-2C F,W,S
Graduate Studies Eligible: No
Prerequisites: Junior or senior standing
Corequisites: There are no corequisites for this course.
Culmination of biomedical engineering thesis research in which a student writes and submits the senior thesis, following departmentally established guidelines, and gives an oral research presentation to at least three departmental faculty members, including the student's adviser. BE499 may not be used as a biomedical engineering area elective.

BE 515 Mechanobiology 4R-0L-4C S

Graduate Studies Eligible: Yes
Prerequisites: BE 232 or consent of instructor
Corequisites: There are no corequisites for this course.
This course will discuss the role physical forces play on biological processes and how mechanical stimuli can be utilized to improve tissue engineering, regenerative medicine, and rehabilitation strategies.

BE 516 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: JR or SR standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers, wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS application: capacitive accelerometer, cantilever and pressure sensor. Students enrolled in BE516 must do project work on a topic selected by the instructor. Cross-listed with CHE 505, ECE 516, EP 510, and ME 516.

BE 520 Introduction to Brain Machine Interfaces 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: BE 321 or ECE 380
Corequisites: There are no corequisites for this course.
This course is an introduction to the basics of motor cortical functions related to voluntary and imagery movements, evoked response potentials, invasive vs. noninvasive electrode design considerations, quantitative EEG analysis techniques used in clinical settings, and the applications of brain-machine interfaces/brain-computer interfaces in the restoration of mobility, communication and motor function.

BE 535 Biomedical Optics 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: PH 113, MA 221 and SR standing or GR standing
Corequisites: There are no corequisites for this course.
Optical techniques for biomedical applications and health care; imaging modalities; laser fundamentals, laser interaction with biological cells, organelles and nanostructures; laser diagnostics and therapy, laser surgery; microscopes; optics-based clinical applications; imaging and spectroscopy; biophotonics. Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both OE 435 and OE 535. Cross-listed with OE 535.

BE 541 Medical Imaging Systems 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: BE 321* or ECE 300 or OE 392** *Graduate standing; or with a grade of B or better; or consent of instructor; **with a grade of B or better or Graduate standing.
Corequisites: There are no corequisites for this course.
Engineering principles of major imaging techniques/modalities for biomedical applications and health care including diagnostic x-ray, computed tomography, nuclear techniques, ultrasound, and magnetic resonance imaging. Topics include general characteristics of medical images; physical principles, signal processing to generate an image, and instrumentation of imaging modalities. Clinical applications of these technologies are also discussed. Cross-listed with ECE584 and OE584.

BE 543 Neuroprosthetics 3R-3L-4C
Graduate Studies Eligible: Yes
Prerequisites: BE 324, and BE 211
Corequisites: There are no corequisites for this course.

This course takes a detailed look at the state of the art in Neuroprosthetics design and applications. Topics include electrode design, sensory prosthetics, functional electrical stimulation, deep brain stimulation and other contemporary research topics.

BE 545 Orthopaedic Biomechanics 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: EM 203 or EM 204, and BE 222, and BE 232 or consent of instructor

Corequisites: There are no corequisites for this course.

This course covers current topics in orthopaedic biomechanics including the application of solid mechanics principles to musculoskeletal activities, orthopaedic implants, and fracture fixation devices. Topics include joint loading; composition and mechanical behavior of orthopaedic tissues; design/analysis of artificial joints and fracture fixation prostheses; osteoporosis and osteoarthritis; and finite element modeling.

BE 550 Research Methods in Biomechanics 3R-3L-4C W

Graduate Studies Eligible: Yes

Prerequisites: BE 232 or consent of instructor

Corequisites: There are no corequisites for this course.

Focuses on the wide range of research methods used in the field of biomechanics. Current literature will be reviewed to analyze the advantages and disadvantages of various research methodologies. Topics will vary based on student interests and background, but may include topics such as motion/force analysis, soft tissue and bone mechanics, joint biomechanics, analysis of joint replacements, and fracture fixation. Laboratory activities will reinforce the lecture topics and students will have the opportunity to investigate a biomechanics research topic in their area of interest.

BE 560 Tissue-Biomaterial Interactions 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: BE 233 or consent of instructor

Corequisites: There are no corequisites for this course.

Addresses interactions between living cells/tissues and implant biomaterials, stressing the importance of molecular- and cellular-level phenomena in initiating and propagating clinically relevant tissue- and systemic- level results.

BE 570 Introduction to Tissue Engineering 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: BIO 110 , and BE 233 or CHE 315 or ME 328 and Junior, Senior, or Graduate standing or permission of instructor

Corequisites: There are no corequisites for this course.

This course provides a broad overview of the latest developments in the field of tissue engineering. Normal structure and function of tissues and organs such as bone, cartilage, nerve, skin, and liver are discussed. Methods of engineering these tissues, or encouraging healing or regeneration that would not otherwise occur, is the focus of the course. The course takes the format of a graduate seminar, with students taking an active role in presenting material to the class and leading discussions.

BE 590 Thesis Research Credits as assigned F,W,S

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Credits as assigned: however, not more than 12 credits will be applied toward the requirements of an M.S. degree.

BE 597 Selected Topics Credits as assigned F,W,S

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.
Selected Topics for Graduate Students Credits as assigned. Maximum 4 credits per term.

Chemical Engineering - Course Descriptions

CHE 110 Programming & Computation for Chemical Engineers 2R-0L-2C S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
An introduction to problem solving and structured programming concepts using spreadsheets and computational software. Spreadsheet applications include graphical analysis, curve-fitting, parameter estimation, numerical differentiation and integration, solution of systems of algebraic (linear and nonlinear) equations and ordinary differential equations.

CHE 199 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

CHE 200 Career Preparation I 1R-0L-0C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: CHE 201
Career choices in chemical engineering. Internships and co-ops. Resume preparation. Interview skills.

CHE 201 Conservation Principles and Balances 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: MA 113, PH 111, and either CHEM 113 or concurrent registration in CHEM 112
Corequisites: There are no corequisites for this course.
An introduction to engineering calculations, the use of common process variables, and conservation and accounting of extensive properties as a common framework for engineering analysis and modeling. Applications of conservation of mass and energy in the analysis of non-reactive chemical engineering processes will be addressed. There will be an introduction to equipment, flowcharts, techniques and methodologies used by practicing chemical engineers.

CHE 202 Basic Chemical Process Calculations 4R-0L-4C W
Graduate Studies Eligible: No
Prerequisites: CHE 201, and MA 221
Corequisites: There are no corequisites for this course.
The course continues to develop concepts from CHE 201 and provides a more extensive treatment of energy balances. Applications of the principles of conservation of mass and energy to reactive and transient systems will also be addressed.

CHE 290 Special Topics in Chemical Engineering Variable See Dept
Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics of current interest in chemical engineering.

CHE 301 Fluid Mechanics 4R-0L-4C F,S
Graduate Studies Eligible: No
Prerequisites: CHE 201, and MA 221
Corequisites: There are no corequisites for this course.
Physical properties of fluids, fluid statics, laminar and turbulent flow. Design of pipe networks and pumps. Fluid flow as momentum transport. Flow through porous media. Non-Newtonian fluid flow. Flow past objects and boundary layer concept. Emphasis is placed on general methods of analysis applicable to any fluid.

CHE 303 Chemical Engineering Thermodynamics 4R-0L-4C F,S
Graduate Studies Eligible: No
Prerequisites: CHE 202, and MA 221
Corequisites: CHE 110
First and second laws of thermodynamics and their application including thermodynamic cycles, closed and open systems. Thermodynamic properties of pure components. Phase equilibria of pure components. Equations of state, state diagrams. Thermodynamic analysis of processes.

CHE 304 Multi-Component Thermodynamics 4R-0L-4C F,W
Graduate Studies Eligible: No
Prerequisites: CHE 303, and MA 222
Corequisites: There are no corequisites for this course.
Properties of mixtures. Phase equilibria for mixtures. Equations of state and activity coefficient models. Chemical reaction thermodynamics. Thermodynamic analysis of processes. Study of phase equilibria involving the use of a process simulator.

CHE 310 Numerical Methods for Chemical Engineers 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: CHE 110, and MA 222 or concurrent enrollment
Corequisites: There are no corequisites for this course.
The objective of this course is to learn the fundamentals of several important numerical methods and how to apply them to solve chemical engineering problems. This will include the study of algorithms to solve systems of algebraic and differential equations, toperform numerical integration, to apply linear and nonlinear regression techniques, and to perform stochastic Monte Carlo simulations. Matlab and Excel will be used as the programming and computing software.

CHE 315 Materials Science and Engineering 4R-0L-4C F,S
Graduate Studies Eligible: No
Prerequisites: CHEM 115 or consent of instructor
Corequisites: There are no corequisites for this course.
Introduction to the properties and processing of metals, ceramics, polymers, and semiconductors. The influences of crystal structure, interatomic bonding, and electronic structure on physical, mechanical, and electrical properties are emphasized. Causes and mitigation of various types of corrosion are explored. Properties and design of composite materials are introduced.

CHE 320 Fundamentals of Heat & Mass Transfer 4R-0L-4C F,W
Graduate Studies Eligible: No
Prerequisites: CHE 202, and CHE 301, and MA 222
Corequisites: CHE 304

Discussion of fundamental heat and mass transfer principles: conduction, forced and free convection, radiation, and diffusion. Mathematical analysis and computation of heat transfer, mass transfer, temperature, and concentration profiles in systems with simple geometries. Finite difference equations. Estimation of local and overall heat and mass transfer coefficients.

CHE 321 Applications of Heat & Mass Transfer 4R-0L-4C W,S

Graduate Studies Eligible: No

Prerequisites: CHE 320, and CHE 304

Corequisites: There are no corequisites for this course.

Use, design, and selection of heat exchangers and heat exchange systems for various applications in the chemical process industries. Study of gas-liquid and liquid-liquid mass transfer operations including gas absorption, extraction, and distillation in equilibrium staged tray columns and packed columns. Quantitative treatment of mass transfer based on material and energy balances, phase equilibrium, and rates of heat and mass transfer. Applications of radiation heat transfer, boiling, and condensation.

CHE 340 Process Control 4R-0L-4C F, W

Graduate Studies Eligible: No

Prerequisites: CHE 202, and MA 222

Corequisites: There are no corequisites for this course.

The mathematics of process dynamics, control system design, Laplace transforms, feedback control theory, characteristics of sensors, transmitters and control elements, stability criteria, and frequency response. Use of control design software is emphasized.

CHE 404 Reaction Engineering 4R-0L-4C F,S

Graduate Studies Eligible: Yes

Prerequisites: CHEM 360, and CHE 304

Corequisites: There are no corequisites for this course.

The course covers the analysis of various reactors including batch and continuous types for homogenous and heterogeneous reactions, single reactions, multiple reactions, reactor cascades, and temperature effects. Computer methods and software for chemical reaction engineering are used.

CHE 405 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S

Graduate Studies Eligible: Yes

Prerequisites: and Junior or Senior standing

Corequisites: There are no corequisites for this course.

Properties of silicon wafers, wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with ECE 416, EP 410, and ME 416.

CHE 409 Professional Practice 1R-0L-1C F

Graduate Studies Eligible: No

Prerequisites: Senior standing in Chemical Engineering

Corequisites: There are no corequisites for this course.

Topics on professional practice, ethics, and contemporary and global issues in the profession are discussed.

CHE 411 Chemical Engineering Laboratory I 2R-3L-3C S

Graduate Studies Eligible: No

Prerequisites: CHEM 225, and CHEM 252, and CHE 321*, and MA 223, and ENGL H290

Corequisites: There are no corequisites for this course.

Principles underlying momentum, mass and energy transfer and the applications of equipment used to accomplish such transfer, introduction to laboratory concepts in data collection, record keeping, interpretation and analysis, and instrumentation including experimental error analysis, regression, model formulation, experimental design, and instrumentation. Written and oral reports are required. Formal instruction on written and oral communication will be provided.

CHE 412 Chemical Engineering Laboratory II 2R- 6L-4C F
Graduate Studies Eligible: No
Prerequisites: CHE 321, and CHE 411 or consent of instructor
Corequisites: CHE 404
Continuation of principles underlying momentum, mass and energy transfer with some emphasis on kinetics, applications of equipment used to accomplish such transfer.

CHE 413 Chemical Engineering Laboratory III 2R- 6L-4C W
Graduate Studies Eligible: No
Prerequisites: CHE 412
Corequisites: There are no corequisites for this course.
Continuation of CHE 412 with further development of hands-on laboratory skills.

CHE 416 Chemical Engineering Design I 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: CHE 321
Corequisites: There are no corequisites for this course.
Introduction to the design process; gross profit analysis; simulation to assist in process creation; synthesis of separation trains; design of separation equipment.

CHE 417 Chemical Engineering Design II 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: CHE 416, and CHE 404
Corequisites: There are no corequisites for this course.
Design of reactor-separator-recycle networks; heat and power integration; batch process scheduling; annual costs, earnings and profitability; preliminary work on a capstone design project.

CHE 418 Chemical Engineering Design III: Capstone Design Project 0R-6L-2C S
Graduate Studies Eligible: Yes
Prerequisites: CHE 417 or consent of instructor
Corequisites: There are no corequisites for this course.
Completion of an open-ended design project that will include written and oral communication of intermediate results and a final written report.

CHE 419 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Graduate Studies Eligible: Yes
Prerequisites: EP 410 or equivalent (See EP 411/511.)
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, and physics. Students enrolled in CHE 419/519, must do project work on a topic selected by the instructor. Cross-listed with EP 411, and ECE 419.

CHE 430 Petrochemical Processes 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: CHE 321 or consent of instructor
Corequisites: There are no corequisites for this course.

Multicomponent separation of petroleum by flash vaporization. Processes for production of lighter petroleum products from heavier derivatives. Production of petrochemicals from natural gas or other fossil fuels. Projects and presentations on refinery and petrochemical processes. Material balances and economic evaluations of refinery processes. Cross listed with CHE 530. Students cannot earn credit for both CHE 430 and CHE 530.

CHE 441 Polymer Engineering 4R-0L-4C SeeDept

Graduate Studies Eligible: Yes

Prerequisites: CHE 404*, and CHEM 251 or consent of instructor

Corequisites: There are no corequisites for this course.

Interrelation of polymer structure, properties and processing. Polymerization kinetics. Methods for molecular weight determination. Fabrication and processing of thermoplastic and thermosetting materials. Student projects.

CHE 460 Particle Technology 4R-0L-4C See Department

Graduate Studies Eligible: Yes

Prerequisites: CHE 202, and CHE 301

Corequisites: There are no corequisites for this course.

Introduction to the fundamentals of particle technology including particle characterization, transport, sampling, and processing. Students will learn about the basic design and scale-up of some industrial particulate systems (including fluidized beds, mixers, pneumatic conveying systems, cyclone separators, and hoppers) as well as environmental and safety issues related to particulate handling.

CHE 462 Membrane Separations 4R-0L-4C See Dept

Graduate Studies Eligible: Yes

Prerequisites: CHE 320 or CE 460

Corequisites: There are no corequisites for this course.

Introduction to transport mechanisms underlying membrane separations and associated industrial processes. Basic design parameters, applications, and limitations will be discussed for several membrane separation methods including reverse osmosis, ultrafiltration, microfiltration, and gas separations. Particular focus on current topics such as membrane fabrication, module design, and challenges to commercial implementation. This course will contain hands-on demonstrations and projects.

CHE 465 Energy and the Environment 4R-0L-4C See Department

Graduate Studies Eligible: Yes

Prerequisites: CHE 303 or CHEM 361 or CE 205 or ME 301 or consent of instructor

Corequisites: There are no corequisites for this course.

This is a survey course in which the energy needs of the world, the ways in which those needs are currently being met, the development and current usage of renewable energy, and the impact of these on the environment, specifically the impact on climate change, are examined. Life cycle analysis is also considered.

CHE 470 Safety, Health, and Loss Prevention 4R-0L-4C See Department

Graduate Studies Eligible: Yes

Prerequisites: CHE 320

Corequisites: There are no corequisites for this course.

Fundamentals of chemical process safety including toxicology, industrial hygiene, toxic release and dispersion models, fires and explosions, designs and procedures to prevent fires and explosions. Overview of federal regulations governing the chemical process industries.

CHE 490 Special Topics in Chemical Engineering Variable See Dept

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics of current interest in chemical engineering.

CHE 499 Directed Research Variable Credit F,W,S
Graduate Studies Eligible: No
Prerequisites: consent of instructor
Corequisites: There are no corequisites for this course.
A special project is assigned to or selected by the student. The publication of research is encouraged. Variable credit. May be repeated up to a maximum of eight credits.

CHE 502 Transport Phenomena 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CHE 320
Corequisites: There are no corequisites for this course.
Most of the course focuses on the derivation, simplification, and solution of the equations of change for momentum, energy, and mass transport. Mathematical determination of velocity profiles and momentum flux for isothermal, laminar flows in both steady and unsteady systems will be covered. Mathematical determination of temperature profiles and heat flux, and concentration profiles and mass flux both in solids and in laminar flows will also be covered. Boundary layer theory will be discussed. Turbulent flow theories may also be addressed.

CHE 504 Advanced Reaction Engineering 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: CHE 404
Corequisites: There are no corequisites for this course.
The course covers strategies for modeling non-ideal reactors and more complex reaction systems. Advanced topics in chemical reactions are analyzed with computer methods and software for reaction engineering.

CHE 505 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: Junior or Senior class standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with BE 516, ECE 516, EP 510, and ME 516.

CHE 513 Advanced Chemical Engineering Thermodynamics 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: CHE 304
Corequisites: There are no corequisites for this course.
Review of thermodynamic principles including fundamental equations and the laws of thermodynamics. Thermodynamics of mixtures, phase equilibria, and thermodynamic analysis of processes. Project based in-depth study of phase equilibria, equations of state, and activity coefficient models. Use of process simulator for phase equilibria calculations. Introduction to statistical thermodynamics.

CHE 515 Nanomaterials Science & Engineering 4R-0L-4C See Department
Graduate Studies Eligible: Yes
Prerequisites: CHE 315 or ME 328 or BE 233 or EP 280 and Junior Standing
Corequisites: There are no corequisites for this course.

Current research trends and industrial activity in the field of nanotechnology. Contains an overview of nanoscale characterization and production methods and emphasizes the roles that chemical functionality, thermodynamics, and physics play in determining the unique properties of nanoscale materials systems. Independent student reviews of current research literature form an integral part of the course.

CHE 519 Advanced MEMS: Modeling & Packaging 3R-3L-4C F

Graduate Studies Eligible: Yes

Prerequisites: EP 410 or equivalent course

Corequisites: There are no corequisites for this course.

Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with EP 511, ME 519, and ECE 519.

CHE 525 Process Analytics 4R-0L-4C See Department

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: CHE 411

Introduction to methodologies used to collect, process, and store data from highly connected systems for applications in making informed engineering decisions. Students will learn about modern industrial control system architecture, data storage and time series databases, asset management, processing of streaming data, and decision making over various time scales.

CHE 530 Petrochemical Processes 4R-0L-4C See Department

Graduate Studies Eligible: Yes

Prerequisites: CHE 321 or consent of instructor

Corequisites: There are no corequisites for this course.

Multicomponent separation of petroleum by flash vaporization. Processes for production of light petroleum products from heavier derivatives. Production of petrochemicals from natural gas or other fossil fuels. Projects, presentations on refinery and petrochemical processes. Material balances and economic evaluations of the refinery processes. Projects and other assignment requirements will be adjusted to the course level. Students must do additional independent work. Cross listed with CHE 430. Students cannot earn credit for both CHE 430 and CHE 530.

CHE 540 Advanced Process Control 4R-0L-4C Not Offered

Graduate Studies Eligible: Yes

Prerequisites: CHE 340 and consent of instructor

Corequisites: There are no corequisites for this course.

Control topics beyond those covered in CHE 440. Topics will be selected from among the following: advanced control using cascade, feed forward, nonlinear, and adaptive control; multivariable systems including RGA analysis and decoupling; a major control system design and implementation project using a modern distributed control system.

CHE 545 Introduction to Biochemical Engineering 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: BIO 110 , and CHEM 330, and CHE 404 or ES 201 or BE 132 or consent of instructor

Corequisites: There are no corequisites for this course.

Survey course introducing biochemical terminology and processes. Enzyme kinetics, cellular genetics, biochemical transport phenomena, and design and operation of

biochemical reactors. Emphasis on applying engineering principles to biochemical situations.

CHE 546 Bioseparations 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: BIO 110 , and CHE 321 or ES 201 or consent of instructor

Corequisites: There are no corequisites for this course.

An analysis of bioseparation processes. Filtration, centrifugation, adsorption, electrophoresis, and chromatography are the primary topics of the course. Applications are emphasized.

CHE 562 Advanced Wastewater Treatment 4R-0L-4C See Dept

Graduate Studies Eligible: Yes

Prerequisites: CE 460

Corequisites: There are no corequisites for this course.

Covers the theory, design and analysis of biological processes for the treatment of wastewater. Treatment processes include suspended and attached growth processes, aerobic and anaerobic processes, biological nutrient removal, aeration and gas transfer, and biosolids processing. Cross-listed with CE 562.

CHE 563 Advanced Water Treatment 4R-0L-4C See Dept

Graduate Studies Eligible: Yes

Prerequisites: CE 460

Corequisites: There are no corequisites for this course.

Covers the theory, design and analysis of physical and chemical processes for the treatment of drinking water. Treatment processes include coagulation and flocculation, gravity separation, granular and membrane filtration, disinfection, air stripping, adsorption, ion exchange, and disinfection. Cross listed with CE 563.

CHE 590 Special Topics in Chemical Engineering 4R-0L-4C F,W,S

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Topics of current interest in chemical engineering. May be repeated.

CHE 597 Special Projects in Chemical Engineering Variable Credit F,W,S

Graduate Studies Eligible: Yes

Prerequisites: consent of instructor

Corequisites: There are no corequisites for this course.

A special project, or series of problems, or research problem is assigned to or selected by the student. A comprehensive report must be submitted at the conclusion of the project. Not to be used as a substitute for CHE 599, Thesis Research. Variable credit. May be repeated up to a maximum of eight credits.

CHE 598 Graduate Seminar 1R-0L-0C F,W,S

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Selected topics in chemical engineering are discussed by graduate students, faculty, and guest speakers.

CHE 599 Thesis Research As assigned F,W,S

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Graduate students only. Credits as assigned; however, not more than 12 credits will be applied toward the requirements of the M.S. degree.

CHE 699 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The work experiences should be informative or integral to the advancement or completion of the student's program requirements. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

Chemistry - Course Descriptions

CHEM 111 General Chemistry I 3R-0L-3C F,W,S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: CHEM 111L
Topics include stoichiometry, nomenclature, phases, and writing balanced chemical equations. Quantum theory is introduced in relation to chemical applications. Atomic structure is introduced. Bonding principles and molecular structure are discussed in terms of Lewis Dot Structures, Valence Bond Theory, VSEPR Theory, Hybridization, and Molecular Orbital Theory.
CHEM 111L General Chemistry I Laboratory 0R-3L-1C F,W,S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: CHEM 111
Fundamental chemistry laboratory skills are introduced along with data analysis in support of topics presented in CHEM111 recitation.
CHEM 112 Chemistry Honors 4R-3L-5C F
Graduate Studies Eligible: No
Prerequisites: Advanced placement
Corequisites: There are no corequisites for this course.
An accelerated course covering topics in CHEM 111 and CHEM 113. Upon successful completion of this course, an additional 3 credits will be awarded. Enrollment is limited to those students who complete the Rose-Hulman online Chemistry Advanced Placement Examination given prior to the freshman orientation period.
CHEM 113 General Chemistry II 3R-0L-3C W,S
Graduate Studies Eligible: No
Prerequisites: CHEM 111, and CHEM 111L
Corequisites: CHEM 113L
Topics in this course include the fundamentals of thermodynamics and kinetics. The fundamentals of chemical equilibrium are introduced. Definitions of acid and bases are discussed utilizing the Bronsted-Lowry and Lewis models. Nuclear chemistry is also included.
CHEM 113L General Chemistry II Laboratory 0R-3L-1C W,S
Graduate Studies Eligible: No
Prerequisites: CHEM 111, and CHEM 111L
Corequisites: CHEM 113

Fundamental chemistry laboratory skills are introduced along with data analysis in support of topics presented in CHEM113 recitation.

CHEM 115 General Chemistry III 3R-0L-3C W, S

Graduate Studies Eligible: No

Prerequisites: CHEM 113, and CHEM 113L or CHEM 112

Corequisites: CHEM 115L

Topics in this course include acid-base reactions, electrochemistry, and coordination chemistry.

CHEM 115L General Chemistry III Laboratory 0R-3L-1C W,S

Graduate Studies Eligible: No

Prerequisites: CHEM 113, and CHEM 113L or CHEM 112

Corequisites: CHEM 115

Fundamental chemistry laboratory skills are introduced along with data analysis in support of topics presented in CHEM113 recitation.

CHEM 199 Professional Experience 1R-0L-1C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

CHEM 200 Career Preparation 1R-0L-1C W

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course is for chemistry and biochemistry majors to be taken in the second year. The course addresses career choices, summer opportunities, employment and graduate school preparation, and curriculum vitae and resumes preparation. Cross-listed with MA200, and SV200.

CHEM 210 Chemistry of Poisons and Potions 2R-0L-2C SeeDept

Graduate Studies Eligible: No

Prerequisites: CHEM 111, and CHEM 111L

Corequisites: There are no corequisites for this course.

This course examines chemical agents found in medicinal plants and their use in different contexts. Specifically, we will investigate the chemical characteristics of these agents commonly used by humans through cultural practices.

CHEM 211 Chemistry of Food and Cooking 2R-0L-2C See Dept.

Graduate Studies Eligible: No

Prerequisites: CHEM 111, and CHEM 111L

Corequisites: There are no corequisites for this course.

The course presents students with the basic structural elements of four categories of food molecules and many of the physical and chemical transformations that occur in food preparation. Among anticipated outcomes will be the ability to assess the role of ingredients and processes in specific recipes thereby allowing participants to make informed decisions about recipe modifications.

CHEM 212 Chemistry of Sport 2R-0L-2C SeeDept

Graduate Studies Eligible: No

Prerequisites: CHEM 111, and CHEM 111L

Corequisites: There are no corequisites for this course.
This course will take a molecule-focused look at the overlap of chemistry and sports. The course will look at types of performance-enhancing drugs and their history, mechanisms of action, claims of efficacy, and detection using case studies

CHEM 213 Chemistry of Art 2R-0L-2 SeeDept
Graduate Studies Eligible: No
Prerequisites: CHEM 111, and CHEM 111L
Corequisites: There are no corequisites for this course.
This course will highlight the intersection of the chemical sciences and visual arts. Focus will be given to understanding the chemical nature and behaviors of dyes, pigments, and paints, pottery and glazes, textiles, and materials used for sculpture. Historical developments of artistic media will be discussed and related to chemical conservation efforts and forgery detection.

CHEM 225 Analytical Chemistry 3R-0L-3C F,S
Graduate Studies Eligible: No
Prerequisites: CHEM 115, and CHEM 115L
Corequisites: CHEM 225L
This laboratory-driven course is an introduction to classical and modern quantitative analysis with emphasis on calculations, separations, and precise and accurate measurements. Theoretical and practical perspectives of chemical analysis are considered. Chemical instrumentation includes recording pH/mV meters, constant rate burets, colorimeters, spectrophotometers, high performance liquid chromatographs and gas-liquid chromatographs.

CHEM 225L Analytical Chemistry Laboratory 0R-3L-1C F,S
Graduate Studies Eligible: No
Prerequisites: CHEM 115, and CHEM 115L
Corequisites: CHEM 225
This course represents the laboratory component of analytical chemistry. Practicums are part of the grade along with reports.

CHEM 251 Organic Chemistry I 3R-0L-3C F,W
Graduate Studies Eligible: No
Prerequisites: CHEM 113, and CHEM 113L or CHEM 112
Corequisites: CHEM 251L
An introduction to the classification of organic compounds, their structural features, including stereochemistry, and concepts related to reaction mechanisms and synthetic methods as it relates to compounds with biochemical relevance.

CHEM 251L Organic Chemistry I Laboratory 0R-3L-1C F,W
Graduate Studies Eligible: No
Prerequisites: CHEM 113, and CHEM 113L or CHEM 112
Corequisites: CHEM 251
Organic Laboratory techniques in running chemical reactions and isolating compounds are developed. Assessment is in part via practicums. Computational chemistry methods and green chemistry approaches are also introduced. Lab will meet 5 times in the term.

CHEM 252 Organic Chemistry II 3R-0L-3C W,S
Graduate Studies Eligible: No
Prerequisites: CHEM 251, and CHEM 251L
Corequisites: CHEM 252L
Continuation of Organic Chemistry I with greater emphasis on reaction mechanisms and an introduction to the methods used to determine structure, including IR and NMR spectroscopy and mass spectrometry.

CHEM 252L Organic Chemistry II Laboratory 0R-3L-1C W,S
Graduate Studies Eligible: No
Prerequisites: CHEM 251, and CHEM 251L
Corequisites: CHEM 252
A continuation of Organic Chemistry I Lab where additional, more complicated synthetic techniques and methods along with additional spectroscopic techniques are introduced.

CHEM 253 Organic Chemistry III 3R-0L-3C S
Graduate Studies Eligible: No
Prerequisites: CHEM 252, and CHEM 252L
Corequisites: CHEM 253L
Continuation of Organic Chemistry II with a focus on carbon-carbon bond-forming reactions, heterocycles, and polyfunctional molecules.

CHEM 253L Organic Chemistry III Laboratory 0R-4L-1C S
Graduate Studies Eligible: No
Prerequisites: CHEM 252, CHEM 252L
Corequisites: CHEM 253
Project based laboratory where techniques and skills developed in the previous organic laboratories are applied to more open-ended problems.

CHEM 270 Special Topics in Chemistry (1-4)R-0L-(1-4)C See Dept
Graduate Studies Eligible: No
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Studies in topics of current chemical interest not addressed in other named courses. A maximum of 4 total credit hours of CHEM270 and CHEM276 can be counted towards a chemistry major.

CHEM 276 Special Topics in Chemistry with Laboratory (0-3)R-(3-6)L-(1-4)C
Graduate Studies Eligible: No
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Studies in topics of current chemical interest not addressed in other named courses. This course will have a laboratory component. A maximum of 4 total credit hours of CHEM270 and CHEM276 can be counted towards a chemistry major.

CHEM 290 Chemical Research 0R-(4-8)L-(1-2)C F, W, S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Research performed under the direction of a faculty member selected by mutual agreement. This course is designed for research performed before taking CHEM291. Students may register for 1 to 2 credit hours per quarter.

CHEM 291 Introduction to Chemical Research 2R-4L-3C W
Graduate Studies Eligible: No
Prerequisites: CHEM 113, and CHEM 113L or CHEM 112 and declared chemistry or biochemistry major.
Corequisites: There are no corequisites for this course.
Students will be introduced to skills necessary for conducting chemical research. Students will gain proficiency in: (1) literature searching of primary, secondary, and tertiary sources emphasizing the use of online databases; (2) laboratory skills involving synthesis, characterization, analysis, and keeping a notebook; (3) safety practice including MSDS interpretation; and (4) ethical conduct in collecting and reporting data and results. Students will be required to attend all seminars during the quarter.

Enrollment is reserved for students who are declared as chemistry or biochemistry majors.

CHEM 326 Bioanalytical Chemistry 3R-4L-4-C W
Graduate Studies Eligible: No
Prerequisites: CHEM 225, and CHEM 225L
Corequisites: There are no corequisites for this course.
Addresses instrumental methods of analysis applicable to biochemistry including instrument design, operating principles, theory and application. Topics include molecular spectroscopic techniques in the infrared, visible and ultraviolet regions, including luminescence and Raman spectroscopy. Separation techniques including liquid chromatography and capillary electrophoresis are also addressed.

CHEM 327 Advanced Analytical Chemistry 3R-4L-4C S
Graduate Studies Eligible: No
Prerequisites: CHEM 326
Corequisites: There are no corequisites for this course.
Addresses theory, operating principles, and application of instrumental methods for chemical analysis in the areas of atomic spectroscopy, x-ray techniques, gas chromatography and electroanalytical methods.

CHEM 330 Biochemistry I 4R-0L-4C F,S
Graduate Studies Eligible: No
Prerequisites: CHEM 251
Corequisites: There are no corequisites for this course.
Includes the structure and function of biological molecules, enzyme kinetics and mechanisms, and the reactions, strategy, and regulation of carbohydrate metabolism.

CHEM 331 Biochemistry II 4R-0L-4C W
Graduate Studies Eligible: No
Prerequisites: CHEM 330, and BIO 210
Corequisites: There are no corequisites for this course.
Includes the reactions, strategy, and regulation of the major metabolic pathways in humans and of selected pathways in plants, and the storage, repair, and transmission of genetic information.

CHEM 360 Introduction to Physical Chemistry for Engineers 4R-0L-4C W,S
Graduate Studies Eligible: No
Prerequisites: CHE 303, CHE 304, and CHEM 115
Corequisites: There are no corequisites for this course.
Introduction to quantum chemistry, statistical thermodynamics, electrochemistry, chemical kinetics, surface chemistry and colloid science.

CHEM 361 Physical Chemistry I 4R-2L-4C F
Graduate Studies Eligible: No
Prerequisites: CHEM 115, and CHEM 115L, and MA 113, and MA 223 or MA 381* See notes below
Corequisites: There are no corequisites for this course.
Covers the laws of thermodynamics, free energy, gases, phase equilibria and solutions. Emphasizes the applications of differential and integral calculus and includes an introduction to statistical thermodynamics and surface chemistry. The laboratory will meet for 4 hours on alternate weeks and will investigate topics associated with thermodynamics and phase equilibrium.

CHEM 362 Physical Chemistry II 3R-2L-4C W
Graduate Studies Eligible: No
Prerequisites: CHEM 361

Corequisites: There are no corequisites for this course.
Covers chemical equilibria, statistical mechanics, kinetics and electrochemistry. The laboratory will meet for 4 hours on alternate weeks.

CHEM 391 Research Proposal 1R-0L-1C F, W, S
Graduate Studies Eligible: No
Prerequisites: CHEM 291
Corequisites: There are no corequisites for this course.
Students will take online lessons related to the generation and communication of research ideas culminating in the production of a research proposal. The research proposal will be written under the direction of a faculty member of record for the student's CHEM490 or by other faculty member selected by mutual agreement.

CHEM 395 Chemistry Seminar 0R-0L-0C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students will be required to attend and/or present research seminars, the number to be determined by the department. The students will register for the course in the fall of the third year and if all the requirements are met, the students will receive a grade of Satisfactory. Failure to meet the requirements during the fall quarter will result in No Grade and the student must complete the requirements by the end of the third year. If the requirements are not completed by the end of the third year, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 420 Electronics for Scientists 3R-4L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 326 or CHEM 327 or consent of instructor
Corequisites: There are no corequisites for this course.
A fundamental course on understanding important electronic systems as they pertain to chemical signals and instrumentation. Topics include analog systems (RC circuits, diodes, transistors, and operational amplifiers), digital systems (logic gates, shift registers, and lock-in amplifiers), and signal enhancement and noise reduction modules. The laboratory component will showcase basic circuit design and construction, and will culminate with a student-built chemical instrument.

CHEM 421 Biochemical Mass Spectrometry 1R-0L-1C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 330
Corequisites: There are no corequisites for this course.
This course will explore the theoretical basis and practical aspects of mass spectrometry, with an emphasis on their use for analysis of biological molecules. Topics include ionization mechanisms and methods for sample preparation and mass spectral analysis, and the course will include a project.

CHEM 422 Fluorescence Spectroscopy 1R-0L-1C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 330
Corequisites: There are no corequisites for this course.
This course will explore the theoretical basis and practical aspects of fluorescence spectroscopy, with an emphasis on their use for analysis of biological molecules. Topics include mechanisms of fluorescence excitation and emission, quenching processes, anisotropy, and time-resolved fluorescence, and the course will include a project.

CHEM 423 NMR Spectroscopy 1R-0L-1C See Dept
Graduate Studies Eligible: Yes

Prerequisites: CHEM 252
Corequisites: There are no corequisites for this course.
This course is designed to provide the basic training and tools necessary to operate the 300MHz Bruker NMR and the associated ICON software. Additionally, the focus will be on sample preparation, acquisition, analysis, and processing of 1H NMR, 13C NMR, COSY and HETCOR (2D NMR), DEPT-90, DEPT-135, heteronuclear NMR, and applications of NMR to related fields. The course will consist primarily of basic and practical NMR instruction.

CHEM 424 Absorption Spectroscopy 2R-0L-2C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 326 or CHEM 327
Corequisites: There are no corequisites for this course.
This course looks at absorption spectroscopy from the microwave to x-ray relating spectra to the molecular and/or atomic processes. The course will consist of both instruction and a project of student choice involving absorption process.

CHEM 425 Raman Spectroscopy 1R-0L-1C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 225
Corequisites: There are no corequisites for this course.
This course explores various theoretical and practical aspects of Raman spectroscopy including fundamental vibrational modes of molecules and selection rules, the physicochemical origin of Raman scattering, Raman spectrometers, lasers, resonance Raman spectroscopy, surface-enhanced Raman spectroscopy (SERS), and applications of Raman spectroscopy. The course includes an independent project in which a Raman spectrum is acquired for a sample of interest.

CHEM 426 Microfluidics 1R-0L-1C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 225
Corequisites: There are no corequisites for this course.
This course explores various theoretical and practical aspects of microfluidics. The course addresses the benefits and challenges of microfluidics in chemistry and chemical analysis and the materials and processes available for fabricating microfluidic devices. General characteristics of microfluidic devices including fluid flow regimes, heat transfer and diffusion are addressed as well as practical applications of microfluidic devices and how various functions like valving and detection are performed. The course includes an independent project involving the design and fabrication of a microfluidic device.

CHEM 427 HPLC 1R-0L-1C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 225
Corequisites: There are no corequisites for this course.
This course will explore various theoretical and practical aspects of HPLC including a review of separation parameters, equilibrium types, retention mechanisms, stationary phases and their performance, mobile phases and their properties and choosing an appropriate separation type.

CHEM 428 Trace Metal Detection 1R-0L-1C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 225
Corequisites: There are no corequisites for this course.

This course aims at providing students with fundamental skills and knowledge in trace metal analysis, for environmental and biological samples. The course will enable students to understand, develop and execute analytical protocols involving recent trace metal analysis methodologies and instrumentation using voltammetry. Students will learn by lectures, class activities, and homework assignments and how to optimize conditions to obtain sufficient analytical performance parameters in terms of selectivity, detection limit, cost, and analysis time.

CHEM 429 Capillary Electrophoresis 1R-0L-1C SeeDept

Graduate Studies Eligible: Yes

Prerequisites: CHEM 225

Corequisites: There are no corequisites for this course.

This course will explore various theoretical principles and chemical/biochemical applications of capillary electrophoresis. Main emphasis will focus on the choice of CE as an alternative form for separations for biochemical samples. Students will learn by lectures, class activities, homework assignments and how to optimize experimental conditions to achieve a good separation.

CHEM 430 Advanced Biochemistry 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: CHEM 330

Corequisites: There are no corequisites for this course.

An in-depth exploration of selected topics from the current biochemistry scientific literature, including molecular mechanisms of infectious diseases and genetic disorders, methods for rational drug design, and relationships between structure and function for biological molecules.

CHEM 433 Biochemistry Laboratory 0R-3L-1C S

Graduate Studies Eligible: Yes

Prerequisites: CHEM 330

Corequisites: There are no corequisites for this course.

Fundamental techniques employed in isolation, characterization and study of biomolecules, and enzyme kinetics. Techniques used may include homogenization, solvent extraction, centrifugation, salt fractionation, chromatography, and electrophoresis.

CHEM 441 Inorganic Chemistry I 4R-0L-4C F

Graduate Studies Eligible: Yes

Prerequisites: CHEM 252, CHEM 362, CHEM 360

Corequisites: There are no corequisites for this course.

The chemistry of non-metals. This course consists of a systematic study of the properties and reactions of the elements and their compounds based upon modern theories of the chemical bond, as well as from the viewpoint of atomic structure and the periodic law.

CHEM 442 Inorganic Chemistry II 3R-4L-4C W

Graduate Studies Eligible: Yes

Prerequisites: CHEM 441

Corequisites: There are no corequisites for this course.

The chemistry of metals. Modern theories such as valence bond, molecular orbital, electrostatic and ligand field are used to explain the properties of complex ions. Synthesis and characterization of complexes are done in the lab.

CHEM 451 Organic Structure Determination 2R-8L-4C See Dept

Graduate Studies Eligible: Yes

Prerequisites: CHEM 253 or instructor consent

Corequisites: There are no corequisites for this course.
Chemical and spectroscopic identification of organic compounds. Study of nuclear magnetic resonance and mass spectrometry, infrared spectroscopy and other techniques applied to structure elucidation and stereochemistry.

CHEM 463 Quantum Chemistry & Molecular Spectroscopy 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CHEM 111, CHEM 111L, PH 112, and MA 221
Corequisites: There are no corequisites for this course.
Covers elementary quantum mechanics with emphasis on applications in molecular structure.

CHEM 470 Special Topics in Chemistry (1-4)R-0L-(1-4)C See Dept
Graduate Studies Eligible: Yes
Prerequisites: or instructor consent
Corequisites: There are no corequisites for this course.
Studies in advanced topics of current chemical interest not addressed in other named courses.

CHEM 476 Special Topics in Chemistry with Laboratory (0-3)R-(3-6)L-(1-4)C See Dept
Graduate Studies Eligible: Yes
Prerequisites: To be taken concurrently with the appropriate elective not accompanied by an identified laboratory component.
Corequisites: There are no corequisites for this course.
Studies in advanced topics of current chemical interest not addressed in other named courses. This course will have a laboratory component.

CHEM 477 Directed Study in Chemistry (1-4)R-0L-(1-4)C F, W, S
Graduate Studies Eligible: No
Prerequisites: or instructor consent
Corequisites: There are no corequisites for this course.
Allows individual study in a topic not usually offered. A student may take 1 to 4 credits. A maximum of 4 credits is permitted.

CHEM 490 Chemical Research Rotation 1R-4L-2C F, W, S
Graduate Studies Eligible: No
Prerequisites: CHEM 291
Corequisites: There are no corequisites for this course.
Open-ended research projects performed as part of a research group. The students will gain proficiency in advanced lab techniques, the scientific method, data management and communication.

CHEM 491 Senior Thesis 1R-0L-1C F, W, S
Graduate Studies Eligible: No
Prerequisites: CHEM 490
Corequisites: There are no corequisites for this course.
Students will publish a thesis on their undergraduate research or a literature review of an advanced topic mutually agreed upon with the instructor.

CHEM 495 Chemistry Seminar 0R-0L-0C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 496 Chemistry Seminar 0R-0L-0C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 497 Senior Presentation 1R-0L-1C F, W, S
Graduate Studies Eligible: No
Prerequisites: CHEM 490
Corequisites: There are no corequisites for this course.
Students will deliver a professional seminar on their undergraduate research or a review of an advanced topic mutually agreed upon with the instructor.

CHEM 499 Independent Chemical Research 0R-(4-8)L-(1-2)C F, W, S
Graduate Studies Eligible: No
Prerequisites: CHEM 291
Corequisites: There are no corequisites for this course.
Research performed under the direction of a faculty member selected by mutual agreement. Students may register for 1 or 2 credit hours per quarter.

CHEM 520 Electronics for Scientists 3R-4L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 326 or CHEM 327 or consent of instructor
Corequisites: There are no corequisites for this course.
A fundamental course on understanding important electronic systems as they pertain to chemical signals and instrumentation. Topics include analog systems (RC circuits, diodes, transistors, and operational amplifiers), digital systems (logic gates, shift registers, and lock-in amplifiers), and signal enhancement and noise reduction modules. The laboratory component will showcase basic circuit design and construction, and will culminate with a student-built chemical instrument. For graduate credit there will be an additional project beyond the requirements for CHEM420. A student may not take both CHEM420 and CHEM520 for credit.

CHEM 530 Advanced Biochemistry 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CHEM 330
Corequisites: There are no corequisites for this course.
An in-depth exploration of selected topics from the current biochemistry scientific literature, including molecular mechanisms of infectious diseases and genetic disorders, methods for rational drug design, and relationships between structure and function for biological molecules. Students enrolled in CHEM 530 must complete a project not covered in CHEM 430. A student may not receive credit for both CHEM 430 and CHEM 530.

CHEM 531 Biochemical Instrumentation 3R-4L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: BIO 210, and CHEM 330
Corequisites: There are no corequisites for this course.
This project-based course includes approaches for the analysis of biochemical experimental problems, experimental design for molecular biology and biochemistry, and the theoretical basis and practical aspects of operating instruments used in biochemical research.

CHEM 532 Biochemical Pharmacology 4R-0L-4C See Dept

Graduate Studies Eligible: Yes
Prerequisites: CHEM 330
Corequisites: There are no corequisites for this course.
Topics include medicinal chemistry and molecular pharmacology. The topics will also include a survey of potential drug targets, the molecular interactions between drugs and their targets, the drug discovery and development process and case studies of drugs treating diseases such as cancer, bacterial and viral infection, and neurological disorders.

CHEM 534 Biochemical Physiology 4R-0L-4C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 330
Corequisites: There are no corequisites for this course.
An application of the principles of biochemistry to understanding the chemical aspects of the functioning of living organisms. This course covers topics related to the molecular mechanisms involved in the maintenance of physiological homeostasis, and when appropriate examines current research in the relevant systems. These mechanisms will be organized by the chemical signaling systems responsible for integrating and communicating the response to internal changes and external stimuli.

CHEM 535 Toxicology for Chemists 4R-0L-4C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 251
Corequisites: There are no corequisites for this course.
A fundamental course on the interaction of chemical agents with the human body. Topics include toxic thresholds and dose-response relationships, toxicological mechanisms of action, and models for physical and aquatic toxicities. Students engage in quantitative structure-activity relationship (QSAR) modeling and hazard assessment.

CHEM 545 Organometallic Chemistry 4R-0L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 115, and CHEM 252
Corequisites: There are no corequisites for this course.
A survey of the chemistry of main group organometallic compounds and organo-transition metal complexes. Reaction mechanisms and uses in organic synthesis and catalysis are studied.

CHEM 552 Synthetic Organic Chemistry 4R-0L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 253
Corequisites: There are no corequisites for this course.
A survey of contemporary methodology in organic synthesis. Retrosynthetic analysis, functional group transformations, condensation chemistry, and organometallic reagents will be stressed. Includes computer assisted synthesis.

CHEM 554 Theoretical Organic Chemistry 4R-0L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 253, and CHEM 361 or CHEM 360 or permission of instructor
Corequisites: There are no corequisites for this course.
Study of physical and chemical methods used to investigate organic reaction mechanisms; the chemistry of carbenes; organic photochemistry.

CHEM 556 Green Chemistry 4R-0L-4C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: CHEM 252
Corequisites: There are no corequisites for this course.

Advanced topics in green chemistry including industrial applications, atom economy, safer solvent substitutions, alternatives assessment, green metrics (PMI, E-factor), and a brief introduction to chemical toxicology.

CHEM 561 Advanced Physical Chemistry 4R-0L-4C SeeDept

Graduate Studies Eligible: Yes

Prerequisites: CHEM 463, and CHEM 360 or CHEM 362

Corequisites: There are no corequisites for this course.

The course covers advanced topics in quantum mechanics, statistical thermodynamics, and kinetics.

CHEM 570 Special Topics in Chemistry (1-4)R-0L-(1-4)C See Dept

Graduate Studies Eligible: Yes

Prerequisites: permission of instructor

Corequisites: There are no corequisites for this course.

Studies in advanced topics of current chemical interest not addressed in other named courses. If cross-listed with CHEM470, students in CHEM570 will need to complete an additional project.

CHEM 581 Polymer Chemistry 3R-4L-4C See Dept

Graduate Studies Eligible: Yes

Prerequisites: CHEM 252 Junior class standing

Corequisites: There are no corequisites for this course.

Polymer synthesis, reactions, and characterization techniques. Structure/property relationships and morphology will be discussed, both for industrially relevant polymers as current topics of from the recent literature. Laboratory sequence consists of polymer synthesis and characterization.

CHEM 582 Physical Properties of Polymeric Materials 4R-0L-4C See Dept

Graduate Studies Eligible: Yes

Prerequisites: CHEM 361 or CHEM 360

Corequisites: There are no corequisites for this course.

In this course the physical properties of polymeric systems will be defined in terms of the models that have been used to characterize them. The behavior of isolated polymers and polymers in solution will be mapped to macroscopic properties of bulk polymeric systems using theories such as Rotational Isomeric State and Flory's Lattice model. Methods of molecular weight determination will be fully developed. Phase transitions will be characterized and related to polymeric and monomeric structural features. Theories of elasticity and viscoelastic behavior will be used to explain macroscopic behaviors of polymeric materials.

CHEM 595 Chemistry Seminar 0R-0L-0C F

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Chemistry graduate students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 596 Chemistry Seminar 0R-0L-0C W

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Chemistry graduate students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 597 Chemistry Seminar 0R-0L-0C S
Graduate Studies Eligible: Yes
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Chemistry graduate students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.
CHEM 599 Thesis Research As assigned F, W, S
Graduate Studies Eligible: Yes
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Graduate students only. Credits as assigned; however, not more than 12 credits will be applied toward the requirements of the M.S. degree.
CHEM 699 Professional Experience 1R-0L-1C See Dept
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The work experiences should be informative or integral to the advancement or completion of the student's program requirements. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

Civil Engineering - Course Descriptions

CE 101 Engineering Surveying 0R-6L-2C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Covers basic principles and practices of surveying. Measurement through the application of surveying techniques; theory of errors and their analysis; concepts of horizontal, vertical, and angular measurement; coordinate systems; basic surveying operations and computations; reading and interpretation of building, highway, and/or bridge plans; traverse computations; applications to construction and design.
CE 111 Geographical Information Systems 2R-0L-2C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The course covers introductory concepts of geographical information systems and related technologies. Topics covered will relate to the use, collection, creation, and analysis of spatial data in applying GIS and related technologies to civil engineering projects.
CE 199 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of

their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as “S” satisfactory, or “U” unsatisfactory based on the written report of the professional experience.

CE 205 Thermodynamics 4R-0L-4C F

Graduate Studies Eligible: No

Prerequisites: MA 112

Corequisites: There are no corequisites for this course.

Covers first law of thermodynamics, second law of thermodynamics, concept of entropy, simple process analysis, properties of pure substances, equations of state, and state diagrams. Stresses use of property tables and charts and application of the first and the second laws to open and closed systems undergoing changes.

CE 250 Sustainable Civil Engineering Design 2R-0L-2C W

Graduate Studies Eligible: No

Prerequisites: EM 103

Corequisites: There are no corequisites for this course.

An introduction to sustainable design of civil engineering systems. Includes treatment of current issues as they relate to design and construction for economic, environmental and social aspects of civil engineering.

CE 303 Engineering Economy 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Emphasizes time value of money and factors related thereto. Familiarizes students with concepts of annual cost, present worth, and minimum rate of return as tools for consideration of economic factors pertinent to the selection of alternate solutions to engineering problems.

CE 310 Computer Applications in Civil Engineering 2R-0L-2C S

Graduate Studies Eligible: No

Prerequisites: EM 202, and EM 203

Corequisites: There are no corequisites for this course.

Students develop solutions to a variety of civil engineering problems using application programs such as Mathcad and Excel. Emphasis is made on problem solving approach and structured programming with software tools useful to civil engineering computation and design.

CE 320 Civil Engineering Materials 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

A study of the origin, nature, performance and selection criteria of various basic materials used in the practice of civil engineering. These include aggregates, portland cement, concrete, and bituminous materials. Emphasis will be placed on standard methods of testing and characterization as related to the mechanical behavior of materials.

CE 321 Structural Mechanics I 4R-0L-4C F

Graduate Studies Eligible: No

Prerequisites: EM 203

Corequisites: There are no corequisites for this course.

Classical structural analysis. Idealizations, stability, reactions and internal forces, influence lines, approximate analysis, and displacements.

CE 336 Soil Mechanics 3R-3L-4C F

Graduate Studies Eligible: No
Prerequisites: EM 203, and EM 301
Corequisites: There are no corequisites for this course.
Introduces the student to the fundamental concepts of soil mechanics. Covers types and properties of soils, lateral and vertical pressures, settlement and consolidation, strength and seepage studies. Includes laboratory investigation of soil properties.

CE 371 Hydraulic Engineering 3R-3L-4C F
Graduate Studies Eligible: No
Prerequisites: EM 301 or CHE 301 or ES 212
Corequisites: There are no corequisites for this course.
Application of basic fluid mechanics principles to the fields of hydraulics and water resources. Topics covered include: open channel flow, closed conduit flow, flow measurement, and turbomachinery. Stresses practical applications in the laboratory.

CE 380 Introduction to Transportation Engineering 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: CE 101
Corequisites: There are no corequisites for this course.
Study of transportation functions and transportation systems; measuring and estimating demand; characteristics of transportation modes, interactions between modes, and mode interfaces; social, environmental, technological, economic, and public policy impacts; techniques of transportation system planning, design, and operation, with an emphasis on highway geometric design.

CE 400 Career Preparation Seminar 1R-0L-0C S
Graduate Studies Eligible: No
Prerequisites: CE 488
Corequisites: There are no corequisites for this course.
Preparation for the student to become a practicing engineer. Topics include Civil Engineering job expectations, continuing education, legal considerations, professionalism, consumer topics, and financial considerations.

CE 421 Structural Mechanics II 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: CE 321
Corequisites: There are no corequisites for this course.
Hand methods for structural analysis of indeterminate structures: approximating drift of frames and solid walls, force method, moment distribution method, distribution of shear when there is a rigid diaphragm, and in-plane diaphragm forces.

CE 431 Structural Design in Steel I 3R-0L-3C S
Graduate Studies Eligible: No
Prerequisites: CE 321
Corequisites: There are no corequisites for this course.
Covers the analysis and design of the basic elements of a steel structure using Load and Resistance Factor Design specifications. Includes tension and compression members, beams, beam-columns and connections.

CE 432 Structural Design in Concrete I 3R-0L-3C W
Graduate Studies Eligible: No
Prerequisites: CE 321
Corequisites: There are no corequisites for this course.
Deals with the analysis and design of reinforced concrete beams, floor slabs, and columns using the Ultimate Strength Design procedure.

CE 436 Foundation Engineering 4R-0L-4C F

Graduate Studies Eligible: Yes
Prerequisites: CE 336, and CE 432
Corequisites: There are no corequisites for this course.
Covers the application of soil mechanics principles to foundation problems. Includes design of building foundations and retaining walls, stability analysis of open cuts and slopes, dewatering methods, and a study of the influence of local geology.

CE 441 Construction Engineering 2R-0L-2C W
Graduate Studies Eligible: No
Prerequisites: Junior class standing or consent of instructor
Corequisites: There are no corequisites for this course.
Covers planning and scheduling techniques for construction engineering: Gantt charts, critical path method, precedence diagramming method, activity on arrow and PERT methods, resource allocation, and time-cost tradeoffs.

CE 442 Cost Engineering 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: Senior class standing
Corequisites: There are no corequisites for this course.
An investigation of some of the cost accounting, cost management and estimating techniques which are used in the construction industry. Various types of estimates will be considered, as will their multiple applications for project management. Special attention will be given to the preparation of detailed estimates based on quantity take-offs and to analyses of production productivity.

CE 445 Construction Methods & Equipment 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: Senior class standing or consent of instructor
Corequisites: There are no corequisites for this course.
A study of economics, fundamental concepts and functional applications of major categories of construction equipment. Operational characteristics, capability and applicability of equipment to heavy, highway and major building construction projects.

CE 450 Civil Engineering Codes & Regulations 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: CE 486
Codes and regulations provide a baseline of expectation for civil engineering practice, and in turn, engineers influence the codes and regulations to create new best practices. This course examines how civil engineers interact with public policy and the legal system to work within CE codes and regulations. This course also includes discussion around the ASCE Code of Ethics and how it relates to the need for community engagement, professional norms, and professional best practices that impact engineering practice.

CE 460 Introduction to Environmental Engineering 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: EM 301 or CHE 301 or ES 212
Corequisites: There are no corequisites for this course.
Introduction to water pollution control, air pollution control, and solid and hazardous waste management. Topics include water treatment, wastewater treatment, impacts of pollutants on lakes and streams, and stream and air quality modeling.

CE 461 Environmental Engineering laboratory 1R-3L-2C S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.

Corequisites: CE 460
Emphasizes laboratory methods and interpretation of laboratory results for chemical analysis of water and wastewater.

CE 471 Water Resources Engineering 4R-0L-4C W
Graduate Studies Eligible: No
Prerequisites: EM 301 or CHE 301 or ES 212
Corequisites: There are no corequisites for this course.
Presents an overview of the engineering, planning, design, and operation of various water resources projects. Topics include surface and groundwater hydrology, sanitary and storm sewer design, dams and reservoirs, water law, wetlands, and nonpoint source pollution.

CE 480 Geometric Design of Highways and Streets 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: CE 380
Corequisites: There are no corequisites for this course.
Highway planning and design with evaluation of multiple alignment alternatives; geometric design of highways: horizontal and vertical alignment, cross-sectional design; intersection design; earthwork measurements and quantities; reverse curve design; legal aspects of transportation engineering; proper use of the American Association of State Highway and Transportation Officials (AASHTO) design guidelines.

CE 481 Traffic Analysis & Design 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: CE 380
Corequisites: There are no corequisites for this course.
Study of fundamentals of traffic engineering; components of the traffic system; intersection types and design elements; basic variables of the traffic system (flow, capacity, level of service, delay); design and analysis of traffic signals and intersections; traffic control and traffic impact analysis; safety performance and traffic crash analysis; use of the Highway Capacity Manual and traffic analysis software.

CE 483 Railroad Engineering 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: Junior standing or consent of instructor
Corequisites: There are no corequisites for this course.
Provides an overview of rail transportation: history, organizations, economics, safety, freight operations, track-train dynamics, signals and communications, motive power and equipment, track components, construction and maintenance. The basic objective of the course is to gain an understanding of railroads as a transportation industry that merges a number of engineering fields as well as other disciplines that contribute to the success of a complex, growth- oriented industry.

CE 486 Civil Engineering Design & Synthesis I 1R-3L-2C F
Graduate Studies Eligible: No
Prerequisites: ENGL H290 and at least six from the following nine courses: CE 321, CE 336, CE 371, CE 380, CE 431, CE 432, CE 441, CE 460, CE 471
Corequisites: CE 450
Civil engineering projects submitted by corporate and governmental sponsors will be initiated by small teams of students to implement principles used in planning, design, and synthesis. Learning objectives include contracting, concept development, concept feasibility, planning and scheduling design work, data collection for subsequent design.

CE 487 Technical System Design & Synthesis 2R-2L-2C W
Graduate Studies Eligible: No

Prerequisites: CE 486
Corequisites: CE 488
Technical system design of subdisciplinary elements of civil engineering projects submitted by corporate and governmental sponsors will be completed by individual team members to fulfill the needs of a team project initiated with CE486 and continuing in CE488. The “x” will be used to identify subdiscipline designation (c = general civil design, e= environmental, g = geotechnical, s = structural, t = transportation, w = water resources).

CE 488 Civil Engineering Design & Synthesis II 1R-2L- 2C W
Graduate Studies Eligible: No
Prerequisites: CE 486
Corequisites: CE 487
Project management by small teams for civil engineering projects submitted by corporate and governmental sponsors will continue. Learning objectives include coordinate of major design work in subdisciplines, progress reporting to the client, critical path model management to keep the project on schedule to fulfill the needs of a team project initiated with CE486 and continuing in CE487.

CE 489 Civil Engineering Design & Synthesis III 1R-3L-2C S
Graduate Studies Eligible: No
Prerequisites: CE 487, and CE 488
Corequisites: There are no corequisites for this course.
Civil engineering projects submitted by corporate and governmental sponsors will be completed. Final recommendations and engineering designs will be presented to the sponsors with due attention to the social, economic, and environmental constraints of the project. Learning objectives include construction planning and cost, final reporting, and public presentation of findings.

CE 490 Directed Studies CE 490 Directed Studies 1-4C Arranged F,W,S
Graduate Studies Eligible: No
Prerequisites: Approval of department head, adviser, and course instructor
Corequisites: There are no corequisites for this course.
Provides the opportunity for the civil engineering students to do a selected project of mutual interest to them and a faculty member or make up for deficiencies in transfer credit hours and topics. Credit is assigned up to 4 credits per term with a maximum of 8 credits toward graduation.

CE 510 Environmental Engineering Externship 0R-12L-4C See Dept
Graduate Studies Eligible: Yes
Prerequisites: Grad or consent of instructor
Corequisites: There are no corequisites for this course.
Environmental engineering externship approved by the department.

CE 520 Structural Engineering Externship 0R-12L-4C
Graduate Studies Eligible: Yes
Prerequisites: Grad or consent of instructor
Corequisites: There are no corequisites for this course.
Structural engineering externship approved by the department.

CE 521 Matrix Methods for Structural Analysis 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: CE 321
Corequisites: There are no corequisites for this course.

Derivation of the direct stiffness method for truss and frame elements. Derivation of the finite element method for 2D plate elements. Requires development of computer programs to implement the direct stiffness method.

CE 522 Structural Dynamics 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: Grad or consent of instructor

Corequisites: CE 521

Analysis and behavior of structural members and systems subject to dynamic loads including basic theory for single-degree-of-freedom and multi-degree-of-freedom analytical models of civil engineering structures; seismic hazard analysis and methods of analysis for seismic loads; response spectra; time history; and linear and nonlinear methods.

CE 523 Advanced Solid Mechanics 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: Grad or consent of instructor

Corequisites: There are no corequisites for this course.

The fundamentals of elasticity are introduced and related to various problems such as beams on elastic foundations, unsymmetrical bending, torsion of thin walled members, and curved beams. Introduction to the analysis and modeling techniques for existing and repaired structures. Design of retrofit measures for a variety of structures using advanced composite materials.

CE 524 Building Design 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: CE 421* *Graduate standing, or consent of instructor and CE 421

Corequisites: There are no corequisites for this course.

Advanced structural analysis and design concepts for buildings: material nonlinearity, plastic design, pushover analysis, bracing, floor vibrations. Course culminates in a design project.

CE 525 Bridge Engineering 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: CE 421, and CE 431, and CE 432

Corequisites: There are no corequisites for this course.

Deals with the various types of bridge structures, the materials of which they are constructed and the manner in which loads are transmitted to the foundation. Introduces concepts of bridge engineering by providing the students with the necessary knowledge and skills to apply the AASHTO LRFD specifications for the analysis and design of highway and bridge superstructure components.

CE 532 Structural Design in Concrete II 3R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: CE 432

Corequisites: There are no corequisites for this course.

Advanced topics in reinforced concrete analysis and design such as serviceability. slender columns, two-way slabs, and strut-and-tie modeling.

CE 533 Connections & Detailing 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: CE 431, and CE 432

Corequisites: There are no corequisites for this course.

Analysis and design of structural systems with emphasis on detailing requirements; behavior of bolted and welded connections, including gusset plates, moment-resistant

connections, and simple connections; design and analysis of base plate and anchoring systems; and an introduction to seismic detailing requirements.

CE 535 Structural Design in Prestressed Concrete 4R-0L-4C F

Graduate Studies Eligible: Yes

Prerequisites: CE 432

Corequisites: There are no corequisites for this course.

Analysis and design of prestressed concrete stru ctures. Beams, slabs, loss of prestress, deflections, precast construction.

CE 537 Retaining Structure Design 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: CE 336, and CE 432

Corequisites: There are no corequisites for this course.

Covers the determination of earth pressures, selection of appropriate retaining wall types, and design of commonly used retaining structures. Includes both external (geotechnical) and internal (structural) analysis.

CE 562 Advanced Wastewater Treatment 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: CE 460

Corequisites: There are no corequisites for this course.

Covers the theory, design and analysis of biological processes for the treatment of wastewater. Treatment processes include suspended and attached growth processes, aerobic and anaerobic processes, biological nutrient removal, aeration and gas transfer, and biosolids processing.

CE 563 Advanced Water Treatment 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: CE 460

Corequisites: There are no corequisites for this course.

Covers the theory, design and analysis of physical and chemical processes for the treatment of drinking water. Treatment processes include coagulation and flocculation, gravity separation, granular and membrane filtration, disinfection, air stripping, adsorption, ion exchange, and disinfection.

CE 564 Aquatic Environmental Chemistry 4R-0L-4C F

Graduate Studies Eligible: Yes

Prerequisites: Senior or Graduate student standing

Corequisites: There are no corequisites for this course.

Emphasis equilibrium relationships of importance in understanding both natural waters and wastewaters. The carbonate system and the concept of pH as a master variable are stressed.

CE 565 Solid & Hazardous Waste Regulation & Treatment 4R-0L-4C On Demand

Graduate Studies Eligible: Yes

Prerequisites: CE 460

Corequisites: There are no corequisites for this course.

Covers solid and hazardous waste management, including characterization, collection system design, waste minimization, design of landfills and incinerators, and remediation principles.

CE 567 Applied Hydrologic Modeling 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: CE 471

Corequisites: There are no corequisites for this course.

Watershed planning and stormwater management strategies are examined using computer simulation models. With an emphasis on conceptual foundation, students will be introduced to some of the most widely used models in the fields of hydrology and stormwater quantity management. Topics examined include watershed loss, transform, and routing methods, as well as model configuration, calibration, and evaluation.

CE 568 Surface Water Quality Modeling 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: CE 460 or consent of instructor

Corequisites: There are no corequisites for this course.

Covers the mathematical analysis of transport and fate of pollutants in natural surface waters and their impact on water quality using analytical and numerical models. Includes one- and two-dimensional steady-state and transient models. Pollutants examined include oxygen-demanding organics, nutrients and toxic compounds.

CE 570 Modeling Open Channel Hydraulics 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: CE 371

Corequisites: There are no corequisites for this course.

Presents steady and unsteady flow problems in open channels and pipes, dealing with mechanics of flow over rigid and mobile boundaries. Covers analysis of river dynamics and hydraulic principles in stormwater conveyance through numerical and computer modeling.

CE 571 Environmental River Mechanics 3R-3L-4C S

Graduate Studies Eligible: Yes

Prerequisites: CE 371

Corequisites: There are no corequisites for this course.

Concepts of fluvial geomorphology and fluvial hydraulics are examined, including natural stream flow, sediment transport, and ecological processes in alluvial rivers. Students will apply these principles to solve common design problems of channel instability and rehabilitation of impaired streams. Students will visit local streams to perform field data collection of channel geometry, bed and bank material, and water quality.

CE 573 Groundwater Analysis 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: CE 471

Corequisites: There are no corequisites for this course.

Covers hydrodynamics of flow through porous media. The primary emphasis is on the analysis of steady and unsteady flow in confined and unconfined aquifers. Groundwater modeling is introduced.

CE 589 Environmental Engineering Design & Synthesis 4R-12L-8C F,W,S

Graduate Studies Eligible: Yes

Prerequisites: Graduate Standing

Corequisites: There are no corequisites for this course.

Environmental engineering projects submitted by external sponsors are undertaken by small teams of students to develop advanced principles used in planning, design, and synthesis. Final recommendations and engineering designs are presented to the sponsors with due attention to the social, economic, and ethical constraints of the project. Each student team also prepares a manuscript of the completed project that is suitable for publication n a peer-reviewed professional journal. The final report to the sponsor and the manuscript prepared by the team must be approved by the team's

graduate committee comprised of at a minimum, the course instructor, a faculty mentor from the CE department, and a faculty external to the CE department.

CE 590 Special Problems 2/4R-0L-2/4C F,W,S
Graduate Studies Eligible: Yes
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Special problems or reading by special arrangement with the faculty.

CE 597 Special Projects in Civil Engineering Variable Credit F,W,S
Graduate Studies Eligible: Yes
Prerequisites: Permission of instructor
Corequisites: There are no corequisites for this course.
A special project, or series of problems, or research problem is assigned to or selected by the student. A comprehensive report must be submitted at the conclusion of the project. Not to be used as a substitute for CE 599, Thesis Research. Variable credit. May be repeated up to a maximum of eight credits.

CE 598 Special Topics in Civil Engineering Variable Credit
Graduate Studies Eligible: Yes
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Studies in advanced topics of current interest.

CE 599 Thesis Research As assigned F,W,S
Graduate Studies Eligible: Yes
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Graduate students only. Credits as assigned; however, not more than 12 credits will be applied toward the requirements of the M.S. degree.

CE 699 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The work experiences should be informative or integral to the advancement or completion of the student's program requirements. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

College and Life Skills - Course Descriptions

RHIT 100 Foundations for Rose-Hulman Success 1R-0L-1C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The purpose of RHIT100 is to learn about services and resources available on campus and help students to successfully transition to college – laying the foundation for their college career. In RHIT100, the focus of the course is you, and you will be challenged to reflect on and analyze your own learning strategies, study skills, and other professional skills that will help you succeed in and out of the classroom.

COMPUTER ENGINEERING - COURSE DESCRIPTIONS

ECE 160 Engineering Practice 0R-4L-2C F,W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
An introduction to electrical and computer engineering, systems engineering design, programming, microcontrollers, soldering and circuit building. Students will work individually and on teams to complete projects and create a system for an end of term competition. Students will also learn about technical documentation and communication. Topics include functions, arrays, conditionals, loops, Boolean algebra, wireless communication, resistors, transistors, diodes motors, sensor, analog and digital inputs and outputs.

ECE 180 Introduction to Signal Processing 3R-3L-4C F,W,S
Prerequisites: MA 112, and ECE 160 or CSSE 120 or ENGD 120 or ME 123 or prior programming experience
Corequisites: There are no corequisites for this course.
An introduction to discrete-time signal processing applied to audio, images, and video. Topics include phasor representation of sinusoidal signals, complex arithmetic, sampling, signal spectra, linear time-invariant systems, frequency response, convolution, filter implementation, and MATLAB programming. Integral laboratory.

ECE 199 Professional Experience 1R-0L-1C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

ECE 203 DC Circuits 3R-3L-4C S, F
Prerequisites: MA 111, and PH 112
Corequisites: There are no corequisites for this course.
A review of the definition of voltage, current, energy and power. An introduction to Ohm's Law, ideal DC independent and dependent voltage and current sources, resistors, inductors, capacitors, and operational amplifiers. Circuit analysis and simplification by using series, parallel, and Wye-Delta reduction, Kirchhoff's laws, mesh and nodal analysis, Thevenin, Norton and Maximum Power Theorems, superposition, and source transformations. An integral laboratory to build electric circuits and measure voltage, current, resistance and power.

ECE 204 AC Circuits 3R-3L-4C F,W
Prerequisites: PH 113*, and either ECE 203** or ENGD 120** or BE 131**, or both ES 213**, and ES 213L** *Prerequisite or concurrent registration **with a grade of C or better
Corequisites: There are no corequisites for this course.
Capacitance, Self and Mutual Inductance. Root-mean-square values of waveforms. Application of phasors to sinusoidal steady-state. Impedance of circuit elements. Mesh and Nodal Analysis applied to ac circuits. Thevenin and Norton theorems applied to ac circuits. Single-phase ac power. Power factor correction. Voltage regulation and efficiency of feeders. Balanced three-phase systems. Ideal and non-ideal transformer models. Integral laboratory.

ECE 205 Circuits & Systems 3R-3L-4C W,S
Prerequisites: ECE 180 or BE 321, and HUM H190, and MA 222, and either ECE 203* or ENGD 120*, or both ES 213*, and ES 213L* *with a grade of C or better; ** or concurrent registration
Corequisites: There are no corequisites for this course.
Introduction to 1st and 2nd order circuits and review of differential equations. Bode plots. System classification, impulse and step response, convolution. Laplace and inverse Laplace transforms, block and signal flow diagrams. Benefits of feedback. Modeling and simulating electrical systems. Matlab and Simulink. Integral laboratory.

ECE 206 Elements of Electrical Engineering 4R-0L-4C W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
A course designed for engineers (other than electrical or computer) covering analysis of passive circuits, introduction to op-amps, instrumentation, sinusoidal steady-state, a-c power, and induction motors. EE and CPE majors may not take this course.

ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S
Prerequisites: ECE 233, CSSE 120, and ECE 160
Corequisites: There are no corequisites for this course.
Sensors and actuators. Input and output devices. Microcontroller architecture. Standard communications protocols. Interrupt generation and processing. Data representation and storage. Memory management. The C programming language and programming styles. Integral laboratory and a term project.

ECE 233 Introduction to Digital Systems 3R-3L-4C F, W, S
Prerequisites: CSSE 120 or ECE 160 or ENGD 120
Corequisites: There are no corequisites for this course.
Number systems, Binary arithmetic, logic gates, forming logic circuits. Boolean algebra, Karnaugh maps. Propagation delay, hazards, common Combinational logic circuits, structures, and design. Contraction, latches, flip-flops, finite state machines, counters, Sequential circuit timing, and designing Sequential circuits. Register design, control and datapath design. Basic computer architecture, including memory. Integral laboratory.

ECE 250 Electronic Device Modeling 3R-3L-4C S,F
Prerequisites: ECE 204 or ECE 205, ES 203* or ES 213*, and ES 213L* * with grade of B or better
Corequisites: There are no corequisites for this course.
Modeling, analysis, and simulation of electronic circuits that contain two-terminal and threeterminal semiconductor devices. Large-signal, biasing, and small-signal analysis models. Introduction to wave shaping circuits, switching circuits, and amplifiers. Integral laboratory.

ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F, S
Prerequisites: ECE 205, and MA 222, and MA 381* *Prerequisite or concurrent registration
Corequisites: There are no corequisites for this course.
Signal modeling. Fourier series and Fourier transforms. Response of systems to periodic and aperiodic signals. Filter characterization and design. Ideal and practical sampling. Use of numerical analysis software. Integral laboratory

ECE 310 Communication Systems 3R-3L-4C W, S
Prerequisites: ECE 380
Corequisites: There are no corequisites for this course.

Transmission of information over bandlimited, noisy communication channels. Line codes, probability of error, intersymbol interference. Modulation techniques, synchronization and frequency conversion. Integral laboratory.

ECE 312 Communication Networks 4R-0L-4C F, W

Prerequisites: MA 381, and CSSE 120

Corequisites: There are no corequisites for this course.

Layered architectures. Circuit and packet switching. The ISO Reference Model. Point-to-point protocols, error control, framing. Accessing shared media, local area networks. Virtual circuits, datagrams, routing, congestion control. Queuing theory. Reliable message transport, internetworking.

ECE 320 Linear Control Systems 3R-3L-4C W,S

Prerequisites: ECE 300*, and ECE 230* or ME 430*

Corequisites: There are no corequisites for this course.

Analysis of linear control systems using classical and modern control theories in both continuous and discrete time. Plant representation, closed loop system representation, time response, frequency response, concept of stability. Root locus, Bode, and Nyquist methods. Computer modeling and simulation of feedback systems, implementation of discrete-time algorithims on microcontrollers.

Prerequisite Notes:
ECE300 and either ECE230 or ME430

ECE 332 Computer Architecture II 4R-0L-4C W, S

Prerequisites: CSSE 232

Corequisites: There are no corequisites for this course.

Instruction-Level Parallelism. Pipelining. Data Hazards. Exceptions. Branch Prediction. Multilength Instructions. Loop Unrolling. TI C6000 Digital Signal Processor. Cache. Memory. MSP430 Microcontroller. PIC Microcontroller. Intel Itanium. Multiprocessors. Hardware Multithreading. Graphics Processors. Supercomputers.

ECE 340 Electromagnetic Fields 4R-0L-4C F,W

Prerequisites: ECE 204 , and MA 222

Corequisites: There are no corequisites for this course.

Static and dynamic fields. Electric and magnetic properties of materials. Energy, force and power. Resistors, capacitors, and inductors. Application in sensing and actuation. Maxwell's equations. Introduction to electromagnetic waves. Use of vector calculus and numeric approximation. Technical reports and/or term papers.

ECE 341 Electromagnetic Waves 4R-0L-4C W,S

Prerequisites: ECE 340

Corequisites: There are no corequisites for this course.

Wave propagation and reflection. Power and lossy materials. Quasistatic analysis. Steady-state and transient analysis of transmission lines. Application in high-speed systems. Introduction to antennas. Technical reports and/or term papers.

ECE 342 Introduction to Electromagnetic Compatibility 3R-3L-4C F,S

Prerequisites: ECE 300 and Computer Engineering Major

Corequisites: There are no corequisites for this course.

Electromagnetic compatibility (EMC) regulations and measurement. Frequency behavior of passive components. Electromagnetic fields and waves. Transient behavior of transmission lines. Dipole and monopole antennas. Four coupling mechanisms: electrical and magnetic fields, common impedance, and electromagnetic wave. Conducted emissions. Radiated emissions. Electromagnetic shielding and grounding.

ECE 343 High-Speed Digital Design 3R-3L-4C W,S
Prerequisites: ECE 300 and Computer Engineering Major
Corequisites: There are no corequisites for this course.
Signal path modeling through connecting lengths of transmission lines with lumped element models of discontinuities. Circuit parameters from geometries and material properties for resistance, capacitance, inductance and transmission line segments. Lossless and lossy transmission line circuit modeling. High-frequency and high-speed behavior of passive components. Frequency spectrum of digital signals. Digital device driver and receiver modeling. Transmission line impedance discontinuity and termination techniques. Electric and magnetic field coupling mechanisms for capacitive and inductive crosstalk. Ground noise, power plane noise and resonance. Signal and power integrity issues in high-speed digital systems at both the printed-circuit board and chip levels.

ECE 351 Analog Electronics 3R-3L-4C F,W
Prerequisites: ECE 205, and ECE 250
Corequisites: There are no corequisites for this course.
Amplifier design and analysis including discrete and integrated circuit topologies. Cascaded amplifier, input and output stages, frequency response. Linear and non-linear op-amp circuits. Introduction to the non-ideal properties of op-amps. Integral laboratory.

ECE 362 Principles of Design 3R-0L-3C W,S
Prerequisites: ECE 204 , and ECE 205, ECE 230, and ECE 233, and ECE 250, and ECE 300
Corequisites: There are no corequisites for this course.
A formal design course that emphasizes the design process. Project management, project reporting and decision-making are learned by student teams as they carry a project through several stages of a formal design process.

ECE 370 Electric Machinery 3R-3L-4C W,S
Prerequisites: ECE 204
Corequisites: There are no corequisites for this course.
An introduction to electric machinery fundamentals. Operating principles and detailed analysis of single-phase and three-phase transformers, power electronics in the context of generators and motors, synchronous generators and motors, induction motors and generators, and dc motors and generators. Integral laboratory.

ECE 371 Conventional & Renewable Energy Systems 3R-3L-4C W
Prerequisites: ECE 204
Corequisites: There are no corequisites for this course.
Conventional and modern sources of energy for power generation in electric power industry with the imposed economic, regulatory, and environmental constraints. Wind, solar-photovoltaic, micro-hydropower, biomass, and fuel cell systems. Integral laboratory.

ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W
Prerequisites: ECE 300, and MA 381
Corequisites: There are no corequisites for this course.
System properties: linearity and time-invariance. Sampling and reconstruction. Convolution in discrete-time systems. Z-transform, FIR and IIR filters. Discrete-time filter design. Discrete Fourier transform. Random Variables and Random Processes.

ECE 398 Undergraduate Projects 1-4C
Prerequisites: Arranged Prereq: Consent of instructor
Corequisites: There are no corequisites for this course.
Special design or research projects.

ECE 412 Software Defined Radio 4R-0L-4C See Dept Advising Site
Prerequisites: ECE 380
Corequisites: There are no corequisites for this course.
Essential concepts of wireless communications. Software defined radio (SDR) architecture. Analog and digital modulation formats. Transmitter and receiver system design and implementation methods. Synchronization techniques. Term project.

ECE 414 Wireless Systems 4R-0L-4C W
Prerequisites: ECE 310
Corequisites: There are no corequisites for this course.
Introduction to wireless communications and networks. Wireless channel models, vector space, modulation and demodulation, optimal receiver design, equalization, channel capacity, multipleaccess techniques, spread spectrum, and multiple-antenna systems. Additional recommended prerequisite: MA371 or MA373 with a grade of B or higher.

ECE 415 Wireless Electronics 2R-6L-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Design, fabrication, and testing of a high frequency transmitter-receiver system including but not limited to oscillators, mixers, filters, amplifiers, and matching networks. Integral laboratory.

ECE 416 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with CHE 405, EP 410, and ME 416.

ECE 418 Fiber Optic Systems 4R-0L-4C S
Prerequisites: ECE 310 Consent of instructor
Corequisites: There are no corequisites for this course.
Analysis and design of common photonic systems such as fiber optic communication links, optical sensing systems, and optical networks. Topics include basic architectures, component overview, system design, and expected degradations along with mitigation techniques. An oral presentation of a technical paper is required.

ECE 419 Advanced MEMS: Modeling and Packaging 3R-3L-4C F
Prerequisites: EP 410 or equivalent course
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with EP 411, and CHE 419.

ECE 420 Discrete-Time Control Systems 4R-0L-4C See Dept Advising Site
Prerequisites: ECE 320
Corequisites: There are no corequisites for this course.
Sampled systems and z-transforms. Transfer function and state-variable models of systems. Discrete-time control of systems including state variable feedback and observer construction.

ECE 425 Introduction to Mobile Robotics 3R-3L-4C W
Prerequisites: CSSE 120, and ECE 320 or ME 406 or BE 350 or CHE 340

Corequisites: There are no corequisites for this course.
This course will introduce the basic principles of mobile robotics history, theory, hardware and control. Topics will include robot components, effectors and actuators, locomotion, sensors, feedback control, control architectures, representation, localization and navigation. This is a project-oriented course and the student will have hands-on experience with a real mobile robot. The student will be required to complete several laboratory assignments and a multidisciplinary team design project.

ECE 430 Microcontroller-Based Systems 3R-3L-4C F

Prerequisites: ECE 250* *For ECE students, consent of instructor for other students.
Corequisites: There are no corequisites for this course.
Microcontroller register set, addressing modes and instruction set. Microcontroller peripheral support modules. Assembly language and C programming. Fundamental data structures. Interrupts. Real time programming. Data communications. Microcontroller interface to displays, digital and analog devices, sensors, and actuators. Embedded system design, implementation and applications. Integrated development environment. Formal final report and oral presentation. Integral laboratory. Credit cannot be obtained for both ECE 331 and ECE 430.

ECE 433 Advanced Digital System Design with Verilog 3R-3L-4C F

Prerequisites: ECE 233
Corequisites: There are no corequisites for this course.
Concepts and designs of combinational and sequential digital systems; Modern design methodology; ASM and ASMD charts for behavioral modeling; Synthesizable Verilog descriptions and synthesis techniques; Design verification and functional simulations; FPGA implementations of digital systems; Timing analysis and constraints; Storage devices; Implementation options; I/O clocking techniques; Synchronous and asynchronous designs; Complex digital systems; IP core applications. Integrated Development Environment. Integral laboratory.

ECE 434 Embedded Linux 3R-3L-4C W

Prerequisites: CSSE 332 or ECE 230 with a grade of B or better; or graduate standing, Operating Systems and Linux experience.
Corequisites: There are no corequisites for this course.
Brief introduction to Linux on an embedded processor. Software development in various languages (C, shell scripts, Python, JavaScript, etc.). Hardware interfacing. Kernel development. Software tools (IDE, gcc, make, node.js, etc.)

ECE 436 Internet of Things 4R-0L-4C S

Prerequisites: ECE 230 or CSSE 132, and ECE 312 or CSSE 432 or consent of instructor
Corequisites: There are no corequisites for this course.
Introduction to the design and development of an Internet of Things (IoT) solution. Provides breadth of knowledge on a broad range of topics, such as sensors, communication, power, cloud storage, data analysis, automation, privacy and security. Focuses on a team design project to provide a complete IoT solution for a real-world application. This is a required course for the minor in Internet of Things for students earning a primary or secondary major in EE, CPE, CS, or SE. Students cannot earn credit for both MDS210 and ECE436.

ECE 452 Power Electronics 3R-3L-4C F

Prerequisites: ECE 250
Corequisites: There are no corequisites for this course.
Analysis and design of networks that use electronic devices as power switches. Silicon-controlled rectifiers, power transistors, power MOSFETS, and IGBTs are used to form

phase-controlled rectifiers, AC voltage controllers, choppers, and inverters. Integral laboratory.

ECE 454 System Level Analog Electronics 3R-3L-4C W

Prerequisites: ECE 351

Corequisites: There are no corequisites for this course.

Analysis and design of Op-Amp circuits: wave shaping circuits, Schmitt triggers, power amplifiers, high power buffers, controlled current sources, peak detectors, sample and hold circuits. Precision Op-Amp Circuits. Non-ideal properties of Op-Amps. Integral laboratory.

ECE 460 Engineering Design I 1R-6L-3C F

Prerequisites: ECE 362, and either ECE 230*, and ECE 310*, and ECE 320*, and ECE 341*, and ECE 351*, and ECE 370* or ECE 371*, and ECE 380* or CSSE 332**, and CSSE 230**, and ECE 250**, and ECE 230**, and ECE 312**, and ECE 332**, and ECE 343**, and either ECE 380** or ECE 320** *For EE: Prereq or concurrent registration in the remainder of course. **For CPE: Prereq or concurrent registration in the remainder of course.

Corequisites: There are no corequisites for this course.

A continuation of a sequence of formal design courses that emphasizes completion of a client-driven project using a formal design process. Student teams carry a project from inception to completion to satisfy the need of a client. Integral laboratory.

ECE 461 Engineering Design II 1R-9L-4C W

Prerequisites: ECE 460

Corequisites: There are no corequisites for this course.

Continuation of the design project from ECE460. Integral laboratory.

ECE 462 Engineering Design III 1R-3L-2C W,S

Prerequisites: ECE 461

Corequisites: There are no corequisites for this course.

Completion of the design project from ECE 460 and ECE 461. Integral laboratory.

ECE 470 Power Systems Analysis I 3R-3L-4C F

Prerequisites: ECE 370

Corequisites: There are no corequisites for this course.

Modeling of power system components that encompass transmission lines, power transformers, synchronous generators, and loads for power system representation and per unit analysis. Formulation of power system representation in the context of power flow analysis. The industry standard Siemens-PTI PSS/E software package will be used for solutions of the large-scale power flow. Economic dispatch by optimum allocation of generation, control of system voltage profile, and real and reactive power flow control by tap-changing transformers. Integral laboratory.

ECE 471 Power Systems Analysis II 4R-0L-4C W

Prerequisites: ECE 470

Corequisites: There are no corequisites for this course.

Modeling of power system components that encompass transmission lines, power transformers, synchronous generators for analysis of power systems during balanced and unbalanced faults/short-circuits with symmetrical components. The industry standard ASPEN One-Liner software package will be used for simulation of large-scale faulted systems. Power system grounding and its impact on fault levels. Power system stability and generator rotor dynamics phenomenon with use of equal-area criterion. Modern approaches to power system stability analysis are introduced. Integral laboratory.

ECE 472 Power Systems Protection 3R-3L-4C S

Prerequisites: ECE 470, and ECE 471
Corequisites: There are no corequisites for this course.
Design and application of relaying schemes for protection of transformers, buses, distribution lines, transmission lines, generators, motors, capacitors, and reactors. Integral laboratory.

ECE 473 Control of Power Systems 3R-3L-4C W
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
Principles of interconnected operation of power systems. Optimum scheduling of generation using economic dispatch and unit commitment. Primary and secondary load-frequency control. Voltage and reactive-power flow control. Principles of state estimation. Integral laboratory.

ECE 480 Introduction to Image Processing 3R-3L-4C W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Basic techniques of image processing. Discrete and continuous two dimensional transforms such as Fourier and Hotelling. Image enhancement through filtering and histogram modification. Image restoration through inverse filtering. Image segmentation including edge detection and thresholding. Introduction to image encoding. Relevant laboratory experiments.

ECE 481 Electronic Music Synthesis 4R-0L-4C S
Prerequisites: ECE 380
Corequisites: There are no corequisites for this course.
Analog synthesis techniques. Instrument control using MIDI. FM, additive and subtractive synthesis. Physical modeling and sound spatialization. Course project.

ECE 483 DSP System Design 3R-3L-4C F
Prerequisites: ECE 380, and MA 381
Corequisites: There are no corequisites for this course.
Study of finite word length effects in DSP systems. Cascaded filter structures. Coefficient quantization, roundoff noise, scaling for overflow prevention. Discrete-time noise, filtering noise, power spectral density. Polyphase filtering, interpolation and decimation. Implementation and system design and test issues for a SSB communication system. Integral laboratory based on a fixed point programming project.

ECE 497 Special Topics in Electrical Engineering 1-4C
Prerequisites: Arranged prerequisite consent of instructor and department head
Corequisites: There are no corequisites for this course.
Topics of current interest to undergraduate students.

ECE 498 Undergraduate Projects 1-4C
Prerequisites: Arranged prerequisite consent of instructor
Corequisites: There are no corequisites for this course.
Special design or research projects.

ECE 510 Error Correcting Codes 4R-0L-4C F (odd years)
Prerequisites: ECE 310* *Graduate standing or with a grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Coding for reliable digital communication. Topics to be chosen from: Hamming and BCH codes, Reed-Solomon codes, convolutional codes, Viterbi decoding, turbo codes, and recent developments, depending on interests of class and instructor. Mathematical background will be developed as needed.

ECE 511 Data Communications 4R-0L-4C F (even years)

Prerequisites: ECE 310*, and MA 381* or ECE 310**, and MA 381** *Graduate standing **with a grade of B or better in both courses, or consent of instructor
Corequisites: There are no corequisites for this course.
Design of digital communication systems. Autocorrelation function and power spectrum, vector space models of signals and noise, optimal receiver structures and performance, bandlimited channels and equalization, convolutional coding.

ECE 512 Probability, Random Processes, and Estimation 4R-0L-4C W
Prerequisites: MA 381, and ECE 380
Corequisites: There are no corequisites for this course.
Review of probability and random variables, random vectors, topics in estimation and detection theory, linear and nonlinear estimation, orthogonality principle, hypothesis testing, random processes, stationarity, correlation functions, and spectra. Additional topics chosen from Wiener and Kalman filtering, and Markov chains.

ECE 516 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior class standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with BE 516, CHE 505, EP 510, and ME 516.

ECE 519 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Prerequisites: EP 410 or equivalent course
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with ME 519, EP 511, and CHE 519.

ECE 530 Advanced Microcomputers 3R-3L-4C S
Prerequisites: *Graduate standing; or with a grade of B or better; or consent of instructor ECE 230* *Graduate standing; or with a grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
32-bit microcontroller architecture. Software development in both assembly language and C language. Hardware interfacing. Use of a real-time-operating system (RTOS). System-on-a-chip (SOC) hardware/software design using a field programmable gate array (FPGA) chip containing an embedded microcontroller cores. Software debugging tools. Integral laboratory.

ECE 531 Digital Test & Product Engineering 3R-3L-4C S
Prerequisites: ECE 230*, and ECE 233*, and ECE 250* *Graduate standing; or with grades of B or better in all three courses; or consent of instructor.
Corequisites: There are no corequisites for this course.
Industrial testing techniques for microcontrollers and other digital integrated circuits. Includes common digital system fault modeling, test generation, and design for testability in addition to memory testing strategies. Integral labs using an industrial grade automatic test environment (ATE).

ECE 532 Advanced Topics in Computer Architecture 4R-0L-4C W
Prerequisites: ECE 332 with a B or better.
Corequisites: There are no corequisites for this course.

Superscalar processors. Out-of-Order Execution. Register Renaming. Dynamic Random Access Memory (DRAM). Prefetching. Trace Cache. Victim Cache. 3D DRAM. Multithreading. Multicore. Cache Coherence. Transactional Memory. Performance Modeling. Power Modeling. Intel Pentium Pro Architecture. Transmeta Crusoe Architecture. Code Morphing. ARMv7 Architecture. Nvidia G80 Architecture.

ECE 534 Advanced Signal & Power Integrity 4R-0L-4C W

Prerequisites: ECE 341*, and ECE 342* or ECE 343* *Graduate standing; or all courses with a grade of B or better; or ECE342 with a grade of B or better, or consent of instructor

Corequisites: There are no corequisites for this course.

Signal and power integrity modeling and measurement in high-speed digital systems at IC, PCB, and chassis levels. High-frequency behavior of passive components and packages. Behavior and SPICE models of drivers and receivers. Lossy transmission lines and discontinuity characterization. Mixedmode s-parameters and other network parameters. Frequency and time-domain modeling of capacitive and inductive crosstalk. Differential signaling techniques; timing conventions. Synchronization. Signal equalization. Power plane noise and resonance. High-speed PCB design guidelines. Measurement techniques including time-domain reflectometry, vector network analyzer and impedance analyzer. PCB simulation. Full-wave simulations.

ECE 540 Antenna Engineering 3R-3L-4C W

Prerequisites: ECE 341* Graduate standing (course not required); *or with a grade of B or better; or consent of instructor.

Corequisites: There are no corequisites for this course.

Electromagnetic radiation, antenna terminology and characteristics, dipole antennas, arrays, aperture antennas, measurements, computer-aided analysis, design projects and reports.

ECE 541 Microwave/Millimeter-Wave Engineering 4R-0L-4C S

Prerequisites: ECE 341 Graduate standing; or with grade of B or better, or consent of instructor

Corequisites: There are no corequisites for this course.

Wave-guiding structures, microwave network analysis, scattering parameters, Z, Y and ABCD parameters, passive devices and components, design, fabrication, simulation and measurement of microwave devices and components, matching strategies, multi-conductor transmission lines and crosstalk.

ECE 542 Advanced Electromagnetics 4R-0L-4C F

Prerequisites: ECE 341 and Graduate standing; or with grade of B or better, or consent of instructor

Corequisites: There are no corequisites for this course.

Maxwell’s equations, EM field theorems, potential functions, power and energy, material properties, wave propagation, reflection and transmission, radiation, scattering, Green's functions, metamaterials and metamaterial-inspired structures, modeling & simulation, measurement technique.

ECE 543 Electromagnetic Metamaterials 4R-0L-4C

Prerequisites: ECE 341* Graduate standing (course not required) *or with grade of B or better; or consent of instructor

Corequisites: There are no corequisites for this course.

Electromagnetic fundamentals, control of permittivity and permeability, dispersion, causality, double-negative materials, epsilon near-zero materials, transmission line-based metamaterials, composite right/left handed wave-guiding structures, even/odd mode analysis, differential signaling, electromagnetic bandgap structures, phase

control, dual band devices, enhanced bandwidth devices, zeroth-order resonators, full wave simulation, device fabrication and laboratory measurement.

ECE 551 Digital Integrated Circuit Design 3R-3L-4C F

Prerequisites: ECE 250, and ECE 233 both with a grade of B or better; or graduate standing.

Corequisites: There are no corequisites for this course.

Design, performance analysis, and physical layout of CMOS logic. Custom and standard cell methodologies. Use of commercial CAD tools. Design issues such as interconnect, timing, and testing methods. Integral laboratory and project.

ECE 552 Analog Integrated Circuit Design 3R-3L-4C W

Prerequisites: ECE 351, and ECE 380 Graduate standing; or with a grade of B or better in both courses; or consent of instructor

Corequisites: There are no corequisites for this course.

Design, performance analysis, and physical layout of analog integrated circuits. Focus on operational amplifier design and op-amp circuits. Introduction to mixed-signal circuit design such as switch-capacitors, A/D, or D/A systems. Integral laboratory and design project.

ECE 553 Radio-Frequency Integrated Circuit Design 3R-3L-4C S

Prerequisites: ECE 310, and ECE 351 Graduate standing (courses not required); or with a grade of B or better; or consent of instructor

Corequisites: There are no corequisites for this course.

Design, analysis, and physical layout of high-frequency analog integrated-circuits for modern RF transceivers. Circuit design for each primary transceiver component. General issues such as impedance matching and design of inductors on integrated circuits. Integral laboratory and design project.

ECE 554 Instrumentation 4R-0L-4C S

Prerequisites: ECE 351 Graduate standing; or with grade of B or better; or consent of instructor

Corequisites: There are no corequisites for this course.

Transducers and their applications. Analog signal processing techniques using operational amplifiers. A/D and D/A converters. Protection from electric shock. Measurement of biological potential waveforms (ECG, EMG, EEG, ENG, EOG, ERG). Ultrasound techniques and instrumentation. X-ray CAT techniques. No laboratory, but many in-class demonstrations and emphasis on circuit simulation.

ECE 556 Power Electronics: DC Power Supplies 3R-3L-4C S

Prerequisites: ECE 351 Graduate standing; or with grade of B or better; or consent of instructor

Corequisites: There are no corequisites for this course.

Analysis and design of AC-DC and DC-DC converters. Linear, basic switching, charge-pump, and fly-back topologies. Introduction to devices used in a power switching supplies. Thermal management. Integral laboratory.

ECE 557 Analog Test & Product Engineering 3R-3L-4C F

Prerequisites: ECE 300, and ECE 351 Graduate standing; or with a grade of B or better in both courses, or consent of instructor

Corequisites: There are no corequisites for this course.

Fundamental skills necessary to be an industrial integrated circuit test engineer or product engineer. Includes the economics associated with testing, impact of fabrication variation on devices, instrumentation associated with industrial testing, turning a data sheet into a test plan, industrial testing techniques for analog circuits, trade-offs between test time and test accuracy, statistical analysis of the data and statistical

process control, the use of device interface boards necessary to control device loading for different tests. Integral labs with an industrial grade automatic tester (ATE).

ECE 558 Mixed-Signal Test & Product Engineering 3R-3L-4C W

Prerequisites: ECE 300, and ECE 233, and ECE 351 Graduate standing; or with grades of B or better in all three courses; or consent of instructor.

Corequisites: There are no corequisites for this course.

Industrial testing techniques for AC and DC tests of mixed-signal integrated circuits using an automatic test environment (ATE). Includes the structure and operation of comparators and standard data converters (DACs, ADCs), common data converter datasheet specifications, impact of data converter design on testing strategies, and statistical analysis of accuracy-time trade-offs. Integral labs using an industrial grade ATE.

ECE 580 Digital Signal Processing 4R-0L-4C W

Prerequisites: ECE 380, and MA 381 *Graduate standing (courses not required); or with grade of B or better in both courses; or consent of instructor. MA367 with a grade of B or higher recommended.

Corequisites: There are no corequisites for this course.

Digital filters. Fundamental concepts of digital signal processing. Analysis of discrete-time systems. Sampling and reconstruction. Theory and application of z-transforms. Design of recursive and nonrecursive digital filters. Window functions. Discrete Fourier transforms and FFT algorithm.

ECE 581 Digital Signal Processing Projects 2R-2L-2 or 4C

Prerequisites: ECE 580 concurrent registration

Corequisites: There are no corequisites for this course.

Computer-aided design of digital filters and other DSP modules. Software and hardware realization using modern DSP chips. DSP chip architectures, C-language programming, and interfacing techniques. Optional advanced project may be done to earn four credit hours; otherwise two credit hours are given. Integral laboratory.

ECE 582 Advanced Image Processing 3R-3L-4C S

Prerequisites: CSSE 120 or Senior standing or Graduate standing

Corequisites: There are no corequisites for this course.

Introduction to image segmentation and recognition. Use of neural networks, fuzzy logic and morphological methods for feature extraction. Advanced segmentation, detection, recognition and interpretation. Relevant laboratory experiments and required project. Cross-listed with OE 537.

ECE 584 Medical Imaging Systems 4R-0L-4C

Prerequisites: ECE 300* or BE 321 or OE 392 *Graduate standing; or ECE300 with grade of B or better; or consent of instructor

Corequisites: There are no corequisites for this course.

Engineering principles of major imaging techniques/modalities for biomedical applications and health care including diagnostic x-ray, computed tomography, nuclear techniques, ultrasound, and magnetic resonance imaging. Topics include general characteristics of medical images; physical principles, signal processing to generate an image, and instrumentation of imaging modalities. Clinical applications of these technologies are also discussed. Cross-listed with BE541 and OE584.

Prerequisite Notes:

Prerequisites - Clarification:
ECE 300 - Continuous-Time Signals & Systems and Graduate standing;

or ECE 300 Continuous-Time Signals & Systems with a grade of B or better
or BE 340 – Biomedical Signal Processing
or OE 392 – Linear Optical Systems with a grade of B or better;
or consent of instructor

ECE 596 Independent Study in Electrical Engineering 1C-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Special research or project based work that is done in consultation with a faculty member. Participation in these projects should require a graduate level of involvement and expectations, otherwise ECE498 Undergraduate Projects should be used. No more than 8 credit hours of ECE596 can be counted towards a graduate degree in the ECE Department without ECE Department Head Approval.

ECE 597 Special Topics in Electrical Engineering 4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Special topics of current interest to graduate students and senior undergraduates.

ECE 598 Thesis Research 1-4C
Prerequisites: Arranged
Corequisites: There are no corequisites for this course.
Thesis topic selected in consultation with adviser. Graduate students only.

ECE 699 Professional Experience 1R-0L-1C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The work experiences should be informative or integral to the advancement or completion of the student's program requirements. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

Computer Science - Course Descriptions

CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
An introduction to programming with an emphasis on problem solving. Problems may include visualizing data, interfacing with external hardware or solving problems from a variety of engineering disciplines. Programming concepts covered include data types, variables, control structures, arrays, and data I/O. Software development concepts covered include testing, debugging, incremental development, understanding requirements, and version control systems.

CSSE 132 Introduction to Systems Programming 3R-3L-4C F,S
Graduate Studies Eligible: No
Prerequisites: CSSE 120
Corequisites: There are no corequisites for this course.
Provides students with understanding of computer system level issues and their impact on the design and use of computer systems. Students will study low-level programming

(assembly) and memory operations, representation of various types of data and programs in memory, and resource/efficiency trade-offs. System requirements such as resource management, security, communication and synchronization are studied and basic systems tools for these tasks are implemented. Course topics will be explored using a variety of hands-on assignments and projects.

CSSE 140 Practical Security I 0R-1L-1C F

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This is an entry-level introduction to exploiting and securing computer systems, networks, and web sites. This shallow introduction exposes students to various applied cybersecurity topics including Firewalls, SSH, passwords, web security, and basic unix system administration. Through a series of hands-on exercises, students will relate these topics to practical ways to secure computers.

CSSE 141 Practical Security II 0R-1L-1C W

Graduate Studies Eligible: No

Prerequisites: CSSE 140

Corequisites: There are no corequisites for this course.

A second-level introduction to exploiting and securing computer systems, networks, and web sites. This class continues the introduction to applied cybersecurity topics including basic Cryptography, network protocol analysis, reverse engineering, steganography, forensics, and more unix system administration. Students are also introduced to capture-the-flag exercises, which are widely practiced cybersecurity skill competitions.

CSSE 142 Practical Security III 2L-2C Term F

Graduate Studies Eligible: No

Prerequisites: CSSE 141

Corequisites: There are no corequisites for this course.

A third-level class on exploiting and securing computer systems, networks, and web sites. This class continues the introduction to applied cybersecurity topics and focus on applying concepts learned in CSSE140/141 to security competitions such as capture-the-flag events. This class exposes students to strategy used in security competitions, teamwork skills for effective competition, and construction of set of exercises used for running a CTF event. Students will work in teams to solve security-oriented problems, apply their skills to create competition challenges/exercises for use in CSSE 141 and for competition training, practice for security competitions, and participate in or run a few security competitions.

CSSE 145 Cybersecurity Seminar 2R-0L-2C Varies

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course provides exposure to leading-edge industrial and academic experts in Cybersecurity and Digital Privacy. Topics including the societal, economic, scientific, and psychological impacts of modern areas of cybersecurity and privacy are examined from both practical and theoretical points of view. Students in this class will attend live and view remote or recorded talks from industry/academic experts, read emergent papers on Cybersecurity and Digital Privacy, participate in discussions or debate about the topics, and reflect on the impacts these topics have on their major area of study. May be repeated for credit with approval from the course instructor when topics are different.

CSSE 199 Professional Experience 1R-0L-1C

Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

CSSE 212 Hardware-oriented Programming 3R-3L-4C
Graduate Studies Eligible: No
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Simple computer architecture. Special hardware-oriented programming. Introduction to the C programming language, especially the use of pointers. Interrupt programming. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S
Graduate Studies Eligible: No
Prerequisites: CSSE 120
Corequisites: There are no corequisites for this course.
Object-oriented programming concepts, including the use of inheritance, interfaces, polymorphism, abstract data types, and encapsulation to enable software reuse and assist in software maintenance. Recursion, GUIs and event handing. Use of common object-based data structures, including stacks, queues, lists, trees, sets, maps, and hash tables. Space/time efficiency analysis. Testing. Introduction to UML.

CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C
Graduate Studies Eligible: No
Prerequisites: A score of 4 or 5 on the APCS A exam or permission of instructor
Corequisites: There are no corequisites for this course.
This course is intended for students who have sufficient programming experience to warrant placement in an accelerated course covering the topics from CSSE 120 and CSSE 220. This course will satisfy the prerequisite requirements for courses that have CSSE 220 as a prerequisite.

CSSE 225 Programming 3 3R-3L-4C
Graduate Studies Eligible: No
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Differences between Java and C++. C++ concepts of object-oriented programming (classes, objects, inheritance, polymorphism). Storage management. Multiple inheritance, operator overloading, friend-concept, exception handling, I/O. Error analysis of programs. Generic programming and introduction to C++ - standard library. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 112, and CSSE 220 with a grade of C or better
Corequisites: There are no corequisites for this course.
This course reinforces and extends students' ability to independently design, develop, and debug object-oriented software that uses correct, clear, and efficient algorithms and data structures. Students study and implement classical data structures such as

list, stack, queue, tree, priority queue, hash table, graph, set, and dictionary. Formal efficiency analysis is used to evaluate the complexity of algorithms for these data structures. Students gain proficiency in writing recursive methods. Students design and implement software individually.

CSSE 232 Computer Architecture I 3R-3L-4C F,W

Graduate Studies Eligible: No

Prerequisites: ECE 233, and CSSE 120

Corequisites: There are no corequisites for this course.

Computer instruction set architecture and implementation. Specific topics include historical perspectives, performance evaluation, computer organization, instruction formats, addressing modes, computer arithmetic, single-cycle and multi-cycle data paths, and processor control. Assembly language programming is used as a means of exploring instruction set architectures. The final project involves the complete design and implementation of a miniscule instruction set processor.

CSSE 240 Principles of Cybersecurity 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: CSSE 120, and HUM H190

Corequisites: There are no corequisites for this course.

This course introduces ethical, theoretical, and practical issues of information security in interconnected systems of computers. Implications of relevant professional codes of ethics are a recurring theme of the course, as are societal and human impacts on computer system security. Foundational topics include access control matrices and standard system models, as well as policies for security, confidentiality, and integrity. Implementation issues include key management, cipher techniques, authentication, principles of secure design, representation of identity, access control mechanisms, information flow, life cycle issues, and formal evaluation and certification techniques. Additional topics include malicious logic, vulnerability analysis, and auditing. Computer system attack techniques are observed and evaluated in a closed environment to motivate and inform discussion and exploration of computer network defense techniques.

CSSE 241 Computing in a Global Society 2R-6L-4C

Graduate Studies Eligible: No

Prerequisites: CSSE 220 or CSSE 221

Corequisites: There are no corequisites for this course.

The ability to work with colleagues from other cultures and to work on international projects are key assets in today's job market. The centerpiece of this course is a real-world computing project that students develop in cooperation with peers from an institution of higher education in a foreign country. Exposes students to the procedures and complexities of working on projects that span many time-zones and cultures. Additionally, students examine the use and impact of computing in a global community. International travel is required; students will be expected to incur additional expenses (will vary depending on the project, institution, and country). May be repeated once (for free elective credit only) if the country involved is different.

CSSE 242 Programming in the Community Variable Credit (1 or 2 credits) F, W, S

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Programming in the Community is a unique course where Rose-Hulman students learn how to become teachers in Computer Science for younger students. As the name suggests, students will go teach CS material to K-12 students at their local school.

Students will be assigned to a teaching team to take turns leading and helping follow along projects for the K-12 students. Students are expected to join a weekly instructor meeting on Teams, then take two teaching trips into the community per week (40 to 50 minute lessons). Transportation can be arranged for students unable to travel to the school. Students of any major are welcome to join. This class is a very real-world experience. It is a great way to learn leadership and teaching skills while doing great community service. May be repeated up to 12 credit hours.

CSSE 252 Computer Game Design 4R-OL-4C

Graduate Studies Eligible: No

Prerequisites: ENGL H290

Corequisites: There are no corequisites for this course.

An introduction to computer game design. Topics include game concepts, game settings and worlds, storytelling and narrative, character development, creating the user experience, gameplay, game balancing, and game genres. Working in teams, students will design their own game and produce several design documents for that game.

CSSE 280 Introduction to Web Programming 3R-3L-4C F, W

Graduate Studies Eligible: No

Prerequisites: CSSE 220 or CSSE 221

Corequisites: There are no corequisites for this course.

Introduction to the client-side and server-side mechanisms for creating dynamic web applications with persistent data storage. Browser-server interaction via HTTP. Static web page creation using current markup and styling languages. Client-side programming with modern scripting languages and the DOM. Server-side programming with emerging web programming languages and frameworks. Persistent data storage with a state-of-the-art database management system. Asynchronous client-server communication via HTTP requests. Development and consumption of REST APIs. Deployment of web applications to cloud platforms or platform as a service providers. Security considerations. This course provides breadth of knowledge of many tools/ technologies rather than deep knowledge of any particular tool/technology. No previous experience with Web development is required.

CSSE 286 Introduction to Machine Learning 4R-0L-4C

Graduate Studies Eligible: No

Prerequisites: Prior programming experience

Corequisites: There are no corequisites for this course.

An introduction to machine learning (ML) systems, with a focus especially on Artificial Intelligence-based systems, versus statistical ones. The course is designed to be useful to students with a basic knowledge of programming and software systems, whether or not they are computer science majors. During the course, students try different machine learning algorithms on data from problems in a domain of interest to them, comparing results with that of other students taking the class, as well as comparing the outcomes of the different algorithms on their own data. A goal of the course is learning how to gain real predictive value from “big data.”

CSSE 290 Special Topics in Computer Science 4C

Graduate Studies Eligible: No

Prerequisites: Arranged prerequiste - permission of instructor

Corequisites: There are no corequisites for this course.

Selected topics of current interest. May be repeated for credit if topic is different.

CSSE 304 Programming Language Concepts 4R-0L-4C F,W

Graduate Studies Eligible: No

Prerequisites: CSSE 230, and CSSE 280

Corequisites: There are no corequisites for this course.
Syntax and semantics of programming languages. Grammars, parsing, data types, control flow, parameter passing, run-time storage management, binding times, functional programming and procedural abstraction, syntactic extensions, continuations, language design and evaluation. Students will explore several language features by writing an interpreter that implements them.

CSSE 332 Operating Systems 4R-0L-4C W,S
Graduate Studies Eligible: No
Prerequisites: CSSE 220 or CSSE 221, and CSSE 132 or CSSE 232
Corequisites: There are no corequisites for this course.
Students learn fundamental concepts of modern operating systems by studying how and why operating systems have evolved. Topics include CPU scheduling, process synchronization, memory management, file systems, I/O systems, privacy and security, and performance evaluation. Students implement parts of an operating system as a means of exploring the details of some of these topics.

CSSE 333 Database Systems 3R-3L-4C W,S
Graduate Studies Eligible: No
Prerequisites: CSSE 230
Corequisites: There are no corequisites for this course.
Relational database systems, with emphasis on entity relationship diagrams for data modeling. Properties and roles of transactions. SQL for data definition and data manipulation. Use of contemporary API's for access to the database. Enterprise examples provided from several application domains. The influence of design on the use of indexes, views, sequences, joins, and triggers. Physical level data structures: B+ trees and RAID. Survey of object databases.

CSSE 335 Introduction to Parallel Computing 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: MA 221 and programming experience
Corequisites: There are no corequisites for this course.
Principles of scientific computation on parallel computers. Algorithms for the solution of linear systems and other scientific computing problems on parallel machines. Course includes a major project on RHIT's parallel cluster. Same as MA 335.

CSSE 340 Foundations of Cybersecurity 4R-0L-4C W
Graduate Studies Eligible: No
Prerequisites: CSSE 132, and CSSE 280
Corequisites: There are no corequisites for this course.
This course introduces ethical, theoretical, and practical issues of information security in interconnected systems of computers. Implications of relevant professional codes of ethics are a recurring theme of the course, as are societal and human impacts on computer system security. Foundational topics include access control matrices and standard system models, as well as policies for security, confidentiality, and integrity. Implementation issues include key management, cipher techniques, authentication, principles of secure design, representation of identity, access control mechanisms, information flow, life cycle issues, and formal evaluation and certification techniques. Additional topics include malicious logic, vulnerability analysis, and auditing. Computer system attack techniques are discussed and explored in a closed environment to motivate and inform discussion and exploration of computer network defense techniques.

CSSE 343 Cybercrime and Digital Forensics 2R-2L-4C
Graduate Studies Eligible: No

Prerequisites: ENGL H100, and either CSSE 132 or Senior Class Standing
Corequisites: There are no corequisites for this course.
This course introduces students to “cybercrime,” how police investigate these crimes, and what forensics techs use to uncover digital evidence. Students will examine the laws, technologies, tools, and procedures used in the investigation and prosecution of computer crimes through case studies, discussions, ethical debates, and hands-on laboratory exercises that uncover and analyze digital evidence. This class covers topics including: basics of criminal law, collection and chain of evidence, search & seizure procedures, digital trail discovery, data recovery, and smartphone investigation.

CSSE 351 Computer Graphics 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: MA 221, and either CSSE 220 or CSSE 221
Corequisites: There are no corequisites for this course.
Computer graphics algorithms, hardware and software. Line generators, affine transformations, line and polygon clipping, interactive techniques, perspective projection, solid modeling, hidden surface algorithms, lighting models, shading, and graphics standards. Programming assignments and a final project are required.

CSSE 352 Computer Game Development 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: CSSE 230
Corequisites: There are no corequisites for this course.
An introduction to designing and developing computer games. Topics include game genres, game design, sprites, game physics, collisions, characters, scripting, graphics, and sound. Students will design and implement their own game using an available game engine.

CSSE 371 Software Requirements Engineering 3R-3L-4C F
Graduate Studies Eligible: No
Prerequisites: CSSE 230, and ENGL H290, and CSSE 333 and Junior standing
Corequisites: There are no corequisites for this course.
Basic concepts and principles of software requirements engineering, its tools and techniques, and methods for modeling software systems. Topics include requirements elicitation, prototyping, functional and non-functional requirements, object-oriented techniques, and requirements tracking.

CSSE 372 Software Project Management 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: CSSE 230
Major issues and techniques of project management. Project evaluation and selection, scope management, team building, stakeholder management, risk assessment, scheduling, quality, rework, negotiation, and conflict management. Professional issues including career planning, lifelong learning, software engineering ethics, and the licensing and certification of software professionals.

CSSE 373 Formal Methods in Specification and Design 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: CSSE 230, and MA 276
Corequisites: There are no corequisites for this course.
Introduction to the use of mathematical models of software systems for their specification and validation. Topics include finite state machine models, models of concurrent systems, verification of models, and limitations of these techniques.

CSSE 374 Software Design 3R-3L-4C W

Graduate Studies Eligible: No
Prerequisites: CSSE 230 and Junior standing
Corequisites: There are no corequisites for this course.
Introduction to the architecture and design of complete software systems, building on components and patterns. Topics include architectural principles and alternatives, design documentation, and relationships between levels of abstraction.

CSSE 375 Software Construction and Evolution 3R-3L-4C S
Graduate Studies Eligible: No
Prerequisites: CSSE 374
Corequisites: There are no corequisites for this course.
Issues, methods and techniques associated with constructing software. Topics include detailed design methods and notations, implementation tools, coding standards and styles, peer review techniques, and maintenance issues.

CSSE 376 Software Quality Assurance 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: CSSE 230
Corequisites: There are no corequisites for this course.
Theory and practice of determining whether a product conforms to its specification and intended use. Topics include software quality assurance methods, test plans and strategies, unit level and system level testing, software reliability, peer review methods, and configuration control responsibilities in quality assurance.

CSSE 386 Data Mining with Programming 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: CSSE 220, and CSSE 280, and MA 221, and either MA 223 or MA 381
Corequisites: There are no corequisites for this course.
An introduction to data mining for large data sets, including data preparation, exploration, aggregation/reduction, and visualization. Elementary methods for classification, association, and cluster analysis are covered. Significant attention will be given to presenting and reporting data mining results. Students may not get credit for both this course and also the MA 384 Data Mining course.

CSSE 400 CSSE Seminar 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
This course presents an overview of current application areas within computer science and software engineering through the use of practical case studies. Students will undertake their own preparation of one or more case studies and present their results. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 402 Theory and Practice of Garbage Collection 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: CSSE 332
Corequisites: There are no corequisites for this course.
Garbage collection (GC) is a method of automatically reclaiming dynamically allocated storage that an application no longer needs. In this course, students will explore the classical problems of garbage collection such as detecting unused objects and reclaiming the space allocated to them. Students will survey the GC literature to become familiar with the current state-of-the-art and future research directions. Students will explore techniques used to implement state-of-the-art garbage collection

algorithms and will design and implement garbage collectors for a memory-managed language (e.g.,Java, C#, php, or Python).

CSSE 403 Programming Language Paradigms 4R-0L-4C F (even years)

Graduate Studies Eligible: Yes

Prerequisites: CSSE 304

Corequisites: There are no corequisites for this course.

A survey of some current and emerging programming languages, focusing on unique language paradigms-ways of structuring solutions or manipulating data. Examples of paradigms include dynamic programming languages, object-oriented programming, highly parallelizable code, and functional programming. Emphasizes developing independent learning techniques that will allow students to acquire skills in new languages quickly. Students will develop basic skills in at least three different languages representing distinct paradigms. They will also be exposed to a selection of other languages. Includes a substantial team project.

CSSE 404 Compiler Construction 4R-0L-4C S (odd years)

Graduate Studies Eligible: Yes

Prerequisites: CSSE 232, and CSSE 304, and CSSE 474 and

Corequisites: There are no corequisites for this course.

Theory and practice of programming language translation. Lexical analysis, syntax analysis, parser generators, abstract syntax, symbol tables, semantic analysis, intermediate languages, code generation, code optimization, run-time storage management, error handling. Students will construct a complete compiler for a small language.

CSSE 413 Artificial Intelligence 4R-0L-4C F

Graduate Studies Eligible: Yes

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

Students investigate how to model and implement intelligent behavior using computers. Topics are chosen from how machines can: solve problems; reason and use knowledge; learn from experience; and perceive and act. Students explore these topics by implementing many of the ideas in software. Readings are drawn both from a textbook and from technical papers in recent conferences and journals.

CSSE 415 Machine Learning 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: MA 221, and either MA 223 or MA 381, and either CHE 310 or CSSE 220 or ECE 230 or MA 332 or MA 386 or ME 323

Corequisites: There are no corequisites for this course.

An introduction to machine learning. Topics include: error metrics, accuracy vs interpretability trade-off, feature selection, feature engineering, bias-variance trade-off, under-fitting vs. overfitting, regularization, cross-validation, the bootstrap method, the curse of dimensionality and dimensionality reduction using the singular value decomposition. Both parametric and nonparametric methods are covered including: k-nearest neighbors, linear and logistic regression, decision trees and random forests, and support vector machines. Same as MA415.

Prerequisite Notes:
Prerequisite Clarification for CSSE415:
Junior Standing and MA221,
and either MA223 or MA381,

and one of CHE310, CSSE220, ECE230, MA332, MA386 (or ME323 or ME327).

CSSE 416 DEEP LEARNING 4R-0L-4C See Dept

Graduate Studies Eligible: No

Prerequisites: See below

Corequisites: There are no corequisites for this course.

An introduction to deep learning using both fully-connected and convolutional neural networks. Topics include: least squares estimation and mean square error, maximum likelihood estimation and cross-entropy, convexity, gradient descent and stochastic gradient descent algorithms, multivariate chain rule and gradient computation using back propagation, linear vs nonlinear operations, convolution, over-fitting vs under-fitting and hyper-parameter optimization, L2, early stopping and dropout regularization, data augmentation and transfer learning. Same as MA416.

Prerequisite Notes:

MA 212 or MA 221, and either MA 223 or MA 381, and either CHE 310 or CSSE 220 or ECE 230 or MA 332 or MA 386 or ME 327

CSSE 432 Computer Networks 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: CSSE 220 or CSSE 221

Corequisites: There are no corequisites for this course.

Organization, design, and implementation of computer networks, especially the Internet. Network protocols, protocol layering, flow control, congestion control, error control, packet organization, routing, gateways, connection establishment and maintenance, machine and domain naming, security. Each of the top four layers of the Internet protocol stack: application (FTP, HTTP, SMTP), transport (TCP, UDP), network (IP), link (Ethernet).

CSSE 433 Advanced Database Systems 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: CSSE 333

Corequisites: There are no corequisites for this course.

This course covers advanced topics in the design and development of database management systems and their modern applications. Topics to be covered include query processing and, in relational databases, transaction management and concurrency control, eventual consistency, and distributed data models. This course introduces students to NoSQL databases and provides students with experience in determining the right database system for the right feature. Students are also exposed to polyglot persistence and developing modern applications that keep the data consistent across many distributed database systems.

CSSE 434 Introduction to the Hadoop Ecosystem 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: CSSE 230 *Some Experience with SQL recommended

Corequisites: There are no corequisites for this course.

This advanced course examines emergent Big Data techniques through hands-on introductions to the various technologies and tools that make up the Hadoop ecosystem. Topics covered include internals of MapReduce and the Hadoop Distributed File system (HDFS), internals of the YARN distributed operating system, MapReduce for data processing, transformation & analysis tools for data at scale (processing terabytes and petabytes of information quickly), scheduling jobs using workflow engines, data transfer tools & real time engines for data processing.

CSSE 435 Robotics Engineering 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: ME 430 or ECE 230
Corequisites: There are no corequisites for this course.
Interdisciplinary course in robotics focusing on communication, software development, kinematics, robot GUI design, sensing, control, and system integration. Labs in the course cover MATLAB GUI development with GUIDE, Denavit-Hartenberg parameters, Arduino programming, Arduino to Android communication, Android app development, and OpenCV4Android image recognition. Students in the course will program an Android + Arduino, 6-wheeled mobile robot with 5 DOF servo arm to participate in an outdoor GPS robotics challenge. Same as ME 435.

CSSE 443 Distributed Systems & IT Security 3R-3L-4C
Graduate Studies Eligible: Yes
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Building complex distributed information systems requires a systematic approach. This course covers the analysis of existing distributed information systems and provides the ability to model simple new distributed applications with special attention to the trustworthiness, reliability and security of information systems. Topics covered include the main architectural models of distributed systems, describing simple distributed applications according to architecture and function, defining simple communication protocols, the benefits of using middleware, the risks of using distributed systems, and safety measures. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 444 Real-time Systems 3R-3L-4C
Graduate Studies Eligible: Yes
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Students will learn the features and specifications of real-time systems. Topics covered include real-time operating systems and programming languages, design patterns for real-time systems, scheduling, synchronization, hybrid task sets, and applications of real-time systems. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 451 Advanced Computer Graphics 4R-0L-4C W (even years)
Graduate Studies Eligible: Yes
Prerequisites: CSSE 351
Corequisites: There are no corequisites for this course.
Advanced topics in computer graphics. Topics will be drawn from current graphics research and will vary, but generally will include ray tracing, radiosity, physically-based modeling, animation, and stereoscopic viewing. Programming assignments and a research project are required.

CSSE 453 Topics in Artificial Intelligence 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: CSSE 413
Corequisites: There are no corequisites for this course.
Advanced topics in artificial intelligence. Topics will vary. Past topics have included machine game playing and machine learning. May be repeated for credit if topic is different.

CSSE 461 Computer Vision 4R-0L-4C S (odd years)
Graduate Studies Eligible: Yes

Prerequisites: MA 221, and either CSSE 220 or CSSE 221 *Also recommended (but not required) either MA371 or MA373.
Corequisites: There are no corequisites for this course.
An introduction to 3D computer vision techniques. Both theory and practical applications will be covered. Major topics include image features, camera calibration, stereopsis, motion, shape from x, and recognition.

CSSE 463 Image Recognition 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: MA 221 Junior standing and programming experience
Corequisites: There are no corequisites for this course.
Introduces statistical pattern recognition of visual data; low-level visual feature extraction (color, shape, edges); clustering and classification techniques. Applies knowledge to various application domains through exercises, large programming projects in Matlab, and an independent research project. Familiarity with probability distributions will be helpful, but not required.

CSSE 473 Design and Analysis of Algorithms 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: CSSE 230, and MA 276, and MA 374
Corequisites: There are no corequisites for this course.
Students study techniques for designing algorithms and for analyzing the time and space efficiency of algorithms. The algorithm design techniques include divide-and-conquer, greedy algorithms, dynamic programming, randomized algorithms and parallel algorithms. The algorithm analysis includes computational models, best/average/ worst case analysis, and computational complexity (including lower bounds and NP-completeness). Same as MA 473.

CSSE 474 Theory of Computation 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CSSE 230, and MA 276, and MA 374
Corequisites: There are no corequisites for this course.
Students study mathematical models by which to answer three questions: What is a computer? What limits exist on what problems computers can solve? What does it mean for a problem to be hard? Topics include models of computation (including Turing machines), undecidability (including the Halting Problem) and computational complexity (including NP-completeness). Same as MA 474.

CSSE 477 Software Architecture 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: CSSE 374 or consent of instructor
Corequisites: There are no corequisites for this course.
This is a second course in the architecture and design of complete software systems, building on components and patterns. Topics include architectural principles and alternatives, design documentation, relationships between levels of abstraction, theory and practice of human interface design, creating systems which can evolve, choosing software sources and strategies, prototyping and documenting designs, and employing patterns for reuse. How to design systems which a team of developers can implement, and which will be successful in the real world.

CSSE 479 Cryptography 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: MA 276, and either CSSE 220 or CSSE 221
Corequisites: There are no corequisites for this course.

Introduction to basic ideas of modern cryptography with emphasis on mathematical background and practical implementation. Topics include: the history of cryptography and cryptanalysis, public and private key cryptography, digital signatures, and limitations of modern cryptography. Touches upon some of the societal issues of cryptography. Same as MA 479.

CSSE 480 Cross-Platform Development 3R-3L-4C F

Graduate Studies Eligible: Yes

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

Programming cross-platform mobile applications that target Android, iOS, and web mobile devices using programmatic UIs, layouts, reusable components, and data persistence via cloud backends. Emphasis is on hands-on use of these components in application development. Includes a substantial team project including UI mockups, design, development, testing, and presentation.

CSSE 481 Web-Based Information Systems 4R-0L-4C F (odd years)

Graduate Studies Eligible: Yes

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

In this course, students learn about several aspects of research: thinking creatively about interesting research problems, researching existing work in a chosen area, and keeping current in a field. Students are exposed to the process of research by writing a pre-proposal for a project that advances the web. Projects either develop new web-technologies or applications or investigate a topic of importance. Based on feedback received, groups of students write a research proposal which goes through a formal peer review process. Approved projects are pursued for the remainder of the quarter. Students present current research as well as give a final presentation of their group project. Selected web-technologies are introduced; in the past, these have included CGI programming and XML technologies.

CSSE 483 Android Application Development 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

An introduction to programming mobile applications using the Android stack. Topics include the activity lifecycle, resources, layouts, intents for multiple activities, menus, fragments and dialogs, adapters, data persistence via shared preferences, SQLite, and web backends. Emphasis is on hands-on use of these components in application development. Includes a substantial team project (UI mockups, user stories, UML design, development, testing, and presentation).

CSSE 484 iOS Application Development 3R-3L-4C W

Graduate Studies Eligible: Yes

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

An introduction to programming mobile applications using the iOS stack. Topics include using X-Code for Swift and Objective-C app development, UI components, Storyboards, view controller actions and outlets, table views, navigation controllers, Core Data, and APIs for backend communication. Emphasis is on hands-on use of these components in application development. Includes a substantial team project (UI mockups, user stories, development, testing, and presentation).

CSSE 487 Senior Research Project I 4C

Graduate Studies Eligible: No

Prerequisites: ENGL H290 and senior standing
Corequisites: There are no corequisites for this course.
Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 488 Senior Research Project II 4C
Graduate Studies Eligible: No
Prerequisites: CSSE 487
Corequisites: There are no corequisites for this course.
Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 489 Senior Research Project III 4C
Graduate Studies Eligible: No
Prerequisites: CSSE 488
Corequisites: There are no corequisites for this course.
Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 490 Special Topics in Computer Science 1-4C
Graduate Studies Eligible: Yes
Prerequisites: Instructor consent
Corequisites: There are no corequisites for this course.
Selected topics of current interest. May be repeated for credit if topic is different.

CSSE 491 Directed Independent Studies 1-4C
Graduate Studies Eligible: Yes
Prerequisites: Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Independent study of an advanced subject not included in regularly offered courses. May be repeated for credit if topic or level is different.

CSSE 492 Undergraduate Research in Computer Science 1-4C
Graduate Studies Eligible: No
Prerequisites: Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Research under direction of a faculty member. Presentation of preliminary and final results to departmental seminar. Presentation of work at professional meetings or by publication in professional journals is strongly encouraged. May be repeated for credit if topic or level is different.

CSSE 493 Undergraduate Research in Software Engineering 1-4C
Graduate Studies Eligible: No
Prerequisites: Consent of instructor and department head
Corequisites: There are no corequisites for this course.
The Computer Science curriculum prepares students for careers in all areas of the computer industry as well as for graduate studies in computer science and computer related fields. Students have also found a computer science major to be excellent preparation for careers in law, medicine, business administration, industrial engineering, biomedical engineering, and other technical and non-technical fields.

CSSE 494 Senior Thesis I 4C
Graduate Studies Eligible: No
Prerequisites: ENGL H290 Consent of instructor and department head

Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 495 Senior Thesis II 4C
Graduate Studies Eligible: No
Prerequisites: CSSE 494 Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 496 Senior Thesis III 4C
Graduate Studies Eligible: No
Prerequisites: CSSE 495 Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 497 Senior Capstone Project I 4C F
Graduate Studies Eligible: No
Prerequisites: CSSE 371, CSSE 374* and senior standing
Corequisites: There are no corequisites for this course.
For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions, recording the investigation experience in a research report, and delivering the research artifacts to the client.

CSSE 498 Senior Capstone Project II 4C W
Graduate Studies Eligible: No
Prerequisites: CSSE 371, CSSE 374, and CSSE 497
Corequisites: There are no corequisites for this course.
For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions,

recording the investigation experience in a research report, and delivering the research artifacts to the client.

CSSE 499 Senior Capstone Project III 4C S

Graduate Studies Eligible: No

Prerequisites: CSSE 371, CSSE 374, and CSSE 498

Corequisites: There are no corequisites for this course.

For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions, recording the investigation experience in a research report, and delivering the research artifacts to the client.

Electrical Engineering - Course Descriptions

ECE 160 Engineering Practice 0R-4L-2C F,W

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

An introduction to electrical and computer engineering, systems engineering design, programming, microcontrollers, soldering and circuit building. Students will work individually and on teams to complete projects and create a system for an end of term competition. Students will also learn about technical documentation and communication. Topics include functions, arrays, conditionals, loops, Boolean algebra, wireless communication, resistors, transistors, diodes motors, sensor, analog and digital inputs and outputs.

ECE 180 Introduction to Signal Processing 3R-3L-4C F,W,S

Graduate Studies Eligible: No

Prerequisites: MA 112, and ECE 160 or CSSE 120 or ENGD 120 or ME 123 or prior programming experience

Corequisites: There are no corequisites for this course.

An introduction to discrete-time signal processing applied to audio, images, and video. Topics include phasor representation of sinusoidal signals, complex arithmetic, sampling, signal spectra, linear time-invariant systems, frequency response, convolution, filter implementation, and MATLAB programming. Integral laboratory.

ECE 199 Professional Experience 1R-0L-1C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

The professional experiences course captures the practical work experiences related to the student’s academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and

enhanced their academic studies. The course will be graded as “S” satisfactory, or “U” unsatisfactory based on the written report of the professional experience.

ECE 203 DC Circuits 3R-3L-4C S, F

Graduate Studies Eligible: No

Prerequisites: MA 111, and PH 112

Corequisites: There are no corequisites for this course.

A review of the definition of voltage, current, energy and power. An introduction to Ohm’s Law, ideal DC independent and dependent voltage and current sources, resistors, inductors, capacitors, and operational amplifiers. Circuit analysis and simplification by using series, parallel, and Wye-Delta reduction, Kirchhoff’s laws, mesh and nodal analysis, Thevenin, Norton and Maximum Power Theorems, superposition, and source transformations. An integral laboratory to build electric circuits and measure voltage, current, resistance and power.

ECE 204 AC Circuits 3R-3L-4C F,W

Graduate Studies Eligible: No

Prerequisites: PH 113*, and either ECE 203** or ENGD 120** or BE 131**, or both ES 213**, and ES 213L** *Prerequisite or concurrent registration **with a grade of C or better

Corequisites: There are no corequisites for this course.

Capacitance, Self and Mutual Inductance. Root-mean-square values of waveforms. Application of phasors to sinusoidal steady-state. Impedance of circuit elements. Mesh and Nodal Analysis applied to ac circuits. Thevenin and Norton theorems applied to ac circuits. Single-phase ac power. Power factor correction. Voltage regulation and efficiency of feeders. Balanced three-phase systems. Ideal and non-ideal transformer models. Integral laboratory.

ECE 205 Circuits & Systems 3R-3L-4C W,S

Graduate Studies Eligible: No

Prerequisites: ECE 180 or BE 321, and HUM H190, and MA 222, and either ECE 203* or ENGD 120*, or both ES 213*, and ES 213L* *with a grade of C or better; ** or concurrent registration

Corequisites: There are no corequisites for this course.

Introduction to 1st and 2nd order circuits and review of differential equations. Bode plots. System classification, impulse and step response, convolution. Laplace and inverse Laplace transforms, block and signal flow diagrams. Benefits of feedback. Modeling and simulating electrical systems. Matlab and Simulink. Integral laboratory.

ECE 206 Elements of Electrical Engineering 4R-0L-4C W,S

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

A course designed for engineers (other than electrical or computer) covering analysis of passive circuits, introduction to op-amps, instrumentation, sinusoidal steady-state, a-c power, and induction motors. EE and CPE majors may not take this course.

ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S

Graduate Studies Eligible: No

Prerequisites: ECE 233, CSSE 120, and ECE 160

Corequisites: There are no corequisites for this course.

Sensors and actuators. Input and output devices. Microcontroller architecture. Standard communications protocols. Interrupt generation and processing. Data representation and storage. Memory management. The C programming language and programming styles. Integral laboratory and a term project.

ECE 233 Introduction to Digital Systems 3R-3L-4C F, W, S
Graduate Studies Eligible: No
Prerequisites: CSSE 120 or ECE 160 or ENGD 120
Corequisites: There are no corequisites for this course.
Number systems, Binary arithmetic, logic gates, forming logic circuits. Boolean algebra, Karnaugh maps. Propagation delay, hazards, common Combinational logic circuits, structures, and design. Contraction, latches, flip-flops, finite state machines, counters, Sequential circuit timing, and designing Sequential circuits. Register design, control and datapath design. Basic computer architecture, including memory. Integral laboratory.

ECE 250 Electronic Device Modeling 3R-3L-4C S,F
Graduate Studies Eligible: No
Prerequisites: ECE 204 or ECE 205, ES 203* or ES 213*, and ES 213L* * with grade of B or better
Corequisites: There are no corequisites for this course.
Modeling, analysis, and simulation of electronic circuits that contain two-terminal and threeterminal semiconductor devices. Large-signal, biasing, and small-signal analysis models. Introduction to wave shaping circuits, switching circuits, and amplifiers. Integral laboratory.

ECE 300 Continuous-Time Signals & Systems 3R-3L-4C F, S
Graduate Studies Eligible: No
Prerequisites: ECE 205, and MA 222, and MA 381* *Prerequisite or concurrent registration
Corequisites: There are no corequisites for this course.
Signal modeling. Fourier series and Fourier transforms. Response of systems to periodic and aperiodic signals. Filter characterization and design. Ideal and practical sampling. Use of numerical analysis software. Integral laboratory

ECE 310 Communication Systems 3R-3L-4C W, S
Graduate Studies Eligible: No
Prerequisites: ECE 380
Corequisites: There are no corequisites for this course.
Transmission of information over bandlimited, noisy communication channels.
Line codes, probability of error, intersymbol interference. Modulation techniques, synchronization and frequency conversion. Integral laboratory.

ECE 312 Communication Networks 4R-0L-4C F, W
Graduate Studies Eligible: No
Prerequisites: MA 381, and CSSE 120
Corequisites: There are no corequisites for this course.
Layered architectures. Circuit and packet switching. The ISO Reference Model. Point-to-point protocols, error control, framing. Accessing shared media, local area networks. Virtual circuits, datagrams, routing, congestion control. Queuing theory. Reliable message transport, internetworking.

ECE 320 Linear Control Systems 3R-3L-4C W,S
Graduate Studies Eligible: No
Prerequisites: ECE 300*, and ECE 230* or ME 430*
Corequisites: There are no corequisites for this course.
Analysis of linear control systems using classical and modern control theories in both continuous and discrete time. Plant representation, closed loop system representation, time response, frequency response, concept of stability. Root locus, Bode, and Nyquist methods. Computer modeling and simulation of feedback systems, implementation of discrete-time algorithims on microcontrollers.

ECE 332 Computer Architecture II 4R-0L-4C W, S
Graduate Studies Eligible: No
Prerequisites: CSSE 232
Corequisites: There are no corequisites for this course.
Instruction-Level Parallelism. Pipelining. Data Hazards. Exceptions. Branch Prediction. Multilength Instructions. Loop Unrolling. TI C6000 Digital Signal Processor. Cache. Memory. MSP430 Microcontroller. PIC Microcontroller. Intel Itanium. Multiprocessors. Hardware Multithreading. Graphics Processors. Supercomputers.

ECE 340 Electromagnetic Fields 4R-0L-4C F,W
Graduate Studies Eligible: No
Prerequisites: ECE 204 , and MA 222
Corequisites: There are no corequisites for this course.
Static and dynamic fields. Electric and magnetic properties of materials. Energy, force and power. Resistors, capacitors, and inductors. Application in sensing and actuation. Maxwell's equations. Introduction to electromagnetic waves. Use of vector calculus and numeric approximation. Technical reports and/or term papers.

ECE 341 Electromagnetic Waves 4R-0L-4C W,S
Graduate Studies Eligible: No
Prerequisites: ECE 340
Corequisites: There are no corequisites for this course.
Wave propagation and reflection. Power and lossy materials. Quasistatic analysis. Steady-state and transient analysis of transmission lines. Application in high-speed systems. Introduction to antennas. Technical reports and/or term papers.

ECE 342 Introduction to Electromagnetic Compatibility 3R-3L-4C F,S
Graduate Studies Eligible: No
Prerequisites: ECE 300 and Computer Engineering Major
Corequisites: There are no corequisites for this course.
Electromagnetic compatibility (EMC) regulations and measurement. Frequency behavior of passive components. Electromagnetic fields and waves. Transient behavior of transmission lines. Dipole and monopole antennas. Four coupling mechanisms: electrical and magnetic fields, common impedance, and electromagnetic wave. Conducted emissions. Radiated emissions. Electromagnetic shielding and grounding.

ECE 343 High-Speed Digital Design 3R-3L-4C W,S
Graduate Studies Eligible: No
Prerequisites: ECE 300 and Computer Engineering Major
Corequisites: There are no corequisites for this course.
Signal path modeling through connecting lengths of transmission lines with lumped element models of discontinuities. Circuit parameters from geometries and material properties for resistance, capacitance, inductance and transmission line segments. Lossless and lossy transmission line circuit modeling. High-frequency and high-speed behavior of passive components. Frequency spectrum of digital signals. Digital device driver and receiver modeling. Transmission line impedance discontinuity and termination techniques. Electric and magnetic field coupling mechanisms for capacitive and inductive crosstalk. Ground noise, power plane noise and resonance. Signal and power integrity issues in high-speed digital systems at both the printed-circuit board and chip levels.

ECE 351 Analog Electronics 3R-3L-4C F,W
Graduate Studies Eligible: No
Prerequisites: ECE 205, and ECE 250
Corequisites: There are no corequisites for this course.

Amplifier design and analysis including discrete and integrated circuit topologies. Cascaded amplifier, input and output stages, frequency response. Linear and non-linear op-amp circuits. Introduction to the non-ideal properties of op-amps. Integral laboratory.

ECE 362 Principles of Design 3R-0L-3C W,S

Graduate Studies Eligible: No

Prerequisites: ECE 204 , and ECE 205, ECE 230, and ECE 233, and ECE 250, and ECE 300

Corequisites: There are no corequisites for this course.

A formal design course that emphasizes the design process. Project management, project reporting and decision-making are learned by student teams as they carry a project through several stages of a formal design process.

ECE 370 Electric Machinery 3R-3L-4C W,S

Graduate Studies Eligible: No

Prerequisites: ECE 204

Corequisites: There are no corequisites for this course.

An introduction to electric machinery fundamentals. Operating principles and detailed analysis of single-phase and three-phase transformers, power electronics in the context of generators and motors, synchronous generators and motors, induction motors and generators, and dc motors and generators. Integral laboratory.

ECE 371 Conventional & Renewable Energy Systems 3R-3L-4C W

Graduate Studies Eligible: No

Prerequisites: ECE 204

Corequisites: There are no corequisites for this course.

Conventional and modern sources of energy for power generation in electric power industry with the imposed economic, regulatory, and environmental constraints. Wind, solar-photovoltaic, micro-hydropower, biomass, and fuel cell systems. Integral laboratory.

ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W

Graduate Studies Eligible: No

Prerequisites: ECE 300, and MA 381

Corequisites: There are no corequisites for this course.

System properties: linearity and time-invariance. Sampling and reconstruction. Convolution in discrete-time systems. Z-transform, FIR and IIR filters. Discrete-time filter design. Discrete Fourier transform. Random Variables and Random Processes.

ECE 398 Undergraduate Projects 1-4C

Graduate Studies Eligible: No

Prerequisites: Arranged Prereq: Consent of instructor

Corequisites: There are no corequisites for this course.

Special design or research projects.

ECE 412 Software Defined Radio 4R-0L-4C See Dept Advising Site

Graduate Studies Eligible: Yes

Prerequisites: ECE 380

Corequisites: There are no corequisites for this course.

Essential concepts of wireless communications. Software defined radio (SDR) architecture. Analog and digital modulation formats. Transmitter and receiver system design and implementation methods. Synchronization techniques. Term project.

ECE 414 Wireless Systems 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: ECE 310

Corequisites: There are no corequisites for this course.

Introduction to wireless communications and networks. Wireless channel models, vector space, modulation and demodulation, optimal receiver design, equalization, channel capacity, multipleaccess techniques, spread spectrum, and multiple-antenna systems. Additional recommended prerequisite: MA371 or MA373 with a grade of B or higher.

ECE 415 Wireless Electronics 2R-6L-4C

Graduate Studies Eligible: Yes

Prerequisites: Consent of instructor

Corequisites: There are no corequisites for this course.

Design, fabrication, and testing of a high frequency transmitter-receiver system including but not limited to oscillators, mixers, filters, amplifiers, and matching networks. Integral laboratory.

ECE 416 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S

Graduate Studies Eligible: Yes

Prerequisites: Junior or Senior standing

Corequisites: There are no corequisites for this course.

Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with CHE 405, EP 410, and ME 416.

ECE 418 Fiber Optic Systems 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: ECE 310 or Consent of instructor

Corequisites: There are no corequisites for this course.

Analysis and design of common photonic systems such as fiber optic communication links, optical sensing systems, and optical networks. Topics include basic architectures, component overview, system design, and expected degradations along with mitigation techniques. An oral presentation of a technical paper is required.

ECE 419 Advanced MEMS: Modeling and Packaging 3R-3L-4C F

Graduate Studies Eligible: Yes

Prerequisites: EP 410 or equivalent course

Corequisites: There are no corequisites for this course.

Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with EP 411, and CHE 419.

ECE 420 Discrete-Time Control Systems 4R-0L-4C See Dept Advising Site

Graduate Studies Eligible: Yes

Prerequisites: ECE 320

Corequisites: There are no corequisites for this course.

Sampled systems and z-transforms. Transfer function and state-variable models of systems. Discrete-time control of systems including state variable feedback and observer construction.

ECE 425 Introduction to Mobile Robotics 3R-3L-4C W

Graduate Studies Eligible: Yes

Prerequisites: CSSE 120, and ECE 320 or ME 406 or BE 350 or CHE 340

Corequisites: There are no corequisites for this course.

This course will introduce the basic principles of mobile robotics history, theory, hardware and control. Topics will include robot components, effectors and actuators,

locomotion, sensors, feedback control, control architectures, representation, localization and navigation. This is a project-oriented course and the student will have hands-on experience with a real mobile robot. The student will be required to complete several laboratory assignments and a multidisciplinary team design project.

ECE 430 Microcontroller-Based Systems 3R-3L-4C F

Graduate Studies Eligible: Yes

Prerequisites: ECE 250* *For ECE students, consent of instructor for other students.

Corequisites: There are no corequisites for this course.

Microcontroller register set, addressing modes and instruction set. Microcontroller peripheral support modules. Assembly language and C programming. Fundamental data structures. Interrupts. Real time programming. Data communications. Microcontroller interface to displays, digital and analog devices, sensors, and actuators. Embedded system design, implementation and applications. Integrated development environment. Formal final report and oral presentation. Integral laboratory. Credit cannot be obtained for both ECE 331 and ECE 430.

ECE 433 Advanced Digital System Design with Verilog 3R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: ECE 233

Corequisites: There are no corequisites for this course.

Concepts and designs of combinational and sequential digital systems; Modern design methodology; ASM and ASMD charts for behavioral modeling; Synthesizable Verilog descriptions and synthesis techniques; Design verification and functional simulations; FPGA implementations of digital systems; Timing analysis and constraints; Storage devices; Implementation options; I/O clocking techniques; Synchronous and asynchronous designs; Complex digital systems; IP core applications. Integrated Development Environment. Integral laboratory.

ECE 434 Embedded Linux 3R-3L-4C W

Graduate Studies Eligible: Yes

Prerequisites: CSSE 332 or ECE 230 with a grade of B or better; or graduate standing, Operating Systems and Linux experience.

Corequisites: There are no corequisites for this course.

Brief introduction to Linux on an embedded processor. Software development in various languages (C, shell scripts, Python, JavaScript, etc.). Hardware interfacing. Kernel development. Software tools (IDE, gcc, make, node.js, etc.)

ECE 436 Internet of Things 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: ECE 230 or CSSE 132, and ECE 312 or CSSE 432 or consent of instructor

Corequisites: There are no corequisites for this course.

Introduction to the design and development of an Internet of Things (IoT) solution. Provides breadth of knowledge on a broad range of topics, such as sensors, communication, power, cloud storage, data analysis, automation, privacy and security. Focuses on a team design project to provide a complete IoT solution for a real-world application. This is a required course for the minor in Internet of Things for students earning a primary or secondary major in EE, CPE, CS, or SE. Students cannot earn credit for both MDS210 and ECE436.

ECE 452 Power Electronics 3R-3L-4C F

Graduate Studies Eligible: Yes

Prerequisites: ECE 250

Corequisites: There are no corequisites for this course.

Analysis and design of networks that use electronic devices as power switches. Silicon-controlled rectifiers, power transistors, power MOSFETS, and IGBTs are used to form phase-controlled rectifiers, AC voltage controllers, choppers, and inverters. Integral laboratory.

ECE 454 System Level Analog Electronics 3R-3L-4C W

Graduate Studies Eligible: No

Prerequisites: ECE 351

Corequisites: There are no corequisites for this course.

Analysis and design of Op-Amp circuits: wave shaping circuits, Schmitt triggers, power amplifiers, high power buffers, controlled current sources, peak detectors, sample and hold circuits. Precision Op-Amp Circuits. Non-ideal properties of Op-Amps. Integral laboratory.

ECE 460 Engineering Design I 1R-6L-3C F

Graduate Studies Eligible: No

Prerequisites: ECE 362, and either ECE 230*, and ECE 310*, and ECE 320*, and ECE 341*, and ECE 351*, and ECE 370* or ECE 371*, and ECE 380* or CSSE 332**, and CSSE 230**, and ECE 250**, and ECE 230**, and ECE 312**, and ECE 332**, and ECE 343**, and either ECE 380** or ECE 320** and *For EE: Prereq or concurrent registration in the remainder of course. **For CPE: Prereq or concurrent registration in the remainder of course.

Corequisites: There are no corequisites for this course.

A continuation of a sequence of formal design courses that emphasizes completion of a client-driven project using a formal design process. Student teams carry a project from inception to completion to satisfy the need of a client. Integral laboratory.

ECE 461 Engineering Design II 1R-9L-4C W

Graduate Studies Eligible: No

Prerequisites: ECE 460

Corequisites: There are no corequisites for this course.

Continuation of the design project from ECE460. Integral laboratory.

ECE 462 Engineering Design III 1R-3L-2C W,S

Graduate Studies Eligible: No

Prerequisites: ECE 461

Corequisites: There are no corequisites for this course.

Completion of the design project from ECE 460 and ECE 461. Integral laboratory.

ECE 470 Power Systems Analysis I 3R-3L-4C F

Graduate Studies Eligible: Yes

Prerequisites: ECE 370

Corequisites: There are no corequisites for this course.

Modeling of power system components that encompass transmission lines, power transformers, synchronous generators, and loads for power system representation and per unit analysis. Formulation of power system representation in the context of power flow analysis. The industry standard Siemens-PTI PSS/E software package will be used for solutions of the large-scale power flow. Economic dispatch by optimum allocation of generation, control of system voltage profile, and real and reactive power flow control by tap-changing transformers. Integral laboratory.

ECE 471 Power Systems Analysis II 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: ECE 470

Corequisites: There are no corequisites for this course.

Modeling of power system components that encompass transmission lines, power transformers, synchronous generators for analysis of power systems during balanced and unbalanced faults/short-circuits with symmetrical components. The industry standard ASPEN One-Liner software package will be used for simulation of large-scale faulted systems. Power system grounding and its impact on fault levels. Power system stability and generator rotor dynamics phenomenon with use of equal-area criterion. Modern approaches to power system stability analysis are introduced. Integral laboratory.

ECE 472 Power Systems Protection 3R-3L-4C S

Graduate Studies Eligible: Yes

Prerequisites: ECE 470, and ECE 471

Corequisites: There are no corequisites for this course.

Design and application of relaying schemes for protection of transformers, buses, distribution lines, transmission lines, generators, motors, capacitors, and reactors. Integral laboratory.

ECE 473 Control of Power Systems 3R-3L-4C W

Graduate Studies Eligible: Yes

Prerequisites: Senior standing or consent of instructor

Corequisites: There are no corequisites for this course.

Principles of interconnected operation of power systems. Optimum scheduling of generation using economic dispatch and unit commitment. Primary and secondary load-frequency control. Voltage and reactive-power flow control. Principles of state estimation. Integral laboratory.

ECE 480 Introduction to Image Processing 3R-3L-4C W

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Basic techniques of image processing. Discrete and continuous two dimensional transforms such as Fourier and Hotelling. Image enhancement through filtering and histogram modification. Image restoration through inverse filtering. Image segmentation including edge detection and thresholding. Introduction to image encoding. Relevant laboratory experiments.

ECE 481 Electronic Music Synthesis 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: ECE 380

Corequisites: There are no corequisites for this course.

Analog synthesis techniques. Instrument control using MIDI. FM, additive and subtractive synthesis. Physical modeling and sound spatialization. Course project.

ECE 483 DSP System Design 3R-3L-4C F

Graduate Studies Eligible: Yes

Prerequisites: ECE 380, and MA 381

Corequisites: There are no corequisites for this course.

Study of finite word length effects in DSP systems. Cascaded filter structures. Coefficient quantization, roundoff noise, scaling for overflow prevention. Discrete-time noise, filtering noise, power spectral density. Polyphase filtering, interpolation and decimation. Implementation and system design and test issues for a SSB communication system. Integral laboratory based on a fixed point programming project.

ECE 497 Special Topics in Electrical Engineering 1-4C

Graduate Studies Eligible: No

Prerequisites: Arranged prerequisite consent of instructor and department head

Corequisites: There are no corequisites for this course.
Topics of current interest to undergraduate students.

ECE 498 Undergraduate Projects 1-4C
Graduate Studies Eligible: No
Prerequisites: Arranged prerequisite consent of instructor
Corequisites: There are no corequisites for this course.
Special design or research projects.

ECE 510 Error Correcting Codes 4R-0L-4C F (odd years)
Graduate Studies Eligible: Yes
Prerequisites: ECE 310* *Graduate standing or with a grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Coding for reliable digital communication. Topics to be chosen from: Hamming and BCH codes, Reed-Solomon codes, convolutional codes, Viterbi decoding, turbo codes, and recent developments, depending on interests of class and instructor. Mathematical background will be developed as needed.

ECE 511 Data Communications 4R-0L-4C F (even years)
Graduate Studies Eligible: Yes
Prerequisites: ECE 310*, and MA 381* or ECE 310**, and MA 381** *Graduate standing **with a grade of B or better in both courses, or consent of instructor
Corequisites: There are no corequisites for this course.
Design of digital communication systems. Autocorrelation function and power spectrum, vector space models of signals and noise, optimal receiver structures and performance, bandlimited channels and equalization, convolutional coding.

ECE 512 Probability, Random Processes, and Estimation 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: MA 381, and ECE 380
Corequisites: There are no corequisites for this course.
Review of probability and random variables, random vectors, topics in estimation and detection theory, linear and nonlinear estimation, orthogonality principle, hypothesis testing, random processes, stationarity, correlation functions, and spectra. Additional topics chosen from Wiener and Kalman filtering, and Markov chains.

ECE 516 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: Junior or Senior class standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with BE 516, CHE 505, EP 510, and ME 516.

ECE 519 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Graduate Studies Eligible: Yes
Prerequisites: EP 410 or equivalent course
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with ME 519, EP 511, and CHE 519.

ECE 530 Advanced Microcomputers 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: ECE 230* *Graduate standing; or with a grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
32-bit microcontroller architecture. Software development in both assembly language and C language. Hardware interfacing. Use of a real-time-operating system (RTOS). System-on-a-chip (SOC) hardware/software design using a field programmable gate array (FPGA) chip containing an embedded microcontroller cores. Software debugging tools. Integral laboratory.

ECE 531 Digital Test & Product Engineering 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: ECE 230*, and ECE 233*, and ECE 250* *Graduate standing; or with grades of B or better in all three courses; or consent of instructor.
Corequisites: There are no corequisites for this course.
Industrial testing techniques for microcontrollers and other digital integrated circuits. Includes common digital system fault modeling, test generation, and design for testability in addition to memory testing strategies. Integral labs using an industrial grade automatic test environment (ATE).

ECE 532 Advanced Topics in Computer Architecture 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: ECE 332 with a B or better.
Corequisites: There are no corequisites for this course.
Superscalar processors. Out-of-Order Execution. Register Renaming. Dynamic Random Access Memory (DRAM). Prefetching. Trace Cache. Victim Cache. 3D DRAM. Multithreading. Multicore. Cache Coherence. Transactional Memory. Performance Modeling. Power Modeling. Intel Pentium Pro Architecture. Transmeta Crusoe Architecture. Code Morphing. ARMv7 Architecture. Nvidia G80 Architecture.

ECE 534 Advanced Signal & Power Integrity 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: ECE 341*, and ECE 342* or ECE 343* *Graduate standing; or all courses with a grade of B or better; or ECE342 with a grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Signal and power integrity modeling and measurement in high-speed digital systems at IC, PCB, and chassis levels. High-frequency behavior of passive components and packages. Behavior and SPICE models of drivers and receivers. Lossy transmission lines and discontinuity characterization. Mixedmode s-parameters and other network parameters. Frequency and time-domain modeling of capacitive and inductive crosstalk. Differential signaling techniques; timing conventions. Synchronization. Signal equalization. Power plane noise and resonance. High-speed PCB design guidelines. Measurement techniques including time-domain reflectometry, vector network analyzer and impedance analyzer. PCB simulation. Full-wave simulations.

ECE 540 Antenna Engineering 3R-3L-4C W
Graduate Studies Eligible: Yes
Prerequisites: ECE 341* Graduate standing (course not required); *or with a grade of B or better; or consent of instructor.
Corequisites: There are no corequisites for this course.

Electromagnetic radiation, antenna terminology and characteristics, dipole antennas, arrays, aperture antennas, measurements, computer-aided analysis, design projects and reports.

ECE 541 Microwave/Millimeter-Wave Engineering 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: ECE 341 and Graduate standing; or with grade of B or better, or consent of instructor

Corequisites: There are no corequisites for this course.

Wave-guiding structures, microwave network analysis, scattering parameters, Z, Y and ABCD parameters, passive devices and components, design, fabrication, simulation and measurement of microwave devices and components, matching strategies, multi-conductor transmission lines and crosstalk.

ECE 542 Advanced Electromagnetics 4R-0L-4C F

Graduate Studies Eligible: Yes

Prerequisites: ECE 341 and Graduate standing; or with grade of B or better, or consent of instructor

Corequisites: There are no corequisites for this course.

Maxwell’s equations, EM field theorems, potential functions, power and energy, material properties, wave propagation, reflection and transmission, radiation, scattering, Green's functions, metamaterials and metamaterial-inspired structures, modeling & simulation, measurement technique.

ECE 543 Electromagnetic Metamaterials 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: ECE 341* Graduate standing (course not required) *or with grade of B or better; or consent of instructor

Corequisites: There are no corequisites for this course.

Electromagnetic fundamentals, control of permittivity and permeability, dispersion, causality, double-negative materials, epsilon near-zero materials, transmission line-based metamaterials, composite right/left handed wave-guiding structures, even/odd mode analysis, differential signaling, electromagnetic bandgap structures, phase control, dual band devices, enhanced bandwidth devices, zeroth-order resonators, full wave simulation, device fabrication and laboratory measurement.

ECE 551 Digital Integrated Circuit Design 3R-3L-4C F

Graduate Studies Eligible: Yes

Prerequisites: ECE 250, and ECE 233 both with a grade of B or better; or graduate standing.

Corequisites: There are no corequisites for this course.

Design, performance analysis, and physical layout of CMOS logic. Custom and standard cell methodologies. Use of commercial CAD tools. Design issues such as interconnect, timing, and testing methods. Integral laboratory and project.

ECE 552 Analog Integrated Circuit Design 3R-3L-4C W

Graduate Studies Eligible: Yes

Prerequisites: ECE 351, and ECE 380 Graduate standing; or with a grade of B or better in both courses; or consent of instructor

Corequisites: There are no corequisites for this course.

Design, performance analysis, and physical layout of analog integrated circuits. Focus on operational amplifier design and op-amp circuits. Introduction to mixed-signal circuit design such as switch-capacitors, A/D, or D/A systems. Integral laboratory and design project.

ECE 553 Radio-Frequency Integrated Circuit Design 3R-3L-4C S

Graduate Studies Eligible: Yes
Prerequisites: ECE 310, and ECE 351 Graduate standing (courses not required); or with a grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
Design, analysis, and physical layout of high-frequency analog integrated-circuits for modern RF transceivers. Circuit design for each primary transceiver component. General issues such as impedance matching and design of inductors on integrated circuits. Integral laboratory and design project.

ECE 554 Instrumentation 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: ECE 351 and Graduate standing; or with grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
Transducers and their applications. Analog signal processing techniques using operational amplifiers. A/D and D/A converters. Protection from electric shock. Measurement of biological potential waveforms (ECG, EMG, EEG, ENG, EOG, ERG). Ultrasound techniques and instrumentation. X-ray CAT techniques. No laboratory, but many in-class demonstrations and emphasis on circuit simulation.

ECE 556 Power Electronics: DC Power Supplies 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: ECE 351 and Graduate standing; or with grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
Analysis and design of AC-DC and DC-DC converters. Linear, basic switching, charge-pump, and fly-back topologies. Introduction to devices used in a power switching supplies. Thermal management. Integral laboratory.

ECE 557 Analog Test & Product Engineering 3R-3L-4C F
Graduate Studies Eligible: Yes
Prerequisites: ECE 300, and ECE 351 and Graduate standing; or with a grade of B or better in both courses, or consent of instructor
Corequisites: There are no corequisites for this course.
Fundamental skills necessary to be an industrial integrated circuit test engineer or product engineer. Includes the economics associated with testing, impact of fabrication variation on devices, instrumentation associated with industrial testing, turning a data sheet into a test plan, industrial testing techniques for analog circuits, trade-offs between test time and test accuracy, statistical analysis of the data and statistical process control, the use of device interface boards necessary to control device loading for different tests. Integral labs with an industrial grade automatic tester (ATE).

ECE 558 Mixed-Signal Test & Product Engineering 3R-3L-4C W
Graduate Studies Eligible: Yes
Prerequisites: ECE 300, and ECE 233, and ECE 351 and Graduate standing; or with grades of B or better in all three courses; or consent of instructor.
Corequisites: There are no corequisites for this course.
Industrial testing techniques for AC and DC tests of mixed-signal integrated circuits using an automatic test environment (ATE). Includes the structure and operation of comparators and standard data converters (DACs, ADCs), common data converter datasheet specifications, impact of data converter design on testing strategies, and statistical analysis of accuracy-time trade-offs. Integral labs using an industrial grade ATE.

ECE 580 Digital Signal Processing 4R-0L-4C W

Graduate Studies Eligible: Yes
Prerequisites: ECE 380, and MA 381 *Graduate standing (courses not required); or with grade of B or better in both courses; or consent of instructor. MA367 with a grade of B or higher recommended.
Corequisites: There are no corequisites for this course.
Digital filters. Fundamental concepts of digital signal processing. Analysis of discrete-time systems. Sampling and reconstruction. Theory and application of z-transforms. Design of recursive and nonrecursive digital filters. Window functions. Discrete Fourier transforms and FFT algorithm.

ECE 581 Digital Signal Processing Projects 2R-2L-2 or 4C
Graduate Studies Eligible: Yes
Prerequisites: ECE 580 or concurrent registration
Corequisites: There are no corequisites for this course.
Computer-aided design of digital filters and other DSP modules. Software and hardware realization using modern DSP chips. DSP chip architectures, C-language programming, and interfacing techniques. Optional advanced project may be done to earn four credit hours; otherwise two credit hours are given. Integral laboratory.

ECE 582 Advanced Image Processing 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CSSE 120 or Senior standing or Graduate standing
Corequisites: There are no corequisites for this course.
Introduction to image segmentation and recognition. Use of neural networks, fuzzy logic and morphological methods for feature extraction. Advanced segmentation, detection, recognition and interpretation. Relevant laboratory experiments and required project. Cross-listed with OE 537.

ECE 584 Medical Imaging Systems 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: ECE 300* or BE 321 or OE 392 *Graduate standing; or ECE300 with grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
Engineering principles of major imaging techniques/modalities for biomedical applications and health care including diagnostic x-ray, computed tomography, nuclear techniques, ultrasound, and magnetic resonance imaging. Topics include general characteristics of medical images; physical principles, signal processing to generate an image, and instrumentation of imaging modalities. Clinical applications of these technologies are also discussed. Cross-listed with BE541 and OE584.

Prerequisite Notes:

Prerequisites - Clarification:
ECE 300 - Continuous-Time Signals & Systems and Graduate standing;
or ECE 300 Continuous-Time Signals & Systems with a grade of B or better
or BE 340 – Biomedical Signal Processing
or OE 392 – Linear Optical Systems with a grade of B or better;
or consent of instructor

ECE 596 Independent Study in Electrical Engineering 1C-4C
Graduate Studies Eligible: Yes
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.

Special research or project based work that is done in consultation with a faculty member. Participation in these projects should require a graduate level of involvement and expectations, otherwise ECE498 Undergraduate Projects should be used. No more than 8 credit hours of ECE596 can be counted towards a graduate degree in the ECE Department without ECE Department Head Approval.

ECE 597 Special Topics in Electrical Engineering 4C
Graduate Studies Eligible: Yes
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Special topics courses of current interest to graduate students and senior undergraduates.

ECE 598 Thesis Research 1-4C
Graduate Studies Eligible: Yes
Prerequisites: Arranged
Corequisites: There are no corequisites for this course.
Thesis topic selected in consultation with adviser. Graduate students only.

ECE 699 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The work experiences should be informative or integral to the advancement or completion of the student's program requirements. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

Engineering Design - Course Descriptions

ENGD 100 Design and Communication Studio 6R-10L-8C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Integrates rhetorical analysis, research methods, and the conventions of academic writing into the design process. Introduces disability studies, a multi-disciplinary field that identifies, challenges, and re-conceptualizes representations of disability. Includes problem definition, analysis, alternate solutions, and specifications of final solutions. Uses sketching, computer-aided drawings, and traditional orthographic drawings to communicate design decisions. Introduces teamwork through group design efforts and instruction. Successful completion of this studio satisfies the requirements of HUM H140, EM 103, and EM 104. Students may not receive credit towards graduation for both ENGD 100 and any of HUM H140, EM 103, and EM 104.

ENGD 101 Representations of Design Studio 1R-5L-2C Not offered
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Uses sketching, computer-aided drawings, and traditional orthographic drawings to develop and communicate design decisions. Emphasizes design intent. Successful

completion of ENGD 101 satisfies the requirements of EM 104. Students may not receive credit towards graduation for both ENGD 101 and EM 104.

ENGD 102 Design Realization Studio 1R-5L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Includes problem definition, stakeholder analysis, design and manufacturing processes, prototyping, and communicating the design. Successful completion of ENGD 102 satisfies the requirements of EM 103. Students may not receive credit towards graduation for both ENGD 102 and EM 103.

ENGD 103 Designing for Disabilities Studio 4R-0L-4C Not offered

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Introduces disability studies, a multi-disciplinary field that identifies, challenges, and re-conceptualizes representations of disability. Integrates concepts from ENGD 101 and ENGD 102 to meet the needs of a client with disabilities. Includes ethnographic observations. Successful completion of ENGD 103 satisfies the requirements of HUM H140. Students may not receive credit towards graduation for both ENGD 103 and HUM H140.

ENGD 110 Circuits, Software Development, and Societal Impact Design Studio 4R-12L-6C W

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Extends the design process to include the development of software, the use of instrumentation and measurement techniques, and the consideration of scientific research and technological development within cultural, historical, and social contexts and values. Introduces fundamental principles and techniques of programming, including classes, objects, and methods. Surveys types of sensors and basic principles of circuit design (including Ohm’s Law, Kirchoff’s Laws). Supplies context in ideas about technical progress and scientific facts, the role of design in social institutions, and issues of gender facing technical professionals and knowledge domains. Students may not receive credit towards graduation for both ENGD110 and any of BE 121, CSSE 120, ES 213, ES 213L, or HUM H190.

ENGD 111 Science, Technology, and Society in Design 02R-0L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Considers scientific research and technological development with cultural, historical, and social contexts and values. Examines role of metrics in design. Successful completion of ENGD 111 and ENGD 121 satisfies the requirements of HUM H190. Students may not receive credit towards graduation for ENGD 111 and HUM H190.

ENGD 112 DC Circuits 1R-6L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Introduces the fundamentals of DC circuit design and analysis. DC circuit analysis tools such as Kirchhoff’s laws, mesh and nodal analysis, superposition, and source transformations are utilized. Surveys types of sensors and basic principles of circuit

design. Successful completion of ENGD 112 satisfies the requirements of BE 121. Students may not receive credit towards graduation for both ENGD 112 and any of BE 121, ES213, or ES213L.

ENGD 113 Software Development Principles 1R-6L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

An introduction to procedural and object-oriented programming with an emphasis on problem solving. Problems may include visualizing scientific or commercial data, interfacing with external hardware such as robots, or solving numeric problems from a variety of engineering disciplines. Introduces fundamental principles and techniques of programming, including classes, objects, and methods. Successful completion of ENGD 113 and ENGD 123 satisfies the requirements of CSSE 120. Students may not receive credit towards graduation for both ENGD 113 and CSSE 120.

ENGD 120 Integrating Electrical, Software, and Societal Systems 4R-12L-6C S

Graduate Studies Eligible: No

Prerequisites: ENGD 110

Corequisites: There are no corequisites for this course.

Continues the design process with software development, instrumentation and measurement techniques, and cultural, historical, and social contexts and values surrounding scientific and technological development work. Adds more advanced programming concepts (implicit loops and conditionals) and tasks of software development (such as development of user interfaces). Includes use of electronic components (op amps, capacitors, inductors) and signal processing (amplifiers and filters). Social contexts for analysis of technology and its history include gender and work. Students may not receive credit towards graduation for ENGD120 and any of CSSE120, ES213, or HUM H190. Successful completion of ENGD110 and ENGD120 satisfies the requirements of BE 131, ES213, ES213L, CSSE120, and HUM H190.

ENGD 121 Science, Technology, and Society in Design 2R-0L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: ENGD 110 or ENGD 111

Corequisites: There are no corequisites for this course.

Considers scientific research and technological development with cultural, historical, and social contexts and values. Scheduled with ENGD 122 and ENGD 123. Successful completion of ENGD 111 and ENGD 121 satisfies the requirements of HUM H190. Students may not receive credit towards graduation for both ENGD 121 and HUM H190.

ENGD 122 AC Circuits 1R-6L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: ENGD 110 or BE 121 or ENGD 112

Corequisites: There are no corequisites for this course.

This course introduces the fundamentals of AC circuit design and analysis. Topics include RLC circuits, equivalent impedance, phasor domain analysis (nodal analysis, mesh current, source superposition, source transformation), and Thevenin and Norton theorems. The concept of linear systems and the use of electronic components (op-amps, capacitors, inductors) will also be introduced. Successful completion of ENGD 122 satisfies the requirements of BE 131. Students may not receive credit towards graduation for both ENGD 122 and any of BE 131, ES213, or ES213L.

ENGD 123 Software Development Principles 1R-6L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: ENGD 110 or ENGD 113
Corequisites: There are no corequisites for this course.
Adds more advanced programming concepts (implicit loops and conditionals) and tasks of software development (such as development of user interfaces). Successful completion of ENGD 113 and ENGD 123 satisfies the requirements of CSSE 120. Students may not receive credit towards graduation for both ENGD 123 and CSSE 120.

ENGD 150 Independent Design Project 1R-2L-2C S
Graduate Studies Eligible: No
Prerequisites: ENGD majors only
Corequisites: There are no corequisites for this course.
Selected design projects. May include computer-aided design, testing, or design methodology. Plan of study for students' specialization must be approved.

ENGD 151 Problem Solving and Data Representation 0.5R-1.5L-1C S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Discusses scientific data representation. Examines efficient methods for acquiring a new programming language. Uses both Excel and MATLAB for problem solving and data representation.

ENGD 190 Selected Topics in Engineering Design 1-4C Arranged F,W,S
Graduate Studies Eligible: No
Prerequisites: ENGD majors only, approval of director, advisor, and course instructor
Corequisites: There are no corequisites for this course.
Selected design projects. Projects may emphasize certain phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 199 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student’s academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as “S” satisfactory, or “U” unsatisfactory based on the written report of the professional experience.

ENGD 200 Systems Accounting and Modeling I 2R-0L-2C W
Graduate Studies Eligible: No
Prerequisites: MA 111 or
Corequisites: There are no corequisites for this course.
Covers systems accounting and modeling approach to engineering science, conservation of mass, linear and angular momentum. 2D and 3D vectors will be introduced and reinforced with examples.

ENGD 205 Systems Accounting and Modeling I 3R-0L-3C W
Graduate Studies Eligible: No
Prerequisites: MA 111
Corequisites: There are no corequisites for this course.
Covers systems accounting and modeling approach to engineering science, conservation of mass, linear and angular momentum. 2D and 3D vectors will be introduced and reinforced with examples. Basic stress-strain, impact/impulse, relative motion, and tipping will be covered.

ENGD 210 Systems Accounting and Modeling II 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: ENGD 200 or EM 121 or equivalent
Corequisites: There are no corequisites for this course.
A common framework for engineering analysis is extended using the concepts of a system, accounting and conservation of extensive properties, constitutive relations, constraints, and modeling assumptions. Stress, strain, and deformation under axial loading are defined. Equilibrium is defined. Conservation equations for mass, charge, momentum and energy, and an entropy accounting equation are developed. Applications are developed from multiple engineering disciplines. Students may not receive credit towards graduation for both ENGD210 and ES201.

ENGD 215 Systems Accounting and Modeling II 3R-0L-3C S
Graduate Studies Eligible: No
Prerequisites: ENGD 205 or EM 121 or equivalent
Corequisites: There are no corequisites for this course.
This course is a continuation of ENGD 205 and emphasizes engineering problem solving using common engineering science concepts: systems, conservation and accounting principles for extensive properties, material properties, constitutive equations, and physical constraints. This framework, combined with appropriate mathematics, provides a powerful tool for modeling and predicting the behavior of the physical world. The course introduces two- and three-dimensional force systems, equilibrium, distributed forces, and strength and elastic deflection of engineering materials under axial loading. Students may not receive credit towards graduation for both ENGD215 and ES201.

ENGD 240 User Experience Design Studio 4R-12L-6C W
Graduate Studies Eligible: No
Prerequisites: ENGD 120
Corequisites: There are no corequisites for this course.
Provides students with instruction and practice in analyzing contexts, audiences, and genres. Stakeholder analysis will be emphasized. SCRUM project management techniques will be introduced. Object-oriented programming concepts, including the use of inheritance, interfaces, polymorphism, abstract data types, and encapsulation to enable software reuse and assist in software maintenance will be introduced. Habits of rhetorical analysis, skills in teaming and collaboration, and techniques for presenting content and evidence will be presented. Systems engineering models will be integrated with software development. User experience and usability testing will be emphasized. Students may not receive credit toward graduation for ENGD 240 and either ENGL H290 or CSSE 220.

ENGD 241 Technical Communication in Design 2R-0L-2C Not offered
Graduate Studies Eligible: No
Prerequisites: See below
Corequisites: There are no corequisites for this course.
Habits of rhetorical analysis, skills in teaming and collaboration, and techniques for presenting content and evidence will be presented. User experience and usability testing will be emphasized. Students may not receive credit toward graduation for both ENGD 241 and ENGL H290.

ENGD 242 Design Thinking 1R-6L-2C Not offered
Graduate Studies Eligible: No
Prerequisites: See below
Corequisites: There are no corequisites for this course.

This course expands design processes to include decision making, design of experiments, and additional processes for monitoring customer requirements.

ENGD 243 Software Development Principles 1R-6L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: See below

Corequisites: There are no corequisites for this course.

SCRUM project management techniques will be introduced. Object-oriented programming concepts, including the use of inheritance, interfaces, polymorphism, abstract data types, and encapsulation to enable software reuse and assist in software maintenance will be introduced. Systems engineering models will be integrated with software development. User experience and usability testing will be emphasized. Students may not receive credit toward graduation for both ENGD 243 and CSSE 220.

ENGD 250 Human Computer Interfaces Studio 4R- 12L-6C S

Graduate Studies Eligible: No

Prerequisites: ENGD 240

Corequisites: There are no corequisites for this course.

Extends the design process to include development of human-computer (HCI) interfaces. Continues with object-oriented programming concepts such as use of common object-based data structures, including stacks, queues, lists, trees, sets, maps, and hash tables. Space/time efficiency analysis. Testing. Introduction to UML. Crafting documents to meet the demands and constraints of professional situations; integrating all stages of the writing process; and collaborating effectively within and across teams will be emphasized. Systems engineering models will be used. Successful completion of both ENGD 240 and ENGD 250 meet the prerequisite requirements of ENGL H290 and CSSE 220. Students may not receive credit toward graduation for both ENGD 250 and either of ENGL H290 or CSSE 220.

ENGD 251 Technical Communication in Design II 2R-0L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: See below

Corequisites: There are no corequisites for this course.

Crafting documents to meet the demands and constraints of professional situations; integrating all stages of the writing process; user experience; usability testing; and collaborating effectively within and across teams will be emphasized. Successful completion of ENGD 241 and ENGD 251 meets the requirements of ENGL H290. Students may not receive credit toward graduation for both ENGD 251 and ENGL H290.

ENGD 252 Design of Human-Computer Interfaces 1R-6L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: See below

Corequisites: There are no corequisites for this course.

Extends the design process to include development of human-computer (HCI) interfaces. User experience will be emphasized.

Prerequisite Notes:

ENGD 240, or both CSSE 220 and ENGD 241, or both ENGD 241 and ENGD 243

ENGD 253 Software Development Principles 1R-6L-2C Not offered

Graduate Studies Eligible: No

Prerequisites: See below

Corequisites: There are no corequisites for this course.

Continues with object-oriented programming concepts such as use of common object-based data structures, including stacks, queues, lists, trees, sets, maps, and hash tables. Space/time efficiency analysis. Testing. Introduction to UML. Successful completion of ENGD 243 and ENGD 253 meets the requirements of CSSE 220. Students may not receive credit toward graduation for both ENGD 253 and CSSE 220.

Prerequisite Notes:

ENGD 240, or both CSSE 220 and ENGD 241, or both ENGD 241 and ENGD 243

ENGD 260 Product Design Studio 4R-12L-6C F
Graduate Studies Eligible: No
Prerequisites: ENGD 100 or equivalent
Corequisites: There are no corequisites for this course.
Continues the design process by examining the interactions between design and manufacturing from the designer's point of view. Common manufacturing processes will be introduced and design guidelines will be developed for each process. Emphasizes a systems engineering approach for new product development. Applies several design methods to integrate concepts of form and function to realize value for the user. Explores the intersections of beauty and utility in design. Visceral, behavioral, and reflective aspects of emotional design are examined.

ENGD 270 Vertically Integrated Project I 1R-2L-2C W
Graduate Studies Eligible: No
Prerequisites: ENGD majors only
Corequisites: There are no corequisites for this course.
This course emphasizes ethics, professionalism, and codes and standards. Students apply concepts to an external situation, either with other majors and/or students in other academic years.

ENGD 271 Design Testing 1R-2L-2C S
Graduate Studies Eligible: No
Prerequisites: ENGD majors only
Corequisites: There are no corequisites for this course.
Students write test plans, conduct experimentation, and reflect on the results.

ENGD 290 Selected Topics in Engineering Design 1-4C Arranged F,W,S
Graduate Studies Eligible: No
Prerequisites: ENGD majors only, approval of director, advisor, and course instructor
Corequisites: There are no corequisites for this course.
Selected design projects. Projects may emphasize certain phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 300 Engineering Practicum I 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: Student must obtain professional work experience such as an internship or co-op
Corequisites: There are no corequisites for this course.
Requires in-depth experience in engineering design processes. May emphasize certain phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 301 Creative Design Practicum 4R-0L-4C See department
Graduate Studies Eligible: No

Prerequisites: Student must obtain professional employment such as an internship or co-op.
Corequisites: There are no corequisites for this course.
Applies creativity techniques to the student's work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 302 Human Factors Practicum 4R-0L-4C See department
Graduate Studies Eligible: No
Prerequisites: Student must obtain professional employment such as an internship or co-op.
Corequisites: There are no corequisites for this course.
Human factors engineering aims to improve human interaction with systems by enhancing safety (reducing the risk of injury), performance (increasing productivity), and satisfaction (acceptance, comfort). Students will learn and be able to identify critical human factors in a system that affect safety, performance, and satisfaction. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling. Students may not receive credit for both ENGD 302 and EGMT 540.

ENGD 303 Systems Architecture Practicum 4R-0L-4C See department
Graduate Studies Eligible: No
Prerequisites: Student must obtain professional employment such as an internship or co-op.
Corequisites: There are no corequisites for this course.
This class will introduce students to the art and science of systems architecting, where systems architecting refers to uncovering the fundamental structure of a system (functional, physical, logical, operational) defined in terms of system's elements, interfaces, processes, constraints, and behaviors that must operate under specific requirements and constraints. Focus will be placed on investigating the broader meaning of architectures, as they relate to organizations and businesses, in addition to engineered systems and products. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling. Students may not receive credit for ENGD 303 and either of EMGT 464 or EMGT 564.

ENGD 304 Material Properties Practicum 2R-0L-2C See department
Graduate Studies Eligible: No
Prerequisites: Student must obtain professional employment such as an internship or co-op.
Corequisites: There are no corequisites for this course.
Introduces properties of metals, ceramics, polymers, and composites. Describes the similarities and differences in the mechanical properties, structure, and processing. Relates material processing to properties through underlying material structure. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 305 Material Selection Practicum 2R-0L-2C See department
Graduate Studies Eligible: No

Prerequisites: ENGD 304 or ME 328 or CHE 315 or BE 233 or CE 320 and student must obtain professional employment such as an internship or co-op.
Corequisites: There are no corequisites for this course.
Explains the definition of common mechanical properties and identifies when a property is important for a given component or application. Carries out design translation to define the function, constraints, objectives, and free variables of an engineering component. Selects the best material for a given application considering all classes of materials including metals, ceramics, polymers, and composites. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 306 Parametric & Equation Based Modeling Practicum 2R-0L-2C See department

Graduate Studies Eligible: No
Prerequisites: EM 104 or ENGD 100 and student must obtain professional employment such as an internship or co-op.
Corequisites: There are no corequisites for this course.
Students will supplement their prior SolidWorks CAD tool knowledge by 1) using advanced modeling techniques like parametric modeling and equation-based design, 2) designing, modeling, and analyzing complex mechanical parts and assemblies using techniques like top-down design, and 3) modeling common, but complex geometries like thread. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 307 Curves and Surfaces Practicum 2R-0L-2C See department

Graduate Studies Eligible: No
Prerequisites: EM 104 or ENGD 100 or BE 118 or ENGD 101 ; and student must obtain professional employment such as an internship or co-op.
Corequisites: There are no corequisites for this course.
Students will supplement their prior SolidWorks CAD tool knowledge by practicing the fundamentals of curve and surface design and designing parts with surfaces. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 308 Lean Manufacturing Process Fundamental Practicum 2R-0L-2C See department

Graduate Studies Eligible: No
Prerequisites: Student must obtain professional employment such as an internship or co-op.
Corequisites: There are no corequisites for this course.
An overview of fundamental lean concepts and application of concepts across value streams. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 309 Lean Manufacturing Kaizen Fundamentals Practicum 2R-0L-2C

Graduate Studies Eligible: No
Prerequisites: ENGD 308 and student must obtain professional employment such as an internship or co-op.

Corequisites: There are no corequisites for this course.
Application of lean concepts at a workstation. Requires Lean Manufacturing Process Fundamentals. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 310 Design for Assembly Practicum 2R-0L-2C See department

Graduate Studies Eligible: No

Prerequisites: EM 204 or BE 222 or EM 203 ; and student must obtain professional employment such as an internship or co-op.

Corequisites: There are no corequisites for this course.
Application of the Boothroyd and Dewhurst methods for estimating assembly costs and designing products for improved assembly and maintenance. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 311 Tolerance Analysis and Application Practicum 2R-0L-2C See department

Graduate Studies Eligible: No

Prerequisites: EM 104 or BE 118 or ENGD 101 or ENGD 100 ; and student must obtain professional employment such as an internship or co-op.

Corequisites: There are no corequisites for this course.
This is an introductory course in tolerance analysis. Students will perform tolerance calculations by hand and using CAD tools. Students will also use worst-case and statistically based techniques to analyze tolerance problems, assembly shift, and make design decisions. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 312 Design for Sheet Metal Fabrication Practicum 2R-0L-2C See department

Graduate Studies Eligible: No

Prerequisites: EM 104 or BE 118 or ENGD 101 or ENGD 100 ; and student must obtain professional employment such as an internship or co-op.

Corequisites: There are no corequisites for this course.
Introduction to methods and guidelines for designing sheet metal parts. Students will use CAD tools to design and analyze manufacturable parts. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 313 Design for Metal Forming Practicum 2R-0L-2C See department

Graduate Studies Eligible: No

Prerequisites: EM 104 or BE 118 or ENGD 100 or ENGD 101 ; and student must obtain professional employment such as an internship or co-op.

Corequisites: There are no corequisites for this course.
Introduction to methods and guidelines for designing extruded and forged parts. Students will use CAD tools to design and analyze manufacturable parts. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling. Introduction to methods and guidelines for designing extruded and forged parts. Students will use

CAD tools to design and analyze manufacturable parts. Students will apply course concepts to their work environment. The work environment must contain some phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 390 Selected Topics in Engineering Design 1-4C Arranged F,W,S
Graduate Studies Eligible: No
Prerequisites: ENGD majors only, approval of director, advisor, and course instructor
Corequisites: There are no corequisites for this course.
Selected design projects. Projects may emphasize certain phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

ENGD 490 Selected Topics in Engineering Design 1-4C Arranged F,W,S
Graduate Studies Eligible: No
Prerequisites: ENGD majors only, approval of director, advisor, and course instructor
Corequisites: There are no corequisites for this course.
Selected design projects. Projects may emphasize certain phases of the design process such as stakeholder analysis, conceptual design, risk analysis, detail design, manufacturing, testing, validation, or recycling.

Engineering Mechanics - Course Descriptions

EM 102 Graphical Communications for Civil Engineers 1R-2L-2C S
Graduate Studies Eligible: No
Prerequisites: CE major only or consent of instructor
Corequisites: There are no corequisites for this course.
Introduces the basic techniques used in engineering and scientific communication. Topics will include sketching of pictorials, computer-aided drawing, orthographic drawings, auxiliary views, reading engineering drawings and using electronic forms of communication. Focus on civil engineering applications.

EM 103 Introduction to Design 1R-3L-2C S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the engineering design process including problem definition, analysis, alternate solutions, specifications of final solution, and techniques of oral and written communications. Stresses the importance of teamwork through group design efforts.

EM 104 Graphical Communications 1R-2L-2C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the basic techniques used in engineering and scientific communication. Topics will include sketching of pictorials, computer-aided drawing, orthographic drawings, auxiliary views, reading engineering drawings and using electronic forms of communication.

EM 120 Engineering Statics 4R-0L-4C F, S
Graduate Studies Eligible: No
Prerequisites: MA 111
Corequisites: There are no corequisites for this course.

Covers two- and three-dimensional force systems, equilibrium, structures, distributed forces, shear and bending moment diagrams, friction, and area moments of inertia. Emphasizes free-body diagrams.

EM 121 Statics & Mechanics of Materials I 4R-0L-4C F, W, S

Graduate Studies Eligible: No

Prerequisites: MA 111

Corequisites: There are no corequisites for this course.

Covers two- and three-dimensional force systems, equilibrium, structures, distributed forces, and strength and elastic deflection of engineering materials due to loads applied axially. Emphasizes free-body diagrams.

EM 202 Dynamics 4R-0L-4C F

Graduate Studies Eligible: No

Prerequisites: MA 112, and EM 120, and PH 111

Corequisites: There are no corequisites for this course.

Kinematics and kinetics of particles in space and rigid bodies in plane motion. Applications of the principles of Newton's laws, work-energy, impulse-momentum, and conservation laws to solutions of simple two-dimensional dynamics problems.

EM 203 Mechanics of Materials 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: EM 120

Corequisites: There are no corequisites for this course.

Strength and elastic deflection of engineering materials due to loads applied axially, in torsion, in bending, and in shear. Combined stresses and principal stresses. Applications to design of beams and shafts.

EM 204 Statics & Mechanics of Materials II 4R-0L-4C F, S

Graduate Studies Eligible: No

Prerequisites: EM 121

Corequisites: There are no corequisites for this course.

Strength and elastic deflection of engineering materials due to loads applied in torsion, in bending, and in shear. Shear diagrams, bending moment diagrams, and area moments of inertia. Combined stresses and principal stresses. Applications to design of beams and shafts.

EM 301 Fluid Mechanics 4R-0L-4C S

Graduate Studies Eligible: No

Prerequisites: EM 202

Corequisites: There are no corequisites for this course.

Covers fluid properties, fluid statics, fluid dynamics, including pipe flow, and turbomachinery. Stresses the control volume approach, Eulerian description of flow, and conservation principles (mass, momentum, and energy).

EM 304 Advanced CAD | Professional Certification 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: EM 104 or ENGD 100 or BE 118

Corequisites: There are no corequisites for this course.

This course covers advanced solid modeling techniques using SolidWorks. It is structured around the certification sequence offered by SolidWorks, and students will become officially certified by SolidWorks in a variety of modeling techniques by the end of the quarter. There are no exams in this course, but students must complete several levels of SolidWorks certification in order to pass. The course also includes two design/ build projects in order to hone the CAD modeling skills of the students.

EM 305 Advanced CAD | Parametric and Equation Driven Design 4R-0L-4C F

Graduate Studies Eligible: No
Prerequisites: EM 104 or ENGD 100 or BE 118, and either ES 201 or ENGD 215 or BE 132, and either EM 204 or BE 222
Corequisites: There are no corequisites for this course.
This course builds on student CAD knowledge in the areas of parametric and equation driven modeling.?Students will apply these techniques to leverage design reuse, build models that respond to changing engineering requirements, and capture both engineering performance and geometry of commonly engineered products and features such as threaded fasteners and snap-fits.?

EM 402 Three-Dimensional Dynamics 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: ES 214
Corequisites: There are no corequisites for this course.
Introduces the kinematics and dynamics of particles and rigid bodies undergoing three-dimensional motion. Topics include the application of linear and angular momenta conservation, energy, Euler angles and other representations of a rotation, and numerical simulation of equations of motion. Additional topics may be added as needed.

EM 403 Advanced Mechanics of Materials 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: ME 480, and MA 221
Corequisites: There are no corequisites for this course.
Establishes the tensor formulation of Generalized Hooke's Law for 3D linear elastic materials. Explores the physical meaning of von Mises failure theory through specialized stress measures (such as hydrostatic stress, octahedral stress, and distortional stress). Explores the use of strain gauges to estimate component stress states. Uses the equations of compatibility to set up the classical formulation of elasticity problems. Establishes mathematical solutions to the plane stress and plane strain problems to derive stress concentration factors.

EM 406 Vibration Analysis 3R-3L-4C F
Graduate Studies Eligible: No
Prerequisites: ES 205
Corequisites: There are no corequisites for this course.
Dynamic analysis of vibrating mechanical systems. Includes studies of single- and multi-degree-of-freedom, damped and undamped systems in both free and forced motion. Applications to vibration isolation and absorption. Lab experiences emphasize the collection, processing, and interpretation of time-response and frequency-response data from sine sweeps and roving hammer tests. Explores numerical modal analysis using CAD software with finite element analysis capabilities.

EM 493 Selected Topics in Engineering & Technology As assigned See Department
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics arranged by instructor.

EM 501 Topics in Fluid Mechanics Arranged See Department
Graduate Studies Eligible: No
Prerequisites: ME 401 or consent of instructor
Corequisites: There are no corequisites for this course.
Course may be repeated for different topics in fluid mechanics.

EM 502 Advanced Dynamics 4R-0L-4C See Department

Graduate Studies Eligible: No
Prerequisites: ES 205
Corequisites: There are no corequisites for this course.
Kinematics and dynamics of particles and rigid bodies in two- and three-dimensional motion. Includes Lagrangian and Hamiltonian formulation of equations of motion. Applications to conservative, nonconservative, holonomic and non-holonomic systems.

EM 503 Advanced Vibration Analysis 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: EM 406
Corequisites: There are no corequisites for this course.
Dynamic analysis of multiple-degree-of-freedom lumped parameter vibrating systems as well as continuous systems. Lagrange's equations of motion. Applications include numerical methods and matrix formulation. Introduction to nonlinear and random vibration analysis. Methods of Rayleigh and Rayleigh-Ritz.

EM 505 Theory of Elasticity 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: EM 203 or EM 204
Corequisites: There are no corequisites for this course.
Introduces the classical formulation of problems in elasticity. Emphasizes the derivation and the applications of the basic constitutive equations of elasticity such as strain-displacement, equilibrium, compatibility, and stress-strain. Covers St. Venant's problems, energy principles, and variational methods.

EM 508 Energy Methods in Engineering Mechanics 4R-0L-4C Not Offered
Graduate Studies Eligible: No
Prerequisites: EM 403, and MA 330
Corequisites: There are no corequisites for this course.
General concepts and principles in mechanics, conservative mechanical systems, and variational methods. Applications to deformable bodies.

Engineering Management - Course Descriptions

EMGT 100 Introduction to Entrepreneurship 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course provides an overview of the principles of entrepreneurship and becoming an entrepreneur in today's society. Topics include opportunity identification, market investigation, product development, developing marketing and business plans, and understanding business, financial, and legal matters related to venture creation. Concepts from the lean startup and canvas tools will be applied.

EMGT 152 Economic Thinking for Entrepreneurs 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: ECON S151 or ECON S152 or consent of instructor
During this course students discuss the economic implications of entrepreneurial actions.

EMGT 175 Personal Finance 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.

The purpose of this course is to provide knowledge on personal finance so that students can learn how to make quality financial decisions that enable them to manage their money daily and to build wealth over a lifetime. Topical areas include saving, spending, paying taxes, and investing, with consideration of insurance to mitigate risk. This course explores conventional and online banking to establish credit and to use debt to achieve goals. Considerable attention is paid to budgeting, with an emphasis on saving for short term needs and longer-term retirement goals through investments in stocks and bonds.

EMGT 197 Special Topics in Engineering Management (1-4)R-0L-(1-4)C F, W, S

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Examines engineering management topics of current interest and/or new courses for engineering management.

EMGT 330 Introduction to Engineering Management 4R-0L-4C Undergraduate Only

Graduate Studies Eligible: No

Prerequisites: Junior standing

Corequisites: There are no corequisites for this course.

Surveys issues important to the management of engineering activities and technological organizations. Topics include such things as the relationship of engineering and technology to management disciplines, the functions of a technical manager, principles and techniques for quality processes, project management, process management, logistics, legal issues, ethics, human resources, communication and organizational behavior.

EMGT 335 Design and Value Creation 4R-0L-4C

Graduate Studies Eligible: No

Prerequisites: Junior standing

Corequisites: There are no corequisites for this course.

This course examines product planning and the design process in a unique multidisciplinary, entrepreneurial way focused on performing design in a market/social context and creating value for the stakeholders involved. Course concepts are applied to examining case examples and to developing new designs and systems. Examples of successful and unsuccessful products are examined. Grand Challenges themes will serve as the focus of the class for many of the design examples and student selected project topics.

EMGT 397 Special Topics in Engineering Management (1-4)R-0L-(1-4)C F, W, S

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Examines engineering management topics of current interest and/or new courses for engineering management.

EMGT 401 Multidisciplinary, Entrepreneurial Design I: Capture the Vision 3R-XL-4C

Graduate Studies Eligible: No

Prerequisites: Junior, Senior, or consent of instructor

Corequisites: There are no corequisites for this course.

Explores design processes characterized by interdisciplinary activity and focus on commercial success. Includes basic design processes with emphasis on data collection and specification, with special attention to the voice of the customer. Develops at least three creativity techniques and identifies sources of ideas for successful innovation.

Demonstrates procedures for assessing markets and establishing conceptual business models and describes the fundamentals of project planning and management. Addresses aspects of professional practice -- -- ethics, communication, contemporary issues, social impacts, global context and team work in the design process. Uses a team project on reverse engineering to tie together course objectives, and identifies an entrepreneurial or appropriate externally sponsored project topic for later courses. Prerequisite: Junior standing or consent of instructor. (Students completing MG 461 may not receive credit for ME 470.)

EMGT 402 Multidisciplinary, Entrepreneurial Design II: Expand the Concept 2R-XL-XC

Graduate Studies Eligible: No

Prerequisites: EMGT 401 or consent of instructor

Corequisites: There are no corequisites for this course.

Expands on the basic design process issues such as solution identification and selection and the assessment of trade-offs and impacts on health, safety, quality, environment, sustainability, and manufacturability. Applies design disciplines to a specific project by using creativity techniques, identifying sustainable competitive advantages and appropriate intellectual property protection procedures. Uses project planning methods to estimate project size and assess risks, as well as other techniques to facilitate rapid product development. Provides experiences in communication, project retrospectives and design reviews. Completes the early stages of a team selected and conducted project in entrepreneurial design that has the approval of students' home department.

EMGT 403 Multidisciplinary, Entrepreneurial Design III: Deliver the Product 2R-XL-XC

Graduate Studies Eligible: No

Prerequisites: EMGT 402 or consent of instructor

Corequisites: There are no corequisites for this course.

Further examines and applies design process disciplines, including techniques such as system modeling, optimization, statistical analysis, design of experiments, FMEA (Failure Modes and Effects Analysis), robust design, simulation and process improvement. Describes key business concepts needed for a business plan and applies them to the team projects. Uses professional project approaches such as metrics, retrospectives, design reviews and proper documentation. Emphasizes team project work with home department approval of specific discipline related design activities and with practical applications of concepts in the realization of functional prototypes or systems. Concludes with written and oral presentations of team project reports.

EMGT 427 Project Management 4R-0L-4C Undergraduate Only

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course examines the major themes of project management including defining the project, developing and monitoring a project plan, and being an effective project manager. Topics include developing project documents, estimating task durations, developing project networks and Gantt charts, reducing project duration, and project tracking. Course topics and approaches align with the Project Management Institute (PMI) body of knowledge. A software tool is used to develop project plans and explore resource allocation and leveling. Effective project management is explored through assignments and leadership scenarios.

EMGT 432 Technical Entrepreneurship 4R-0L-4C

Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the principles and tools for innovation and entrepreneurship in technologically based businesses. Includes perspectives for both independent entrepreneurs and intrapreneurs. Develops basic concepts of business planning. Emphasizes a major group business plan based upon a technological innovation. May be used as a management core class.

EMGT 445 Quality Methods 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: MA 223 or MA 382 or consent of instructor.
Corequisites: There are no corequisites for this course.
Introduction to various aspects of quality control and statistical process control (SPC) to include the following topics: history of quality control, Deming and his management philosophies, review and development of statistical tools and probability methods associated with quality control and SPC, development and application of control charts for continuous and discrete data, time-weighted control charts, identification of common cause variation in a process, identification and removal of special cause variation in a process, data transformations and distribution modeling, rational subgrouping, process capability analysis, and the use of statistical software for data analysis and SPC. The use of real-world data in exercises will be emphasized. Other topics to be included as time allows: Six Sigma methodology and language, general measurement system analysis, gage repeatability and reproducibility.

EMGT 446 Statistical Methods in Six Sigma 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: MA 223 or MA 382 or consent of instructor.
Corequisites: There are no corequisites for this course.
A course on statistical methods used in the Six Sigma to include the following topics: the history of Six Sigma, certification and belts, the Define-Measure-Analyze-Improve-Control (DMAIC) methodology, review of statistical tools associated Six Sigma (e.g., the “Magnificent Seven,” inference, graphics), project election tools (e.g., Voice of Customer, Affinity Diagram, Critical to Quality Diagram), Define phase tools (e.g., Spaghetti Diagram, Kano Model, Root Cause Analysis, Cause and Effect Diagram), computation of Sigma Levels and Defects per Million, Measure phase tools (e.g., Gage Repeatability and Reproducibility, Attribute Agreement Analysis, descriptive and inferential statistics), Analyze phase tools (e.g., Cause and Effect Matrix, Failure Modes and Effects Analysis, Design of Experiments), Improve phase tools (e.g., practical applications to improve a real-world process), Control phase tools (e.g., control charts, capability analysis), cost of poor quality, and the use of statistical software for data analysis. The use of real-world data in exercises will be emphasized. Other topics to be included as time allows: lean methodologies, team formations, Taguchi’s loss function, regression, process tampering.

EMGT 447 Six Sigma in Practice 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: EMGT 446 or consent of instructor.
Corequisites: There are no corequisites for this course.
This course is devoted to selecting and completing a real-world Six Sigma Green or Black Belt project either on-campus or in the community. It assumes knowledge of the statistical and managerial methods in Six Sigma and the DMAIC process, including those in the EMGT446 course description (e.g., CTQ Diagram, Gage R&R, FMEA).

EMGT 462 Risk Analysis and Management 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course will introduce students to principles and methods of risk analysis and risk management, as related to diverse engineering and socio-technical systems. Students will learn how to: identify, prioritize and quantify risks; perform qualitative and quantitative risk assessments and develop risk models; assess uncertainty; identify, evaluate, and prioritize risk management alternatives; and communicate risk to stakeholders. Through the use of varied example problems and case studies, students will develop an understanding of the appropriate use of risk analysis and management methods for engineering and policy decision making under uncertainty.

EMGT 464 Systems Architecture 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This class will introduce students to the art and science of systems architecting, where systems architecting refers to uncovering the fundamental structure of a system (functional, physical, logical, operational) defined in terms of system's elements, interfaces, processes, constraints, and behaviors that must operate under specific requirements and constraints. Focus will be placed on investigating the broader meaning of architectures, as they relate to organizations and businesses, in addition to engineered systems and products. Students will be introduced to heuristic and model-based approaches for systems architecting. Through case-studies and example problems in areas of production and manufacturing systems, intelligent transportation systems, social systems, and others, students will be able to apply the principles, processes and tools of systems architecting in order to structure and support the system development process of a balanced, well-integrated and socially and financially acceptable system.

EMGT 467 Economic Analysis of Engineering Projects 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This class will introduce students to critical principles of economic analysis of engineering projects. In particular, students will explore the process of making economic decisions under the influence of possibly uncertain future conditions and events. These economic decisions might involve investing in new facilities, improving existing production processes, or developing and marketing new products or services in the private and public sectors. Deterministic and multi-attribute evaluation approaches will be discussed. Students will be introduced to methodologies including capital budgeting, cost estimating, various alternative comparison methods, and life cycle costing. Additionally, students will be introduced to the concept of welfare economics through which they will explore economic impacts of infrastructure projects in the public sector. Emphasis will be placed on systems thinking and a systems approach to defining and solving economic problems.

EMGT 472 Reliability Engineering 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: MA 381 or consent of instructor.
Corequisites: There are no corequisites for this course.

A course that introduces probabilistic models and statistical methods used in the analysis of reliability problems. Topics include: a general review of necessary topics from probability and statistics, the definition of reliability in an engineering setting, reliability's history and development, case studies that identify reliability as an essential field of study in today's world, exploration of the common distributions used to model failure and survival times, as well as hazard rates, the determination of lifetime characteristics of a product using graphical and quantitative methods, estimation of parameters for lifetime models, examination of the types of data, censored and uncensored, commonly found in reliability studies, the practice of fitting appropriate models to data, assessing the fit and adequacy of a model with parameter estimates to reliability data, and the use of Minitab to aid in the investigation of parameter estimation and model adequacy for reliability data.

EMGT 481 Multi-Objective Optimization 4R-0L-4C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course will consider how humans make optimal decisions in an uncertain environment, when they have to simultaneously satisfy multiple objectives/goals under limited resources. Specifically we will consider: how to structure multi-objective problems, different methods and theories of quantifying preferences over multiple objectives a priori or a posteriori, multi-objective optimization methods without preference specification, multi-attribute utility theory, value trade-offs, risk attitudes, and other topics like fuzzy methods. We will also consider the applications of these theories and methods to various problems, including managerial and operational business issues, public policy issues, development of new businesses, etc.

EMGT 484 Systems Thinking and Evaluation 4R-0L-4C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course will focus on applying systems thinking and methodologies, as well as parametric and nonparametric statistical methods to evaluate alternative system designs and design performance measures. Students will learn how to: identify and evaluate system goals, requirements and performance measures; design experiments to assess system performance; apply decision analysis techniques to diverse trade studies; and generate a business case for presenting technical analysis results.

EMGT 486 Introduction to Supply Chain Management 4R-0L-4C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Introduces and discusses traditional operations within supply chains including changes due to evolving technologies and globalization. Demonstrates relationships between suppliers, customers, and competitors and how they affect the entire manner in which organizations can efficiently globally integrate and optimize their manufacturing and business operations. Cross-listed with EMGT 586.

EMGT 497 Special Topics in Engineering Management (1-4)R-0L-(1-4)C

Graduate Studies Eligible: No

Prerequisites: May require consent of instructor or specific prerequisites.

Corequisites: There are no corequisites for this course.

Examines particular engineering management topics of current interest and/or new courses for engineering management and other students. May require consent of instructor or specific prerequisites.

EMGT 511 Graduate Seminar I 1R-0L-1C F

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Selected topics relevant to Engineering management are discussed by graduate students, faculty, and guest speakers.

EMGT 512 Graduate Seminar II 1R-0L-1C W

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Selected topics relevant to Engineering management are discussed by graduate students, faculty, and guest speakers.

EMGT 513 Graduate Seminar III 1R-0L-1C S

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Selected topics relevant to Engineering management are discussed by graduate students, faculty, and guest speakers.

EMGT 514 Graduate Seminar IV 1R-0L-1C Summer

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Selected topics relevant to Engineering management are discussed by graduate students, faculty, and guest speakers.

EMGT 520 Accounting for Technical Managers 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

An introduction to accounting principles and practices as related to financial and managerial accounting. The uses of accounting information and the means by which pertinent accounting data are gathered and analyzed for internal purposes and management decisions.

EMGT 521 Financial Management in a Technical Environment 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

A comprehensive survey of financial concepts, techniques, instruments, and procedures which are related to the financial structure, assets management, dividend policy, and the capital budgeting decisions of a firm. Basic skills in financial analysis are developed. Operations of domestic and international financial markets are covered.

EMGT 523 Marketing in New Product Development 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course explores marketing concepts and marketing strategy within the context of new product development. Topics addressed include: market research methods, market segmentation, product positioning (4 Ps), pricing strategies, alliances,

elasticity, advertising & brands, and the champion role. Student projects define a new product idea, apply course concepts to the development of that idea (segmentation, pricing, etc.) and present their analysis to the class. The course includes the 'NPDChallenge'simulation that demonstrates marketing issues an entrepreneur faces in developing a new product.

EMGT 524 Production/Operations Management 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course provides an introduction to operations management for the technical manager including contemporary management principles and technical methods. Topics covered include development of operations strategies, process analysis, aggregate planning, supply chains, lean manufacturing, and Manufacturing Resource Planning (MRP) and Just in Time (JIT) topics. Case studies and simulation exercises are used to illustrate class concepts.

EMGT 525 Human Resources Management 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Examines Human Resource Management for engineers who may or may not have direct reports (subordinates). Key focus topics include systematic changes that influence employees' behavior, attitudes, and performance throughout the employment lifecycle. Furthermore, we explore value-added HRM practices related to analyzing/ designing work, recruiting and selection, training and development, evaluating performance, and the creation of positive employee relations in today's workplace.

EMGT 527 Project Management 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course examines the major themes of project management including defining the project, developing and monitoring a project plan, and being an effective project manager. Topics include developing project documents, estimating task durations, developing project networks and Gantt charts, reducing project duration, and project tracking. Course topics and approaches align with the Project Management Institute (PMI) body of knowledge. A software tool is used to develop project plans and explore resource allocation and leveling. Effective project management is explored through assignments and leadership scenarios. A student may not receive credit for both EMGT427 and EMGT527. Students enrolled in EMGT527 must fulfill additional course objectives and assignments not required of students enrolled in EMGT427.

EMGT 529 Organizational Behavior 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: Senior standing or consent of instructor

Corequisites: There are no corequisites for this course.

This course will introduce students to principles and theories related to management and organizational behavior. The goal is to transfer or develop knowledge and skills for high performance in a complex technical business environment requiring engineers to make and communicate sound decisions, and react appropriately to unanticipated events. The concepts and techniques for maximizing the effectiveness of engineers in the achievement of organizational and project goals are also emphasized. Topics include power, teaming, motivation, selection, and development while understanding

individual characteristics, attitudes, and behaviors. Additionally, we will examine how the use of Emotional Intelligence (EI) will be useful to the advancement of organizations that are culturally diverse.

EMGT 532 Technical Entrepreneurship 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Examines the principles and tools for innovation and entrepreneurship in technologically based businesses. Includes perspectives for both independent entrepreneurs and intrapreneurs. Develops basic concepts of business planning. Emphasizes a major group business plan based upon a technological innovation. May be used as a management core class.

EMGT 536 Leadership and Global Challenges 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course examines the art of leadership and its development in our increasingly globalized society. The course will examine different leadership theories and styles, overview the driving forces for globalization, and the unique challenges globalization and cross-cultural interactions impose on leaders. Through a variety of simulations, case studies, and other hands-on activities, students will begin to understand and develop competencies that global leaders must have to be successful.

EMGT 537 Facilities Management 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: SR or GR Class standing or consent of instructor

Corequisites: There are no corequisites for this course.

This course provides comprehensive analysis of the major issues in facilities management and planning of production and service facilities. The course emphasizes the use of quantitative and qualitative analysis in the design process. Topics include facility location, plant layout, space requirements, materials handling, personal requirements, system flow analysis, facility design, design algorithms, and distribution systems.

EMGT 540 Human Factors 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: JR, SR, or GR Standing

Corequisites: There are no corequisites for this course.

Human factors engineering aims to improve human interaction with systems by enhancing safety (reducing the risk of injury), performance (increasing productivity), and satisfaction (acceptance, comfort). Students will learn and be able to identify critical human factors in a system that affect safety, performance, and satisfaction. Some topics include the basic knowledge of human sensory mechanism (visual, auditory, tactile), cognition (perception, attention, information processing, memory, learning), and macrocognition (levels of behavior, decision making, situation awareness), their capabilities and limitations in interacting with products and systems.

EMGT 541 Work Analysis and Design 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: JR, SR, or GR Standing

Corequisites: There are no corequisites for this course.

This course is about fundamentals of work method in human-production systems. The course focuses on operation and process analysis, manual work analysis, engineering

anthropometry in a workspace, physical variabilities, principles of workspace layout to arrange equipment and work flow, stress and workload, hazard management, and applying engineering methods to improve the workspace with increasing the efficiency, productivity and safety.

EMGT 542 Measuring User Experience 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: JR, SR, or GR Standing

Corequisites: There are no corequisites for this course.

This course discusses users' goals and needs interacting with products or systems (e.g. web and mobile applications) and introduces customer/user experience research methods. The course provides methods to quantify the user experience. It includes the basics of design of experiments, collecting, analyzing, and presenting usability metrics, including performance, issue-based, self-reported, behavioral, physiological, and emotional metrics. Topics include case studies discussing how organizations have successfully used usability metrics and how user experience research helps practitioners make business cases to stakeholders.

EMGT 548 Six Sigma's Body of Knowledge 4R-0L-4C SeeDept

Graduate Studies Eligible: Yes

Prerequisites: EMGT 445 , and EMGT 446

Corequisites: There are no corequisites for this course.

This course introduces students to topics covered in a professional society's Six Sigma Green Belt Body of Knowledge (BOK) to pass a professional Six Sigma green belt exam. It provides a broad overview of Six Sigma topics not covered in the Six Sigma Minor's core courses (e.g., team communication, project planning tools, cycle-time reduction). In addition, the curriculum includes a review of required hand calculation skills (e.g., statistical distribution tables) and statistically complex topics (multi-var studies, regression). As a Six Sigma green belt, students will be equipped to support and champion Six Sigma implementation in their organizations.

EMGT 551 Intellectual Property for Engineers and Scientists 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Examines the influence intellectual property law has on the professional practice of engineers, scientists and engineering managers. Topics to be considered include: extracting value from intellectual property; patentable subject matter; novelty and loss of right; non-obviousness requirement; utility requirement; patent prosecution; patent litigation; designing around valid US patents; international patent rights; copyrights; trade secrets; and trademarks.

EMGT 552 Business Law for Technical Managers 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Introduces the legal issues that will likely arise during a lifetime of employment at the management level. Topics to be considered include: business ethics; dispute resolution; intentional torts; negligence and strict liability; criminal law and procedure; contracts, sales, warranties, and products liability; negotiable instruments; bankruptcy; employment law; labor law; business organizations; consumer law; and real property law.

EMGT 561 Failures of Engineered Systems 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Reviews past failures of engineered systems in order to improve an engineering manager's ability to anticipate, prevent, and respond to failures. The technical, human factor, and organizational root causes of the failures of engineered systems are examined. Case studies are used to illustrate the techniques that have been developed to analyze, investigate and prevent failures. Additionally, regulatory and legal responses to failures are also explored.

EMGT 562 Risk Analysis and Management 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
This course will introduce students to principles and methods of risk analysis and risk management, as related to diverse engineering and socio-technical systems. Students will learn how to: identify, prioritize and quantify risks; perform qualitative and quantitative risk assessments and develop risk models; assess uncertainty; identify, evaluate, and prioritize risk management alternatives; and communicate risk to stakeholders. Through the use of varied example problems and case studies, students will develop an understanding of the appropriate use of risk analysis and management methods for engineering and policy decision making under uncertainty. A student may not receive credit for both EMGT462 and EMGT562. Students enrolled in EMGT562 must complete a project not covered in EMGT462.

EMGT 564 Systems Architecture 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
This class will introduce students to the art and science of systems architecting, where systems architecting refers to uncovering the fundamental structure of a system (functional, physical, logical, operational) defined in terms of system's elements, interfaces, processes, constraints, and behaviors that must operate under specific requirements and constraints. Focus will be placed on investigating the broader meaning of architectures, as they relate to organizations and businesses, in addition to engineered systems and products. Students will be introduced to heuristic and model-based approaches for systems architecting. Through case-studies and example problems in areas of production and manufacturing systems, intelligent transportation systems, social systems, and others, students will be able to apply the principles, processes and tools of systems architecting in order to structure and support the system development process of a balanced, well-integrated and socially and financially acceptable system. A student may not receive credit for both EMGT464 and EMGT564. Students enrolled in EMGT564 must complete a project not covered in EMGT464.

EMGT 567 Economic Analysis of Engineering Projects 4R-0L-4C
Graduate Studies Eligible: Yes
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
This class will introduce students to critical principles of economic analysis of engineering projects. In particular, students will explore the process of making economic decisions under the influence of possibly uncertain future conditions and events. These economic decisions might involve investing in new facilities, improving existing production processes, or developing and marketing new products or services in the private and public sectors. Deterministic and multi-attribute evaluation approaches will

be discussed. Students will be introduced to methodologies including capital budgeting, cost estimating, various alternative comparison methods, and life cycle costing. Additionally, students will be introduced to the concept of welfare economics through which they will explore economic impacts of infrastructure projects in the public sector. Emphasis will be placed on systems thinking and a systems approach to defining and solving economic problems. A student may not receive credit for both EMGT467 and EMGT567. Students enrolled in EMGT567 must complete a project not covered in EMGT467.

EMGT 570 Lean Six Sigma 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: SR or GR Class standing or consent of instructor

Corequisites: There are no corequisites for this course.

This course focuses on the current lean six sigma engineering and technology techniques, principles, and philosophies relevant to manufacturing and service sectors. The course content emphasizes the DMAIC (Define, Measure, Analyze, Improve and Control) methodology in combined with the Lean techniques and practices through analytical and quantitative tools. Students will practice lean six sigma tools and methods by applying the DMAIC framework on practical problems in order to improve processes, increase efficiency, reduce or eliminate wastes and variation, and/or save money.

EMGT 581 Multi-Objective Optimization 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: Senior standing or consent of instructor

Corequisites: There are no corequisites for this course.

This course will consider how humans make optimal decisions in an uncertain environment, when they have to simultaneously satisfy multiple objectives/goals under limited resources. Specifically we will consider: how to structure multi-objective problems, different methods and theories of quantifying preferences over multiple objectives a priori or a posteriori, multi-objective optimization methods without preference specification, multi-attribute utility theory, value trade-offs, risk attitudes, and other topics like fuzzy methods. We will also consider the applications of these theories and methods to various problems, including managerial and operational business issues, public policy issues, development of new businesses, etc. A student may not receive credit for both EMGT481 and EMGT581. Students enrolled in EMGT581 must complete a project not covered in EMGT481.

EMGT 583 Management Information Systems 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: JR, SR, or GR Standing

Corequisites: There are no corequisites for this course.

The class provides a broad understanding of information technology in organizations. It includes case studies to understand different strategies in using information systems in E-business. Topics include business processes, competitive advantages, business pressures on organizations, and strategies to response to the pressures, the value of information and organizing information by databases. The tools used include Microsoft Excel and Access.

EMGT 584 Systems Thinking and Evaluation 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: Senior standing or consent of instructor

Corequisites: There are no corequisites for this course.

This course will focus on applying systems thinking and methodologies, as well as parametric and nonparametric statistical methods to evaluate alternative system

designs and design performance measures. Students will learn how to: identify and evaluate system goals, requirements and performance measures; design experiments to assess system performance; apply decision analysis techniques to diverse trade studies; and generate a business case for presenting technical analysis results. A student may not receive credit for both EMGT484 and EMGT584. Students enrolled in EMGT584 must complete a project not covered in EMGT484.

EMGT 585 Statistics for Technical Managers 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Examines basic statistics and probability while focusing on concepts most relevant to becoming an effective Engineering Manager. Students will learn to collect and analyze data to make statistically sound managerial decisions. Discussions related to descriptive statistics, hypothesis testing, confidence intervals, power calculations, correlation, linear/multiple regression, and analysis of variance (ANOVA). Students will complete a graduate-level project utilizing course concepts.

EMGT 586 Supply Chain Management 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Examines disruptions to traditional operations within supply chains due to changes in both technology and globalization. Shows how relationships between suppliers, customers, and competitors have changed dramatically to affect the entire manner in which organizations perform their manufacturing and business operations. Describes product supply chain complexity and the implications of expanding global customer bases, increasing supplier dependence, and larger ranges of locations and customers. Outcomes include the abilities to identify and define the critical components of supply chains, apply best practices in the buyer-seller relationship and understand why managing a supply chain is an important strategic capability for an organization. Cross-listed with EMGT 486.

EMGT 587 Systems Engineering 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This course provides and introduction to system modeling and analysis techniques with primary focus on model-based systems engineering (MBSE). Topics covered include the systems life cycle, requirements, system models, integration, and qualification. Special focus is placed on the development of a series of model-based views to represent a complex system. System analysis topics of risk and reliability are included. Case studies and examples span mechanical, electrical, and other disciplines.

EMGT 589 Manufacturing Systems 4R-0L-4C

Graduate Studies Eligible: Yes

Prerequisites: Senior standing or consent of instructor

Corequisites: There are no corequisites for this course.

Provides a comprehensive introduction to manufacturing systems covering the behavior laws at work in batch production or assembly lines. Includes production strategy, scheduling, and control methods and detailed analysis of fundamental manufacturing measures such as cycle time, throughput, capacity, work-in-process, inventory, and variability. Explores historical practices and the natural behaviors that are described in laws for manufacturing that help managers understand basic factory physics.

EMGT 590 Integrated Project as assigned; however, not more than 8 credits can be applied to MS degree requirements

Graduate Studies Eligible: Yes

Prerequisites: Completion of technical component and business core or permission of instructor

Corequisites: There are no corequisites for this course.

The integration of business and technical considerations in new product development. The identification of managerial and engineering challenges faced in developing a commercially viable new product within the context of a rapidly changing and highly competitive business environment. Readings, case studies and individual projects dealing with strategic planning, entrepreneurship, new product development, and related topics. The focus is on a major team project. This integrated project must include the identification of a new product including all relevant business and technical issues and the development of a detailed plan for profitably bringing this new product to market. A final report with oral presentations is required.

EMGT 597 Special Management Topics in Engineering Management (1-4)R-0L-(1-4)C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Examines particular management topics of current interest and/or new courses for engineering management and other graduate students and upper level undergraduates. May require consent of instructor or specific prerequisites.

EMGT 598 Special Technical Topics in Engineering Management (1-4)R-0L-(1-4)C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Examines particular technical topics of current interest and/or new courses for engineering management and other graduate students and upper level undergraduates. May require consent of instructor or specific prerequisites.

EMGT 699 Professional Experience 1R-0L-1C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The work experiences should be informative or integral to the advancement or completion of the student's program requirements. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

EMGT ESC Escalate Program Participant 0C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Students participating in the Escalate entrepreneurship program will be enrolled in this zero credit section each quarter. The course will be graded S or U. A grade of S will be given for completing the required Escalate courses, attending required professional development activities, and completing required project activities. Only students in the Escalate cohort may enroll in this section.

NOTE: In courses which include a laboratory, satisfactory completion of the laboratory work is required in order to pass the course.

EP Electives:
Courses from any science or engineering department which are of relevant level to the area concentration. If not in the area concentration, courses should be 300 level or above. It is recommended that students take a sequence of classes from the area concentration. This will fulfill engineering science elective in their engineering curriculum.

Engineering Physics - Course Descriptions

EP 180 Engineering at the Nanoscale 2R-0L-2C S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduction to nanoscience and engineering: properties and behavior of materials, devices, and systems (natural and artificial) at nanoscale, applications of nanoscience. Characterization techniques: Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), and thin film measurements. Basic cleanroom safety and experience, microfabrication processing techniques: photolithography, thin film deposition. Intro to design and data analysis software.

EP 199 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

EP 280 Introduction to Nanoengineering 3.5R-1.5L-4C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: PH 113
Scaling laws in small systems; electronics and photonics devices and systems, basics of quantum and statistical mechanics, nanomaterials and fabrication: examples of zero, one, two, and three dimensional nanostructures, carbon nanotubes, Nanoelectronics: basics of solid state physics; electron energy band, semiconductors, tunneling and quantum structures, molecular electronics, Nanophotonics in metals and semiconductors, surface plasmon resonance and applications, photonic bandgap crystals.

EP 290 Directed Study 1-4C
Graduate Studies Eligible: No
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Research for freshmen and sophomore students under the direction of a physics or optical engineering faculty member. May earn up to a maximum of 2 credits for meeting the graduation requirements. The student must make arrangements with a faculty member for the research project prior to registering for this course.

EP 320 FUNDAMENTALS OF THIN FILMS: FABRICATION AND APPLICATIONS 3R-3L-4C F (every other year)
Graduate Studies Eligible: No
Prerequisites: EP 280
Corequisites: There are no corequisites for this course.
Two- and three-dimensional nanostructures, including thin film materials, single and multi-layer nano-films, electronic energy band structures, thin-film and high-k electronics, multiple quantum well devices, and optical bandgap engineering. Thin film characterization, thermal properties of thin films, growth kinetics, coating and thin film fabrication techniques: sputtering, thermal evaporation, PECVD, and atomic layer deposition.

EP 330 Material Failure 3R-3L-4C W
Graduate Studies Eligible: No
Prerequisites: PH 112
Corequisites: There are no corequisites for this course.
Principles of material failure; appearance, physical cause and mathematical description with emphasis on the materials used for micro-scale devices and assemblies. Failure types considered include Rupture, Fatigue, Creep, Corrosion, Electromigration, Electrical Overstress, Electrical Discharge and Thermal. Experiments illustrate the failure type and the machines used to study them. These include Electron, Optical and X-ray microscopes, Spectroscopy and Tension machines. A brief description of the working of each machine will be given.

EP 380 Nanotechnology, Entrepreneurship & Ethics 3.5R-1.5L-4C S
Graduate Studies Eligible: No
Prerequisites: EP 280
Corequisites: There are no corequisites for this course.
Scaling laws in small systems; mechanical, biological, fluidics, and thermal systems. Nanomaterials and nanofabrication. Nanomechanics: cantilever oscillation, atomic-force microscopy (AFM) and its applications, nano-biotechnology, machinery of cell, and molecular motors. Nanoscale optics, Nanoscale heat: conduction, convection, and blackbody radiation. Basics of fluidics, nanoscale fluidics and applications, entrepreneurship and ethics, concepts and tools in innovation and social impacts of nanotechnology.

EP 395 NANOSCALE FABRICATION & CHARACTERIZATION TECHNIQUES 3R-3L-4C F (every other year)
Graduate Studies Eligible: No
Prerequisites: EP 280
Corequisites: There are no corequisites for this course.
Fabrication and characterization techniques for zero- and one-dimensional nanoscale materials and devices. Process design and development. Bottom-up and top-down synthesis techniques. Assembly and self-assembly of nanomaterials into macro-articles. Synthesis techniques including liquid phase growth, chemical vapor deposition, and plasma synthesis. Characterization techniques such as microscopies, various spectroscopies, thermogravimetric analysis, and differential scanning calorimetry. Laboratory is a team project in which students will design, fabricate, and characterize nanomaterials.

EP 406 Semiconductor Devices & Fabrication 3R-3L-4C W
Graduate Studies Eligible: No
Prerequisites: PH 405 or PH 505
Corequisites: There are no corequisites for this course.

Physical properties and applications of semiconductor devices including bipolar junction transistors (BJT), metal-semiconductor contacts (Schottky and ohmic), junction field effect transistors (JFET and MESFET), metal-oxide semiconductor (MOS) interfaces and field effect transistors (MOSFET and CMOS), photoconductors, photodetectors (PIN and APD), solar cells, light emitting diodes (LED), and laser diodes. Laboratory experiments will cover the following topics: characterization of semiconductor devices, op-amps, CMOS, NAND and other logic and analog components. Cross-listed with EP 506.

EP 407 NANOELECTRONIC AND SEMICONDUCTOR DEVICES 2R-6L-4C F

Graduate Studies Eligible: No

Prerequisites: EP 406 or EP 506

Corequisites: There are no corequisites for this course.

Fabrication and characterization of micro/nanoelectronic devices; Process integration of various technologies, including CMOS, 2D materials, and nanowires; Surface processing for improved performance, including passivation, anti-reflection structures, and protective coatings. Process and device simulators illustrate concepts introduced in class. Laboratory is an integral component of this class in which students will fabricate a multi-junction semiconductor device. In-process measurement results are compared with final electrical test results and simulated designs.

EP 408 Microsensors and Actuators 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: EP 410 or Junior or Senior standing, and consent of instructor

Corequisites: There are no corequisites for this course.

Microelectromechanical (MEMS) systems composed of microsensors, microactuators, and electronics integrated onto a common substrate. Design, fabrication, and operation principles. Examples of microsensors covered in the course include: thermal, radiation, mechanical, chemical, and biological. Laboratory is a team design project in which the students fabricate sensing devices such as pressure or thermal sensors and then characterize their behavior. Cross-listed with EP 508.

EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: Junior or Senior class standing

Corequisites: There are no corequisites for this course.

Properties of silicon wafers, wafer-level processes, vacuum systems, thin-film deposition via PVD, dry and wet etching, photolithography, surface and bulk micromachining, process integration, MEMS applications: heat actuators, capacitive accelerometer, DLP, bio-sensor, and pressure sensor. Cross-listed with ME 416, ECE 416, and CHE405.

EP 411 Advanced topics in MEMS 3R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: EP 410 or equivalent course

Corequisites: There are no corequisites for this course.

Topics such as: Microlithography, design process, modeling; analytical and numerical. Use of software for layout design and device simulation. Characterization and reliability of MEMS devices. MEMS and microelectronic packaging. Introduction to microfluidic systems. Applications in engineering, biomedicine, and chemistry. Cross-listed with ECE 419, and CHE 419.

EP 415 Engineering Physics Design I 2R-6L-4C S

Graduate Studies Eligible: No

Prerequisites: EP 380 or and Junior or Senior standing

Corequisites: ENGL H290
Principles of design. Codes of ethics appropriate to engineers. Case studies related to optical engineering and engineering physics professional practice, teamwork, contemporary issues, patents and intellectual property. Team-oriented design project work on selected topics in optical engineering and engineering physics. Introduction to product development practices, product research, planning and project management. Preliminary design of a product and product specifications. Deliver a design document specific to customer needs and constraints. Cross-listed with OE 415.

EP 416 Engineering Physics Design II 2R-6L-4C F
Graduate Studies Eligible: No
Prerequisites: EP 415
Corequisites: There are no corequisites for this course.
Team-based capstone design project following structured design processes and utilizing knowledge gained from prior coursework. Project planning and budgeting, development of product/process specifications, application of engineering standards, system design and prototyping subject to multiple realistic constraints (cost, schedule, and performance). Formal midterm design review. Deliver initial statement of work and interim technical report. Laboratory activities supporting the formal design process. Cross-listed with OE 416.

EP 417 Engineering Physics Design III 2R-6L-4C W
Graduate Studies Eligible: No
Prerequisites: EP 416
Corequisites: There are no corequisites for this course.
Continuation of EP 416. System design and prototyping, performance testing, and data analysis. Formal midterm design review. Demonstration of a functional prototype. Deliver oral presentation and final technical report. Cross-listed with OE 417.

EP 450 Nanomedicine 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: PH 113 or Junior or Senior standing and consent of instructor
Corequisites: There are no corequisites for this course.
Material presented includes the functions and properties of medical nanodevices, the design and fabrication of nanorobots and nanoparticles, the current and potential applications of nanomedicine. Introduction to cancer cell biology and techniques for selective targeting of cancer cells, simulations of the optical and thermal properties of normal and cancerous cell organelles. Nanoplasmonics: Lorentz-Mie simulations of optical properties of nanoparticles, the use of plasmonic nanoparticles in diagnosis and therapy. Introduction to the nanophotodynamic therapies and the new dynamic modes in selective nanophotothermolysis of cancer, the design and methods of activation of nanodrugs. Time and space evolutions of thermal fields in and around the nano- bio-particles and nanoclusters. Ablation of the soft and hard biological tissues by activated nanoparticles.

EP 470 Special Topics in Engineering Physics 2-4C
Graduate Studies Eligible: No
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Lectures on special topics in engineering physics.

EP 490 Directed Study 1-4C
Graduate Studies Eligible: No
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.

Research for junior and senior students under the direction of a physics and optical engineering faculty member. May earn up to a maximum of 2 credits for meeting the graduation requirements. The student must make arrangements with a faculty member for the research project prior to registering for this course.

EP 506 Semiconductor Devices & Fabrication 3R-3L-4C W

Graduate Studies Eligible: No

Prerequisites: PH 405 or PH 505

Corequisites: There are no corequisites for this course.

Physical properties and applications of semiconductor devices including bipolar junction transistors (BJT), metal-semiconductor contacts (Schottky and ohmic), junction field effect transistors (JFET and MESFET), metal-oxide semiconductor (MOS) interfaces and field effect transistors (MOSFET and CMOS), photoconductors, photodetectors (PIN and APD), solar cells, light emitting diodes (LED), and laser diodes. Laboratory experiments will cover the following topics: characterization of semiconductor devices, op-amps, CMOS, NAND and other logic and analog components. Graduate credit requires a more advanced project. Cross-listed with EP 406.

EP 507 NANOELECTRONIC AND SEMICONDUCTOR DEVICES 2R-6L-4C F

Graduate Studies Eligible: Yes

Prerequisites: EP 406 or EP 506 or consent of instructor

Corequisites: There are no corequisites for this course.

Fabrication and characterization of micro/nanoelectronic devices; Process integration of various technologies, including CMOS, 2D materials, and nanowires; Surface processing for improved performance, including passivation, anti-reflection structures, and protective coatings. Process and device simulators illustrate concepts introduced in class. Laboratory is an integral component of this class in which students will fabricate a multi-junction semiconductor device. In-process measurement results are compared with final electrical test results and simulated designs. Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both EP 407 and EP 507.

EP 508 Microsensors and Actuators 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: EP 410 or Junior or Senior standing and consent of instructor

Corequisites: There are no corequisites for this course.

Microelectromechanical (MEMS) systems composed of microsensors, microactuators, and electronics integrated onto a common substrate. Design, fabrication, and operation principles. Examples of microsensors covered in the course include: thermal, radiation, mechanical, chemical, and biological. Laboratory is a team design project in which the students fabricate sensing devices such as pressure or thermal sensors and then characterize their behavior. Cross-listed with EP 408.

EP 510 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: Junior or Senior standing

Corequisites: There are no corequisites for this course.

Properties of silicon wafers, wafer-level processes, vacuum systems, thin-film deposition via PVD, dry and wet etching, photolithography, surface and bulk micromachining, process integration, MEMS applications: heat actuators, capacitive accelerometer, DLP, bio-sensor, and pressure sensor. Students must do additional project work on a topic selected by the instructor. Cross-listed with BE 516, CHE 505, ECE 516, and ME 516.

EP 511 Advanced topics in MEMS 3R-3L-4C F

Graduate Studies Eligible: No
Prerequisites: EP 410 or EP 510 or consent of instructor
Corequisites: There are no corequisites for this course.
Topics such as: Microlithography. Design process, modeling; analytical and numerical. Use of software for layout design and device simulation. Characterization and reliability of MEMS devices. MEMS and microelectronic packaging. Introduction to microfluidic systems. Applications in engineering, biomedicine, and chemistry. Students must do additional project work on a topic selected by the instructor. Cross-listed with ME 519, ECE 519, and CHE 519.

Engineering Science - Course Descriptions

ES 201 Conservation & Accounting Principles 4R-0L-4C F,W
Graduate Studies Eligible: No
Prerequisites: EM 121, and MA 113, and PH 111
Corequisites: There are no corequisites for this course.
A common framework for engineering analysis is developed using the concepts of a system, accounting and conservation of extensive properties, constitutive relations, constraints, and modeling assumptions. Conservation equations for mass, charge, momentum and energy, and an entropy accounting equation are developed. Applications taken from all engineering disciplines stress constructing solutions from basic principles.

ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Graduate Studies Eligible: No
Prerequisites: ES 201 with a grade of C or better
Corequisites: There are no corequisites for this course.
Extend the conservation and accounting framework to examine fluid motion. Topics include dimensional analysis, pressure variation in both stationary and moving fluids, viscous effects including boundary layers, laminar and turbulent flow. Applications include lift and drag, pipe flow, compressible flow. Fundamental concepts are enriched by laboratory experiences.

ES 203 Electrical Systems 3R-3L-4C F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 113, and PH 112, and EM 121 or EM 120
Corequisites: There are no corequisites for this course.
Circuit elements, Kirchhoff's laws, equivalent circuits, voltage and current dividers, and analysis techniques for both DC and the phasor domain. AC circuits and power. Operational amplifiers. Integral laboratory.

ES 204 Mechanical Systems 2 2/3R-1L-3C W,S
Graduate Studies Eligible: No
Prerequisites: BE 100 or ENGD 120 or CSSE 120, and ENGD 215
Corequisites: There are no corequisites for this course.
Conservation and accounting equations applied to mechanical systems. Kinematics and kinetics of particles in space and of rigid bodies in plane motion.

ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F
Graduate Studies Eligible: No
Prerequisites: ES 213, and ES 213L or ECE 203 or ENGD 120, and ES 214, and MA 222
Corequisites: There are no corequisites for this course.

Conservation and accounting principles are used to model engineering systems comprising mechanical, electrical, fluid, and thermal elements. Dynamic behavior and performance criteria are characterized in the time and frequency domains. Topics include block diagrams, deriving and solving differential equations of motion, experimental parameter identification and model validation, teaming, and reporting engineering results.

ES 212 Fluid Systems 3R-3L-4C W,S

Graduate Studies Eligible: No

Prerequisites: ES 201 With a grade of C or higher

Corequisites: There are no corequisites for this course.

Extend the conservation and accounting framework to examine fluid motion. Topics include dimensional analysis, pressure variation in both stationary and moving fluids, viscous effects including boundary layers, laminar and turbulent flow, and compressibility effects. Applications include similitude, lift and drag, pipe flow, nozzle and diffuser flow. Fundamental concepts are enriched by laboratory experiences.

ES 213 Electrical Systems 3R-0L-3C

Graduate Studies Eligible: No

Prerequisites: MA 113, PH 112, and either EM 121 or EM 120 or CHE 110 or EP 180 or ENGD 215 or BE 132 or OE 172

Corequisites: There are no corequisites for this course.

Circuit elements, Kirchhoff's laws, equivalent circuits, voltage and current dividers, and analysis techniques for both DC and the phasor domain. AC circuits and power. Operational amplifiers.

ES 213L Electrical Systems Lab 0R-3L-1C

Graduate Studies Eligible: No

Prerequisites: Concurrent registration in or successful completion of ES213 Laboratory component of ES213.

Corequisites: There are no corequisites for this course.

Students will learn the basic use of the function generator, multimeter, oscilloscope, and power supply. Lab activities will occur on a weekly basis and will reinforce the topics covered in ES213. Should be taken in the same quarter as ES213.

ES 214 Mechanical Systems 3R-1L-4C W,S

Graduate Studies Eligible: No

Prerequisites: ES 201*, ME 123 or BE 100 or CSSE 120 *ES 201 with a grade of C or higher

Corequisites: ES 212

Conservation and accounting equations applied to mechanical systems. Kinematics and kinetics of particles in space and of rigid bodies in plane motion.

International students for whom English is not their native language will be required to take an assessment test to gauge their reading, writing, speaking and listening proficiency in English. The purpose of this testing is to ensure that all students have the proper communication skills to advance successfully through the challenging Rose-Hulman curriculum. Based on this assessment, some students will be required to take one or more English as a Second Language (ESL) courses. Those students must successfully complete ESL 102 prior to taking RH131 Rhetoric and Composition.

In addition:

- Students may not drop an ESL course.

- Students may not apply more than eight credits of ESL coursework toward free elective credits in their major if applicable.
- Students placed in an ESL course must enroll in that course every term it is offered until the ESL requirement is completed..

English Second Language - Course Descriptions

ESL 101 Reading and Writing 1 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
For non-native speakers of English. Focuses on the basic patterns and conventions of U.S. academic prose. Familiarizes students with essential essay structures with particular emphasis on identifying, developing, and supporting a thesis. Deepens knowledge of grammar and academic vocabulary. Introduces the topic of academic integrity and appropriate use of outside source material.

ESL 102 Reading and Writing 2 4R-0L-4C F,W,S
Graduate Studies Eligible: No
Prerequisites: ESL 101 or placement via ESL exam
Corequisites: There are no corequisites for this course.
For non-native speakers of English. Reviews the basic patterns and conventions of U.S. academic reading and writing. Introduces students to formal research techniques and provides extensive practice with incorporating outside sources and using strategies for maintaining academic integrity. Guides students through readings in academic journals and articles. Students required to take ESL102 must successfully complete the course prior to taking RH 131.

ESL 111 Listening and Speaking 3R-1L-4C F,W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
For non-native speakers of English. Develops spoken fluency with emphasis on the basic pronunciation, rhythm, and intonation patterns of English. Prepares students for academic presentations with a particular focus on STEM vocabulary. Develops students' academic listening and note-taking skills.

ESL 399 Special Topics (1-4 credits) 4R-OL-4C Arranged
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
For non-native speakers of English. Examines a selected ESL topic in depth. A particular offering may require a prerequisite or consent of the instructor.

ESL 499 Directed Study (1-4 credits) 4R-OL-4C Arranged
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
For non-native speakers of English. Allows for individual study of an ESL topic selected by the instructor and the student(s). A plan of study, regular meetings with the instructor, and a major term project are required.

Geology - Course Descriptions

GEOL 270 Geology for Engineers & Environmental Scientists 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: CHEM 111
Corequisites: There are no corequisites for this course.
Physical, historical, chemical, structural and environmental aspects of earth science addressed from an engineer's or environmental scientist's perspective. The course includes study of minerals and rocks, investigation of geologic hazards, an introduction to rock and soil mechanics, case studies, and interpretation of topographic maps, geologic maps and aerial photographs.

Mathematics - Course Descriptions

MA 105 Calculus A 5R-0L-5C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Calculus and analytic geometry in the plane. Algebraic and trigonometric functions. Limits and continuity. Differentiation, geometric and physical interpretations of the derivative. Introduction to integration and the Fundamental Theorem of Calculus. A student cannot earn credit for both MA 105 and MA 111.
MA 106 Calculus B 4R-0L-4C W
Graduate Studies Eligible: No
Prerequisites: MA 105
Corequisites: There are no corequisites for this course.
Definitions, properties, and derivatives of exponentials and logarithms. Antiderivatives, integral properties, integration by substitution, integration by parts, integrals of transcendental functions, numerical integration, applications of integration, and improper integrals. Applications of integration, e.g. area, displacement, volumes of revolution, arc length, surface area of revolution, and work. Newton's method. Computer algebra systems.
MA 107 Calculus C 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: MA 106
Corequisites: There are no corequisites for this course.
Partial fractions and Integration. Hyperbolic functions. Separable first order differential equations, applications of separable first order differential equations. Series of constants, power series, Taylor polynomials, Taylor and McLaurin series. Computer algebra systems.
MA 111 Calculus I 5R-0L-5C F,W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Calculus and analytic geometry in the plane. Algebraic and transcendental functions. Limits and continuity. Differentiation, geometric and physical interpretations of the derivative, Newton's method. Introduction to integration and the Fundamental Theorem of Calculus. A student cannot earn credit for both MA 105 and MA 111.
MA 112 Calculus II 5R-0L-5C F,W,S
Graduate Studies Eligible: No

Prerequisites: MA 111
Corequisites: There are no corequisites for this course.
Techniques of integration, numerical integration, applications of integration. L'Hopital's rule and improper integrals. Separable first order differential equations, applications of separable first order differential equations. Series of constants, power series, Taylor polynomials, Taylor and McLaurin series.

MA 113 Calculus III 5R-0L-5C F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 112
Corequisites: There are no corequisites for this course.
Vectors and parametric equations in three dimensions. Functions of several variables, partial derivatives, maxima and minima of functions of several variables, multiple integrals, and other coordinate systems. Applications of partial derivatives and multiple integrals.

MA 190 Contemporary Mathematical Problems 2R-0L-2C S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: MA 113
A seminar-style course consisting of an overview of selected contemporary problems and areas in the mathematical sciences. Problems to be discussed will be selected from recent publications in research and applications, famous problems, and outstanding problems of great significance.

MA 199 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

MA 200 Career Preparation 1R-0L-1C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course is for mathematics majors to be taken in the second year. The course addresses career choices, summer opportunities, employment and graduate school preparation, and curriculum vitae and resumes preparation. Cross-listed with CHEM 200 and PH200.

MA 221 Matrix Algebra & Differential Equations I 4R-0L-4C F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 113
Corequisites: There are no corequisites for this course.
First order scalar differential equations including basic solution techniques and numerical methods. Second order linear, constant coefficient differential equations, including both the homogeneous and non-homogeneous cases. Basic matrix algebra with emphasis on understanding systems of linear equations from algebraic and geometric viewpoints, and eigenvalues and eigenvectors. Introduction to complex arithmetic. Applications to problems in science and engineering.

MA 222 Matrix Algebra & Differential Equations II 4R-0L-4C F,W,S

Graduate Studies Eligible: No
Prerequisites: MA 221
Corequisites: There are no corequisites for this course.
Laplace transforms. Solution of systems of first order linear differential equations by matrix methods and investigation of their solution structure determined by eigensystems. Phase portrait analysis and classification of the nature of the stability of critical points for linear and nonlinear systems. Fourier series and application to solving elementary boundary value problems. Applications to problems in science and engineering.

MA 223 Engineering Statistics I 4R-0L-4C F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 111, and ENGL H100 or ENGD 100 or HUM H190
Corequisites: There are no corequisites for this course.
This is an introductory course in applied statistics emphasizing data analysis. The course is designed to support the research cycle including the formulation of a question of interest, effective data collection techniques, informative data summaries, and appropriate inferences from data. Communication of results and statistical concepts is emphasized. Statistical software will be used for the data analysis throughout, including analysis of variance and simple linear regression. A student cannot take both MA223 and MA382 for credit.

MA 276 Introduction to Proofs 4R-0L-4C F, W
Graduate Studies Eligible: No
Prerequisites: MA 112
Corequisites: There are no corequisites for this course.
Introduction to writing mathematical proofs. Logic: direct proof, contradiction, contrapositive, counterexamples. Induction. Recursion. Sets: relations (order, equivalence), functions. Properties of infinite sets. Basic number theory. Important preparation for further courses in theoretical mathematics.

MA 290 Topics in Mathematics Variable 1-4 Hours See Dept
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Variable Topics in Mathematics

MA 323 Geometric Modeling 4R-0L-4C W (Even years)
Graduate Studies Eligible: No
Prerequisites: MA 113
Corequisites: There are no corequisites for this course.
Covers some of the mathematical methods for describing physical or virtual objects in computer aided geometric design (CAGD) and computer graphics. Emphasizes methods for curve and surface modeling, and discusses both the underlying geometric concepts and the practical aspects of constructing geometric models of objects. Topics covered include Bezier curves, Hermite curves, B-splines, Bezier patches, subdivision surfaces. In discussing these, ideas from analytic geometry, differential geometry, affine geometry, combinatorial geometry, and projective geometry will be introduced.

MA 327 Low Dimensional Topology 4R-0L-4C W (odd years)
Graduate Studies Eligible: No
Prerequisites: MA 113 or consent of instructor
Corequisites: There are no corequisites for this course.
An introduction to the topology of one-, two-, and three-dimensional manifolds and its application to other areas of mathematics and science. Topics may include,

but are not restricted to, classification of curves and surfaces, Euler characteristic, tiling and coloring theorems, graph embeddings, vector fields, knots and links, and elementary algebraic topology. Intended for science and engineering majors as well as mathematics majors.

MA 330 Vector Calculus 4R-0L-4C F,S

Graduate Studies Eligible: No

Prerequisites: MA 222

Corequisites: There are no corequisites for this course.

Calculus of vector- valued functions of one and several variables. Topics include differentiation (divergence, gradient and curl of a vector field) and integration (line integrals and surface integrals). Applications of Green's theorem, Stokes' theorem and the divergence theorem to potential theory and/or fluid mechanics will be provided.

MA 332 Introduction to Computational Science 4R-0L-4C F,W

Graduate Studies Eligible: No

Prerequisites: MA 221

Corequisites: There are no corequisites for this course.

An introduction to Computational Science using Matlab. Floating point arithmetic, Matlab programming, solution of nonlinear equations, interpolation, least squares problems, numerical differentiation and integration, solution of linear systems.

MA 335 Introduction to Parallel Computing 4R-0L-4C S

Graduate Studies Eligible: No

Prerequisites: MA 221 and programming experience

Corequisites: There are no corequisites for this course.

Principles of scientific computation on parallel computers. Algorithms for the solution of linear systems and other scientific computing problems on parallel machines. Course includes a major project on RHIT's parallel cluster. Same as CSSE 335.

MA 336 Boundary Value Problems 4R-0L-4C F,S

Graduate Studies Eligible: No

Prerequisites: MA 222

Corequisites: There are no corequisites for this course.

Introduction to boundary value problems and partial differential equations. Emphasis on boundary values problems that arise from the wave equation, diffusion equation, and Laplace's equation in one, two and three dimensions. Solutions to such boundary value problems will be discussed using Fourier series, numerical techniques, and integral transforms.

MA 341 Topics in Mathematical Modeling 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: MA 222

Corequisites: There are no corequisites for this course.

An introduction to techniques of mathematical modeling involved in the analysis of meaningful and practical problems arising in many disciplines including mathematical sciences, operations research, engineering, and the management and life sciences. Topics may include creative and empirical model construction, model fitting, models requiring optimization, and modeling dynamic behavior. Student participation in significant individual and group projects will be emphasized.

MA 342 Computational Modeling 4R-0L-4C S

Graduate Studies Eligible: No

Prerequisites: MA 222, and either CE 310 or CHE 310 or MA 332 or ME 327

Corequisites: There are no corequisites for this course.

Computational modeling and simulation of scientific problems using Matlab. Students will create and utilize computer-based models to solve practical problems. Monte Carlo methods, linear systems, solution of ODEs.

MA 351-6 Problem Solving Seminar 1R-0L-1C F,W,S

Graduate Studies Eligible: No

Prerequisites: consent of instructor

Corequisites: There are no corequisites for this course.

An exposure to mathematical problems varying widely in both difficulty and content. Students will be expected to participate actively, not only in the solution process itself but also in the presentation of finished work, both orally and in writing. A student may earn a maximum of six credits in MA 351-6. Cannot count toward mathematics major core hours or the math minor.

MA 366 Introduction to Real Analysis 4R-0L-4C F, W

Graduate Studies Eligible: No

Prerequisites: MA 371, and MA 276

Corequisites: There are no corequisites for this course.

Calculus of functions of a single variable. A more careful development of the basic concepts of analysis, including sequences, limits, continuity, differentiability, integration, infinite series, power series, Taylor's Theorem, and uniform convergence, with an emphasis on proof.

MA 367 Functions of a Complex Variable 4R-0L-4C S

Graduate Studies Eligible: No

Prerequisites: MA 221

Corequisites: There are no corequisites for this course.

Elementary properties of analytic functions including Cauchy's theorem and its consequences, Laurent series, the Residue Theorem, and mapping properties of analytic functions.

MA 371 Linear Algebra I 4R-0L-4C F,S

Graduate Studies Eligible: No

Prerequisites: MA 221 or consent of instructor

Corequisites: There are no corequisites for this course.

Similar to MA373, but with an emphasis on the theory behind matrices and vector spaces. Systems of linear equations, Gaussian elimination, and the LU decomposition of a matrix. Projections, least squares approximations, and the Gram-Schmidt process. Eigenvalues and eigenvectors of a matrix. The diagonalization theorem. The singular value decomposition of a matrix. Introduction to vector spaces. Some proof writing will be required. Those interested in applications of matrices and vector spaces should take MA373. A student cannot take both MA 371 and MA 373 for credit.

MA 373 Applied Linear Algebra for Engineers 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: MA 221 or consent of instructor

Corequisites: There are no corequisites for this course.

Similar to MA 371, but with emphasis on applications of matrices and vector spaces. Systems of linear equations, Gaussian elimination, and the LU decomposition of a matrix. Projections, least squares approximations, and the Gram-Schmidt process. Eigenvalues and eigenvectors of a matrix. The diagonalization theorem. The singular value decomposition of a matrix. Those interested in the theory behind matrices and vector spaces should take MA 371. A student cannot take both MA 371 and MA 373 for credit.

MA 374 Combinatorics 4R-0L-4C F, W, S

Graduate Studies Eligible: No
Prerequisites: MA 112
Corequisites: There are no corequisites for this course.
A first course in combinatorics. Basic counting principles, permutations, combinations. Combinatorial proof. The pigeonhole principle. The principle of inclusion/exclusion. Generating functions. Recurrence relations. Additional topics in combinatorics, which may include permutation groups and Burnside's Lemma, Polya enumeration, multivariate generating functions, combinatorial designs, Ramsey theory, order relations, or other topics at the discretion of the instructor.

MA 376 Abstract Algebra 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: MA 276
Corequisites: There are no corequisites for this course.
An introduction to Group Theory. Topics include: matrix groups, groups of integers modulo a natural number, symmetric and dihedral groups, homomorphisms, subgroups, cosets, quotient groups and group actions. Applications, possibly including games and puzzles, cryptography, and coding theory. Other topics may also be introduced according to time and student interest.

MA 378 Number Theory 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: consent of instructor
Corequisites: There are no corequisites for this course.
Divisibility, congruences, prime numbers, factorization algorithms, RSA encryption, solutions of equations in integers, quadratic residues, reciprocity, generating functions, multiplicative and other important functions of elementary number theory. Mathematical conjecture and proof, mathematical induction.

MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 113
Corequisites: There are no corequisites for this course.
Introduction to probability theory; axioms of probability, sample spaces, and probability laws (including conditional probabilities). Univariate random variables (discrete and continuous) and their expectations including these distributions: binomial, Poisson, geometric, uniform, exponential, and normal. Introduction to moment generating functions. Introduction to jointly distributed random variables. Univariate and joint transformations of random variables. The distribution of linear combinations of random variables and an introduction to the Central Limit Theorem. Applications of probability to statistics.

MA 382 Introduction to Statistics with Probability 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: MA 381
Corequisites: There are no corequisites for this course.
This is an introductory course in statistics. Dual emphasis is placed on deriving statistical techniques and using the methods within data analyses. Study design and informative data summaries motivate the statistical inference techniques for linear models. Statistical thinking and communication skills are developed through analysis of data from a variety of fields. A statistical programming language is used for data visualization, analysis, and simulations. A student cannot take both MA 223 and MA 382 for credit.

MA 383 Engineering Statistics II 4R-0L-4C F

Graduate Studies Eligible: No
Prerequisites: MA 223 or MA 382
Corequisites: There are no corequisites for this course.
Hypothesis testing, confidence intervals, sample size determination, and power calculations for means and proportions; two factor analysis of variance (with and without interactions); analysis of several proportions; confidence and prediction intervals for estimated values using simple linear regression; Pearson (linear) correlation coefficient; introduction to multiple regression to include polynomial regression; review of fundamental prerequisite statistics will be included as necessary.

MA 384 Data Mining 4R–0L–4C
Graduate Studies Eligible: No
Prerequisites: CSSE 120, and MA 221, and either MA 223 or MA 381
Corequisites: There are no corequisites for this course.
An introduction to data mining for large data sets, include data preparation, exploration, aggregation/reduction, and visualization. Elementary methods for classification, association, and cluster analysis are covered. Significant attention will be given to presenting and reporting data mining results.

MA 386 Statistical Programming 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: MA 223 or MA 382 and previous programming course
Corequisites: There are no corequisites for this course.
Computational data analysis is an essential part of modern statistics. This course provides a practical foundation for students to compute with data. This course will introduce students to tools for data management, manipulation and analysis that are common in statistics and data science. The R computing language will be introduced. Topics will include data structures in R, writing functions, webscraping, data cleaning (both quantitative and textual data), processing unstructured data, static and interactive graphical presentations of data, and coding of modern algorithms for data analysis (bootstrapping and Monte Carlo methods).

MA 390 Topics in the Mathematics of Engineering 1-2C Arranged
Graduate Studies Eligible: No
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
A succinct mathematical study that is supportive of the engineering curricula. Topics could be chosen from signal processing, fluid dynamics, thermodynamics, as well as others. A student may take the course for credit more than once provided the topics are different.

MA 415 Machine Learning 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: MA 221*, and either MA 223 or MA 381, and either CHE 310 or CSSE 220 or ECE 230 or MA 332 or MA 386 or ME 323 or ME 327 Prerequisite Clarification for MA415: Junior standing and MA221, and either MA223 or MA381, and one of CHE310, CSSE220, ECE230, MA332, MA386 or (ME323 or ME327).
Corequisites: There are no corequisites for this course.
An introduction to machine learning. Topics include: error metrics, accuracy vs interpretability trade-off, feature selection, feature engineering, bias-variance trade-off, under-fitting vs. overfitting, regularization, cross-validation, the bootstrap method, the curse of dimensionality and dimensionality reduction using the singular value decomposition. Both parametric and nonparametric methods are covered including: k-

nearest neighbors, linear and logistic regression, decision trees and random forests, and support vector machines. Same as CSSE415.

MA 416 Deep Learning 4R-0L-4C Arranged

Graduate Studies Eligible: Yes

Prerequisites: MA 221, and either MA 223 or MA 381, and either CHE 310 or CSSE 220 or ECE 230 or MA 332 or MA 386 or ME 327

Corequisites: There are no corequisites for this course.

An introduction to deep learning using both fully-connected and convolutional neural networks. Topics include: least squares estimation and mean square error, maximum likelihood estimation and cross-entropy, convexity, gradient descent and stochastic gradient descent algorithms, multivariate chain rule and gradient computation using back propagation, linear vs nonlinear operations, convolution, over-fitting vs under-fitting and hyper-parameter optimization, L2, early stopping and dropout regularization, data augmentation and transfer learning.

MA 421 Tensor Calculus & Riemannian Geometry 4R-0L-4C Fall (Odd years)

Graduate Studies Eligible: Yes

Prerequisites: MA 330

Corequisites: There are no corequisites for this course.

An introduction to the calculus of tensor fields and the local geometry of manifolds.Topics covered include: manifolds, tangent space, cotangent spaces, vector fields, differential forms, tensor fields, Riemannian metrics, covariant derivative and connections, parallel transport and geodesics, Ricci tensor, Riemannian curvature tensor. Applications will be given in physics (general relativity, mechanics, string theory) and engineering (continuum mechanics).

MA 423 Topics in Geometry 4R-0L-4C Arranged

Graduate Studies Eligible: No

Prerequisites: MA 371 or MA 373 or consent of instructor

Corequisites: There are no corequisites for this course.

An advanced geometry course with topics possibly chosen from the areas of projective geometry, computational geometry, differential geometry algebraic geometry, Euclidean geometry or non-Euclidean geometry. A student may take the course for credit more than once provided the topics are different.

MA 430 Topics in Applied Mathematics 4R-0L-4C Arranged

Graduate Studies Eligible: No

Prerequisites: Instructor permission

Corequisites: There are no corequisites for this course.

A topics course in the general area of continuous applied mathematics. Topics may include mathematical physics, mathematical biology, mathematical finance, mathematics of vision, PDEs, image processing methods, continuum mechanics, dynamical systems, and mathematical modeling. A student may take the course for credit more than once provided the topics are different.

MA 431 Calculus of Variations 4R-0L-4C Arranged

Graduate Studies Eligible: Yes

Prerequisites: MA 330

Corequisites: There are no corequisites for this course.

Euler-Lagrange and Hamiltonian equations, with possible applications in mechanics, electrostatics, optics, quantum mechanics and elasticity theory. An introduction to “direct methods.” Applications will be chosen in accordance with the interest of the students. Both classical and numerical methods have their place in this course.

MA 433 Numerical Analysis 4R-0L-4C W

Graduate Studies Eligible: Yes
Prerequisites: MA 332 or MA 366 or MA 371 or MA 435
Corequisites: There are no corequisites for this course.
Root-finding, computational matrix algebra, nonlinear optimization, polynomial interpolation, splines, numerical integration, numerical solution of ordinary differential equations. Principles of error analysis and scientific computation. Selection of appropriate algorithms based on the numerical problem and on the software and hardware (such as parallel machines) available.

MA 434 Topics in Numerical Analysis 4R-0L-4C Arranged
Graduate Studies Eligible: No
Prerequisites: MA 433
Corequisites: There are no corequisites for this course.
An extension of the material presented in MA433. Topics may include numerical problems, numerical solution of partial differential equations (finite differences, finite elements, spectral methods), sparse matrices, global optimization, approximation theory. A student may take the course for credit more than once provided the topics are different.

MA 435 Finite Difference Methods 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: MA 332 or MA 371 or MA 373 or MA 433
Corequisites: There are no corequisites for this course.
An introduction to finite difference methods for linear parabolic, hyperbolic, and elliptic partial differential equations. Consistency, stability, convergence, and the Lax Equivalence Theorem. Solution techniques for the resulting linear systems.

MA 436 Introduction to Partial Differential Equations 4R-0L-4C F (even years)
Graduate Studies Eligible: Yes
Prerequisites: MA 330
Corequisites: There are no corequisites for this course.
Partial differential equations, elliptic, hyperbolic, and parabolic equations. Boundary and initial value problems. Separation of variables, special functions. Eigenfunction expansions. Existence and uniqueness of solutions. Sturm-Liouville theory, Green's function.

MA 438 Advanced Engineering Mathematics 4R-0L-4C W
Graduate Studies Eligible: No
Prerequisites: MA 222 and senior standing
Corequisites: There are no corequisites for this course.
A fast-paced course in advanced applied mathematics for engineering and physics students that combines aspects of MA330, MA336, and MA373. Applied linear algebra, including abstract vector spaces, linear operators, eigentheory, diagonalization, and the matrix exponential; review of partial differentiation and multiple integration, including Lagrange multipliers and other optimization topics; vector analysis, including the Jacobian matrix and the del operator in standard coordinate systems; and Fourier series with application to the solution of partial differential equation boundary value problems. Students who receive credit for MA438 may only receive credit for at most one of MA330, MA336, MA371, and MA373.

MA 439 Mathematical Methods of Image Processing 4R-0L-4C F (Odd years)
Graduate Studies Eligible: Yes
Prerequisites: MA 221
Corequisites: There are no corequisites for this course.

Mathematical formulation and development of methods used in image processing, especially compression. Vector space models of signals and images, one- and two-dimensional discrete Fourier transforms, the discrete cosine transform, and block transforms. Frequency domain, basis waveforms, and frequency domain representation of signals and images. Convolution and filtering. Filter banks, wavelets and the discrete wavelet transform. Application to Fourier based and wavelet based compression such as the JPEG compression standard. Compression concepts such as scalar quantization and measures of performance.

MA 444 Deterministic Models in Operations Research 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: MA 371 or MA 373 , and programming experience

Corequisites: There are no corequisites for this course.

Formulation of various deterministic problems as mathematical optimization models and the derivation of algorithms to solve them. Optimization models studied include linear programs, integer programs, and various network models. The course will emphasize modeling, algorithm design, and the associated mathematical theory, e.g. polyhedral, duality, convex analysis. Some computer programming is expected.

MA 445 Stochastic Models in Operations Research 4R-0L-4C S (even years)

Graduate Studies Eligible: Yes

Prerequisites: MA 381, and MA 221

Corequisites: There are no corequisites for this course.

Introduction to stochastic mathematical models and techniques that aid in the decision-making process. Topics covered include a review of conditional probability, discrete and continuous Markov chains, Poisson processes, queueing theory (waiting line problems), and reliability.

MA 446 Combinatorial Optimization 4R-0L-4C S (odd years)

Graduate Studies Eligible: Yes

Prerequisites: MA 276, and CSSE 220

Corequisites: There are no corequisites for this course.

An introduction to graph- and network-based optimization models, including spanning trees, network flow, and matching problems. Focus is on the development of both models for real-world applications and algorithms for their solution.

MA 450 Mathematics Seminar 1R-0L-1C F,W,S

Graduate Studies Eligible: No

Prerequisites: Consent of instructor

Corequisites: There are no corequisites for this course.

A student must attend at least 10 mathematics seminars or colloquia and present at one of the seminars, based on material mutually agreed upon by the instructor and the student. A successful presentation is required for a passing grade. As seminars may not be offered every week during the quarter a student may extend the course over more than one quarter, but it must be completed within two consecutive quarters. A student may take this course a maximum of four times.

MA 460 Topics in Analysis 4R-0L-4C Arranged

Graduate Studies Eligible: No

Prerequisites: Instructor permission

Corequisites: There are no corequisites for this course.

An advanced topics course in analysis. Topic of the course could be advanced topics in real analysis, advanced topics in complex analysis, analysis on manifolds, measure theory or an advanced course in applied analysis (differential equations). May be taken more than once provided topics are different

MA 461 Topics in Topology 4R-0L-4C Arranged
Graduate Studies Eligible: No
Prerequisites: MA 366 or consent of instructor
Corequisites: There are no corequisites for this course.
Introduction to selected topics from point-set topology or algebraic topology from a rigorous point of view. Possible topics include metric spaces, general topological spaces, compactness, connectedness, separation axioms, compactification and metrization theorems, homotopy and homology, and covering spaces. Intended for mathematics majors planning to pursue graduate study in mathematics.

MA 466 Introduction to Functional Analysis 4R-0L-4C Arranged
Graduate Studies Eligible: Yes
Prerequisites: MA 366
Corequisites: There are no corequisites for this course.
An introduction to the theory of Banach spaces emphasizing properties of Hilbert spaces and linear operators. Special attention will be given to compact operators and integral equations.

MA 470 Topics in Algebra 4R-0L-4C Arranged
Graduate Studies Eligible: No
Prerequisites: Instructor permission
Corequisites: There are no corequisites for this course.
An advanced topics course in algebra. Topic of the course could be commutative algebra, Galois theory, algebraic geometry, Lie groups and algebras, or other advanced topics in algebra. May be taken more than once provided topics are different.

MA 471 Linear Algebra II 4R-0L-4C S (even years)
Graduate Studies Eligible: Yes
Prerequisites: MA 371 or MA 373
Corequisites: There are no corequisites for this course.
Continuation of Linear Algebra I. Properties of Hermitian and positive definite matrices and factorization theorems (LU, QR, spectral theorem, SVD). Linear transformations and vector spaces.

MA 473 Design & Analysis of Algorithms 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: CSSE 230, and MA 276, and MA 374
Corequisites: There are no corequisites for this course.
Students study techniques for designing algorithms and for analyzing the time and space efficiency of algorithms. The algorithm design techniques include divide-and-conquer, greedy algorithms, dynamic programming, randomized algorithms and parallel algorithms. The algorithm analysis includes computational models, best/average/worst case analysis, and computational complexity (including lower bounds and NP-completeness). Same as CSSE 473.

MA 474 Theory of Computation 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CSSE 230, and MA 276, and MA 374
Corequisites: There are no corequisites for this course.
Students study mathematical models by which to answer three questions: What is a computer? What limits exist on what problems computers can solve? What does it mean for a problem to be hard? Topics include models of computation (including Turing machines), undecidability (including the Halting Problem) and computational complexity (including NP-completeness). Same as CSSE 474.

MA 475 Topics in Discrete Mathematics 4R-0L-4C Arranged

Graduate Studies Eligible: No
Prerequisites: MA 276, and MA 374 ; additional prerequisites may be required at the discretion of the instructor
Corequisites: There are no corequisites for this course.
An extension of the material presented in MA 276 and 374. Topics may include combinatorial design, Fibonacci numbers, or the Probabilistic Method, among others. A student may take the course for credit more than once provided the topics are different.

MA 476 Algebraic Codes 4R-0L-4C S (odd years)
Graduate Studies Eligible: Yes
Prerequisites: MA 276, and MA 374
Corequisites: There are no corequisites for this course.
Construction and theory of linear and nonlinear error correcting codes. Generator matrices, parity check matrices, and the dual code. Cyclic codes, quadratic residue codes, BCH codes, Reed-Solomon codes, and derived codes. Weight enumeration and information rate of optimum codes.

MA 477 Graph Theory 4R-0L-4C S (even years)
Graduate Studies Eligible: Yes
Prerequisites: MA 276, and MA 374
Corequisites: There are no corequisites for this course.
An introduction to the theory and applications of directed and undirected graphs. Possible topics include the following: Connectivity, subgraphs, graph isomorphism, Euler trails and circuits, planarity and the theorems of Kuratowski and Euler, Hamilton paths and cycles, graph coloring and chromatic polynomials, matchings, trees with applications to searching and coding, and algorithms dealing with minimal spanning trees, articulation points, and transport networks

MA 478 Topics in Number Theory 4R-0L-4C Arranged
Graduate Studies Eligible: No
Prerequisites: MA 378 or MA 374 or consent of the instructor
Corequisites: There are no corequisites for this course.
Advanced topics in Number Theory. Topics may include elliptic curve cryptography, the Fermat-Wiles Theorem, elliptic curves, modular forms, p-adic numbers, Galois theory, diophantine approximations, analytic number theory, algebraic number theory. A student may take the course for credit more than once provided the topics are different.

MA 479 Cryptography 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CSSE 220, and MA 276
Corequisites: There are no corequisites for this course.
Introduction to basic ideas of modern cryptography with emphasis on mathematical background and practical implementation. Topics include: the history of cryptography and cryptanalysis, public and private key cryptography, digital signatures, and limitations of modern cryptography. Touches upon some of the societal issues of cryptography (same as CSSE 479)

MA 480 Topics in Probability or Statistics 4R-0L-4C Arranged
Graduate Studies Eligible: No
Prerequisites: Instructor permission
Corequisites: There are no corequisites for this course.
An advanced course in probability or statistics. Possible topics include (but are not restricted to) reliability, discrete event simulation, multivariate statistics, Bayesian statistics, actuarial science, nonparametric statistics, categorical data analysis, and time series analysis. May be taken more than once provided topics are different.

MA 481 Mathematical Statistics 4R-0L-4C W (even years)
Graduate Studies Eligible: Yes
Prerequisites: MA 382, or both MA 381 and consent of instructor
Corequisites: There are no corequisites for this course.
An introduction to mathematical statistics. Review of distributions of functions of random variables. Moment generating functions. Limiting distributions. Point estimation and sufficient statistics. Fisher information and Rao-Cramer inequality. Theory of statistical tests.

MA 482 Biostatistics 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: MA 223 or MA 382
Corequisites: There are no corequisites for this course.
This course introduces statistical techniques for addressing the challenges that arise in the analysis of data from the biological sciences (including biology, biomedical engineering, and the medical community). Topics include linear regression modeling, nonlinear regression, repeated measures analysis (including mixed models), and survival/reliability analysis (analysis of time-to-event data). Flexible modeling strategies including relaxing linearity and distributional assumptions are discussed. Additional topics are introduced when discussing articles found in the literature, including properties of study design, power, meta-analysis, missing data, and causal inference. No prerequisite knowledge of biology is assumed. Review of fundamental prerequisite statistics will be included as necessary.

MA 483 Bayesian Data Analysis 4R-0L-4C W (Odd years)
Graduate Studies Eligible: Yes
Prerequisites: MA 381
Corequisites: There are no corequisites for this course.
This course offers an introduction to statistical inference under the Bayesian framework in addition to elements of basic study design. Building from Bayes' Rule for probability computations, we develop a framework of estimation, hypothesis testing and prediction. Topics include the construction of prior distributions to quantify a priori beliefs about unknown parameters, modeling available data, and using data to update beliefs about parameters. Applications include inference for a single response, comparing groups, and regression models; modern applications will be covered, time permitting. The course will make use of heavy use of computational tools for Bayesian inference, including Markov Chain Monte Carlo (MCMC) methods.

MA 485 Applied Linear Regression 4R-0L-4C W (odd years)
Graduate Studies Eligible: Yes
Prerequisites: MA 221, and either MA 223 or MA 382
Corequisites: There are no corequisites for this course.
This is an applied course in multiple linear regression. The techniques presented, all with respect to linear models, develop skills in selecting an appropriate model and performing statistical inference. The use of data from a variety of fields helps demonstrate method implementation and the communication of results in practice. A statistical programming language aids in creating reproducible analysis results.

MA 487 Design of Experiments 4R-0L-4C W (even years)
Graduate Studies Eligible: Yes
Prerequisites: MA 223 or MA 382
Corequisites: There are no corequisites for this course.
This is an applied course in design of experiments. Emphasis is placed on designing statistical studies to solve problems in engineering and science. A variety of designs

are presented, including the full factorial, screening, response surface, and split plot. It is demonstrated how constraints on the randomization process due to the design are related to the appropriate analysis method and meaning of the results. Statistical software is used for data analysis throughout.

MA 490 Topics in Mathematics Variable credit

Graduate Studies Eligible: No

Prerequisites: Consent of instructor

Corequisites: There are no corequisites for this course.

This course will cover advanced topics in mathematics not offered in listed courses.

MA 491 Introduction to Mathematical Modeling 2C F

Graduate Studies Eligible: No

Prerequisites: Senior Standing or permission of the instructor

Corequisites: There are no corequisites for this course.

An introduction to the process of mathematically modeling a problem, including data collection, defining the appropriate mathematical model and interpreting the results of the proposed model. Emphasis placed on the modeling process, using examples from both continuous and discrete mathematics.

MA 495 Research Project in Mathematics Variable Credit

Graduate Studies Eligible: No

Prerequisites: Consent of instructor

Corequisites: There are no corequisites for this course.

An undergraduate research project in mathematics or the application of mathematics to other areas. Students may work independently or in teams as determined by the instructor. Though the instructor will offer appropriate guidance in the conduct of the research, students will be expected to perform independent work and collaborative work if on a team. The course may be taken more than once provided that the research or project is different.

MA 496 Senior Capstone I 2C or 4C See Department

Graduate Studies Eligible: No

Prerequisites: Senior Standing or permission of the instructor

Corequisites: There are no corequisites for this course.

Individual study and research of a topic in mathematics. Topic is expected to be at an advanced level.

MA 497 Senior Capstone II 2C See Department

Graduate Studies Eligible: No

Prerequisites: MA 496 or permission of instructor

Corequisites: There are no corequisites for this course.

Individual study and research of a topic in mathematics. Topic is expected to be at an advanced level.

MA 498 Senior Capstone III 2C See Department

Graduate Studies Eligible: No

Prerequisites: MA 497 or permission of instructor

Corequisites: There are no corequisites for this course.

Individual study and research of a topic in mathematics. Topic is expected to be at an advanced level.

MA 538 Advanced Engineering Mathematics 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: Graduate standing

Corequisites: There are no corequisites for this course.

A fast-paced course in advanced applied mathematics for graduate-level engineering students. Applied linear algebra, including abstract vector spaces, linear operators, eigentheory, diagonalization, and the matrix exponential; review of partial differentiation and multiple integration, including Lagrange multipliers and other optimization topics; vector analysis, including the Jacobian matrix, the del operator in standard coordinate systems, and line integrals; and Fourier series with application to the solution of partial differential equation boundary value problems. Students may not receive credit for both MA438 and MA538.

MA 580 Topics in Advanced Probability Theory & Its Applications 4R-0L-4C Arranged

Graduate Studies Eligible: No

Prerequisites: MA 381

Corequisites: There are no corequisites for this course.

Advanced topics in probability theory as well as applications that are not offered in the listed courses.

MA 581 Topics in Advanced Statistics 4R-0L-4C Arranged

Graduate Studies Eligible: No

Prerequisites: MA 223 or MA 381 and Consent of instructor

Corequisites: There are no corequisites for this course.

This course will cover advanced topics in mathematical statistics as well as applied statistics that are not offered in the listed courses.

MA 590 Graduate Topics in Mathematics Variable Credit

Graduate Studies Eligible: No

Prerequisites: Consent of instructor

Corequisites: There are no corequisites for this course.

This course will cover graduate-level topics in mathematics not offered in listed courses.

Mechanical Engineering - Course Descriptions

ME 123 Computer Programming 4R-0L-4C F,W,S

Graduate Studies Eligible: No

Prerequisites: ME/PHOE major or permission of instructor

Corequisites: There are no corequisites for this course.

Software tools and engineering processes for mechanical engineers. Topics may include: structured programming (Matlab), simulation of rigid body motion, presentation software, and spreadsheets. Introduction to teaming and creativity.

ME 193 Selected Topics in Design Hours as assigned. Maximum 4 credits per term. See Department

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Selected student design projects. May include testing and/or computer aided design.

ME 199 Professional Experience 1R-0L-1C See Department

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

The professional experiences course captures the practical work experiences related to the student’s academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and

enhanced their academic studies. The course will be graded as “S” satisfactory, or “U” unsatisfactory based on the written report of the professional experience.

ME 293 Selected Topics in Design Hours as assigned. Maximum 4 credits per term. See Department

Graduate Studies Eligible: No

Prerequisites: Sophomore class standing

Corequisites: There are no corequisites for this course.

Selected student design projects. May include testing and/or computer aided design.

ME 301 Applications of Thermodynamics 4R-0L-4C F,W

Graduate Studies Eligible: No

Prerequisites: CHEM 111, and CHEM 111L, and ES 201* or CE 205 *With a grade of C or better

Corequisites: There are no corequisites for this course.

Extend the conservation and accounting framework to examine energy-conversion systems. Topics include thermodynamic properties of pure substances, gas mixtures, exergy analyses, power and refrigeration cycles, psychrometric processes, combustion, and propulsion.

ME 302 Heat Transfer 4R-0L-4C S,F

Graduate Studies Eligible: No

Prerequisites: ES 212 or CHE 301 or EM 301, and MA 222

Corequisites: There are no corequisites for this course.

Introduces the basic modes of heat transfer, heat transfer properties, steady and unsteady one-dimensional heat conduction, free and forced convection, radiation and heat exchangers. Other topics may include numerical methods and boiling and condensation.

ME 304 Introduction to the Design of Mechanisms 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: ME 123 or ENGD 120 or CSSE 120 or BE 100

Corequisites: There are no corequisites for this course.

This course will cover a set of computational tools to design and analyze mechanisms to achieve specific goals. The specific focus of this course is to study kinematics (study of motion without regards to forces) of a mechanism. Students learn how to model and solve for the position, velocity, acceleration of linkages using vectors. They also study the kinematics of gear trains and specifically, planetary gear trains.

ME 305 Introduction to Aerospace Engineering 4R-0L-4C S

Graduate Studies Eligible: No

Prerequisites: ES 212

Corequisites: There are no corequisites for this course.

Application of fundamental engineering concepts to aerospace systems. Aircraft performance and stability. Physical properties of the standard atmosphere. Aerodynamics of the airplane including lift, drag and pitching moment estimation. Introduction to orbital mechanics.

ME 317 Design for Manufacturing 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: EM 104

Corequisites: There are no corequisites for this course.

This is an introductory course that examines the interactions between design and manufacturing from the designer's point of view. Common manufacturing processes will be introduced and design guidelines will be developed for each process. The successful student will leave this class with an appreciation that a designer must consider the

method of manufacture during the design process to ensure that a product is functional, economically viable, and safe.

ME 318 Material Processing in Manufacturing 4R-0L-4C Not Offered

Graduate Studies Eligible: No

Prerequisites: ME 328

Corequisites: There are no corequisites for this course.

An introductory course in the control of the properties of materials during manufacturing. Covers the interrelationship between material properties and the principal manufacturing processes like hot and cold working, casting, welding, heat treating and machining. Emphasizes the importance of considering manufacturability when making material selection decisions in design.

ME 321 Measurement Systems 3R-3L-4C W,S

Graduate Studies Eligible: No

Prerequisites: EM 103, and ES 205, and MA 223

Corequisites: There are no corequisites for this course.

Fundamentals of measurement systems in mechanical engineering including transducer operation, signal conditioning, data reduction, and presentation of results. Transducer and measurement system characteristics including resolution, sensitivity, loading, time response, and frequency response. Operating principles of basic instrumentation for measurement of mechanical quantities such as force, torque, pressure, temperature, and flow. Topics include uncertainty analysis, data analysis, calibration, data acquisition, presentation of results, and an introduction to experiment design.

ME 323 Numerical Methods in Engineering 1R-3L-2C W,S

Graduate Studies Eligible: No

Prerequisites: ME 123 or CSSE 120 and

Corequisites: There are no corequisites for this course.

Engineering problems often lead to analytically intractable equations. This course combines structured programming and applied numerical methods to obtain approximate engineering solutions. Strategies include root finding, numerical integration, finite difference, initial value and boundary value problems. Matlab is used as the programming language for solving iterative problems numerically.

ME 327 Numerical Methods of Engineering Analysis 3R-3L-4C W,S

Graduate Studies Eligible: No

Prerequisites: ME 123 or BE 100 or CSSE 120, and MA 222

Corequisites: There are no corequisites for this course.

This is an inter-disciplinary course focusing on the generation and interpretation of numerical solutions and the processing of numerical data for engineering problems. Topics include approximate solutions to nonlinear algebraic and differential equations, initial and boundary value problems, numerical integration and differentiation, optimization, data conditioning, and regression analysis. Trade-offs between accuracy and cost are emphasized. Matlab is used as the programming language.

ME 328 Materials Engineering 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: CHEM 111

Corequisites: There are no corequisites for this course.

Introduces properties of metals, ceramics, polymers, and composites. Relates material processing to properties through underlying material structure. Overviews the materials available to engineers and discusses applications and material selection.

ME 359 Vehicle System Modeling 4R-0L-4C F

Graduate Studies Eligible: No

Prerequisites: ES 201
Corequisites: There are no corequisites for this course.
Excel and Simulink are used to create reactive and predictive models of vehicle powertrains, both electric and internal combustion. Drive cycles are introduced, the powertrains are iteratively refined, and insightful observations are made with respect to vehicle performance. The course concludes with modeling a vehicle of the student's choosing.

ME 380 Creative Design 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: Permission of instructor
Corequisites: There are no corequisites for this course.
Emphasis on the creative process in engineering design. Students will develop their design capability by exploring various conceptual blocks, using creative enhancement techniques and participating in on-the-spot design.

ME 393 Selected Topics in Design As assigned. Maximum 4 credits per term. See Department
Graduate Studies Eligible: No
Prerequisites: Junior class standing
Corequisites: There are no corequisites for this course.
Selected student design projects. May include testing and/or computer aided design.

ME 397 Special Topics in Mechanical Engineering 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics of current interest in mechanical engineering at the 300-level.

ME 401 Foundations of Fluid Mechanics 4R-0L-4C SeeDept
Graduate Studies Eligible: Yes
Prerequisites: ES 212 or EM 301, and MA 222
Corequisites: There are no corequisites for this course.
Covers the fundamental concepts of fluid dynamics with an emphasis on physical understanding. Topics include fluid kinematics, control-volume and differential analyses of fluid motion, similitude, potential flow, vorticity transport, low Reynolds number flow, boundary-layer physics, stability of laminar flow, and turbulent transport. Topics may be added or deleted as needed.

ME 402 Advanced Heat Transfer 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: ME 302
Corequisites: There are no corequisites for this course.
This course covers additional topics in conduction, convection and radiation heat transfer as well as an introduction to mass transfer, phase change and numerical methods.

ME 404 Advanced Design of Mechanisms 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: ME 304, and either ES 201 or ENGD 215 or BE 132
Corequisites: There are no corequisites for this course.
This course will cover some intermediate topics in the design of mechanisms including position analysis of three, four, five and sixbar linkages, cam analysis and design, including motion of the cam/follower system, the method of constraints in kinematics, and velocity, acceleration and force analysis using the method of constraints. The method of virtual work will be used to conduct force analysis for the inverse dynamic

problem. Extensive use will be made of MATLAB (or similar software) for plotting and animating solutions to mechanism design problems.

ME 405 Theoretical Aerodynamics 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: ES 212

Corequisites: There are no corequisites for this course.

Introduction to aerodynamics theory. Development of equations of conservation of mass and momentum. Vorticity, induced velocity and irrotational flow. Stream function, velocity potential, Laplace's equation and the principle of superposition. Flow about a body, the Kutta-Joukowski Theorem. Concepts of thin airfoil and finite wing theory. Exact solutions to elementary viscous flow problems.

ME 406 Control Systems 3R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: ES 205

Corequisites: There are no corequisites for this course.

Basic principles of feedback control theory. Mathematical modeling and performance analysis of dynamical systems. Includes stability analysis, root locus compensation and design, frequency response analysis. Implementation of control system analysis and design is gained with several laboratory experiences.

ME 407 Power Plants 4R-0L-4C See Department

Graduate Studies Eligible: No

Prerequisites: ME 301

Corequisites: There are no corequisites for this course.

Steam, cogeneration and combined cycles are studied with the aid of property software. Various components of the cycles are studied in detail. A survey of alternative power sources is presented. Tours of power plants are taken when available.

ME 408 Renewable Energy 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: ES 212 or equivalent

Corequisites: There are no corequisites for this course.

Covers renewable energy sources such as solar heating and cooling, wind energy, biomass, and photovoltaic energy. Surveys the energy availability of these sources and life cycle cost and present value used to evaluate the system. Students will design a system which utilizes a renewable energy source and economically evaluate the system.

ME 409 Air Conditioning 4R-0L-4C See Department

Graduate Studies Eligible: No

Prerequisites: ES 212, and ME 302

Corequisites: There are no corequisites for this course.

Human comfort and the properties of air. Air conditioning in residences, public and industrial buildings using vapor compression and absorption units. Cooling loads, psychrometry, fans, duct sizing and layout, automatic control, and acoustic design considerations.

ME 410 Internal Combustion Engines 4R-0L-4C F

Graduate Studies Eligible: Yes

Prerequisites: ES 212 or CHE 301

Corequisites: There are no corequisites for this course.

Study of spark ignition and compression ignition engines. Influences of engine design features on performance, economy, and air pollution. Influence of the combustion process, carburetion, fuel injection and ignition characteristics on engine operation.

ME 411 Propulsion Systems 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: ME 301
Corequisites: There are no corequisites for this course.
Application of basic principles in the study of the performance characteristics of air and space vehicles. Aerodynamics of steady one dimensional isentropic compressible flow. Shock waves, gas turbines, turbojet, turbofan, turboprop, turboshaft, ram jet, rocket, nuclear propulsion and space propulsion systems are discussed and compared.

ME 412 Lean Manufacturing 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course introduces students to lean manufacturing - the identification of value and elimination of waste in a manufacturing process. The course will feature frequent assigned reading and discussion as well as factory simulations, factory tours, and projects. Students will develop a fundamental understanding of lean principles and will be able to apply their knowledge in any profession.

ME 414 Materials Selection in Mechanical Design 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: EM 204
Corequisites: There are no corequisites for this course.
Introduces the Ashby approach to materials selection, a systematic method for choosing materials for applications based on design constraints, design objectives, and combinations of relevant materials properties. All classes of materials are considered, including metals, ceramics, polymers, and composites. The CES EduPack software is used extensively throughout the course. Project work is emphasized.

ME 415 Corrosion & Engineering Materials 4R-0L-4C Not Offered
Graduate Studies Eligible: No
Prerequisites: ME 328 or CHE 315
Corequisites: There are no corequisites for this course.
Presents fundamentals of metallurgy and corrosion mechanisms in engineering metals. Discusses various classes of corrosion and methods of mitigating corrosion with emphasis on practical situations.

ME 416 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Graduate Studies Eligible: No
Prerequisites: Junior or Senior standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with EP 410, ECE 416, and CHE 405.

ME 417 Advanced Materials Engineering 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: ME 328, and EM 203 or EM 204
Corequisites: There are no corequisites for this course.
Fundamentals of deformation and fracture in metals, polymers, and ceramics with application to design. Emphasis on time-temperature dependence of polymers, brittle behavior of advanced ceramics, and the fracture mechanics approach to design of high strength and critical application materials.

ME 419 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Graduate Studies Eligible: No
Prerequisites: EP 410 or equivalent
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics.

ME 421 Mechanical Engineering Laboratory 0R-6L-2C F,W
Graduate Studies Eligible: No
Prerequisites: ME 321, and ENGL H290
Corequisites: There are no corequisites for this course.
Introduction to engineering experimentation, centered on an experimental project planned and executed by students. Uncertainty analysis, instrumentation systems, and statistical design of experiments. Emphasis on project on project planning and execution, developing a scope of work, interim deliverables, and reporting engineering results.

ME 422 Finite Elements for Engineering Applications 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: EM 204
Corequisites: There are no corequisites for this course.
Introduces finite element methodology from a strongly theoretical perspective. Emphasizes solving various 1D and 2D static, transient, and modal problem statements including trusses, beams, plane stress, plane strain, and axisymmetric models. Problems of interest similar to those found in Statics I and II, as well as Machine Component Design. Also assesses higher order bases, time stepping procedures, and iterative solvers. Utilizes Matlab and ANSYS for computational work. Upon completion of this class you should be “useful” to a Computer Aided Engineering group from both a theory and implementation standpoint.

ME 423 Fatigue 4R-0L-4C See Department
Graduate Studies Eligible: No
Prerequisites: EM 204
Corequisites: There are no corequisites for this course.
Introduces modern methods in fatigue analysis and testing, with a focus on metal fatigue. Covers the stress-life approach, the strain-life approach, and crack growth analysis based on fracture mechanics.

ME 424 Mechanics of Composites 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: EM 204, and ME 328
Corequisites: There are no corequisites for this course.
Introduction to the basic mechanical aspects of composite materials such as: types / classification of composites, micro and macro-mechanical models for material properties, stress/strain analysis, and the manufacturing or composites. Specific focus is given to fiber-reinforced composite materials. Project work is emphasized.

ME 425 Aerospace Engineering Laboratory 1R-3L-2C See Department
Graduate Studies Eligible: No
Prerequisites: ES 212
Corequisites: There are no corequisites for this course.
Introduction to experiment planning and execution. Projects involve wind tunnel testing including measurement of forces and moments and flow visualization.

Student organized and executed with direct faculty consultation. Emphasis on written presentation.

ME 426 Turbomachinery 4R-0L-4C See Department

Graduate Studies Eligible: No

Prerequisites: ES 205

Corequisites: There are no corequisites for this course.

Introduces the theory and issues related to the design of axial and radial flow turbines, compressors and pumps. Euler's equation and vector diagrams are used to evaluate energy transfer and efficiency.

ME 427 Introduction to Computational Fluid Dynamics 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: ES 212, and ME 323 or ME 327

Corequisites: There are no corequisites for this course.

Covers the key components of a CFD calculation: mesh generation, numerical algorithm and turbulence modeling. Survey of solution strategy includes both the finite volume and the finite difference methods. Issues on formal order of accuracy, dissipation, dispersion, stability and space-time coupling are discussed in detail. Both structured programs and commercial software will be used as vehicles in obtaining a CFD solution.

ME 428 Materials Research and Instrumentation 4R-0L-4C See Department

Graduate Studies Eligible: No

Prerequisites: CHEM 111 and junior standing.

Corequisites: There are no corequisites for this course.

Introduces students to small scale manufacturing methods (deposition, lithography, and etching techniques) and instrumentation for probing these materials (scanning electron microscopy, x-ray diffraction, Raman spectroscopy, and profilometry). Electronic, magnetic, and optical properties are also discussed including (semi-conductivity, dielectric behavior, ferroelectricity, piezoelectricity, types of magnetism, and quantum dots). Students are expected to read journal articles throughout the course related to these topics and to conduct research in an area of interest in a small team.

ME 429 Experimental Fluid Mechanics 2R-6L-4C W

Graduate Studies Eligible: No

Prerequisites: ES 212

Corequisites: There are no corequisites for this course.

An introduction to experimental methods used to study thermal/fluid phenomena. Techniques studied include pressure and force measurement, particle image velocimetry (PIV), laser-induced fluorescence (LIF), laser Doppler velocimetry (LDV), constant temperature/constant current hot-wire anemometry (CTA/CCA), and schlieren/ shadowgraph imaging. Focus is placed on understanding the comparative strengths and weaknesses of techniques in a variety of situations.

ME 430 Mechatronic Systems 3R-3L-4C F,W

Graduate Studies Eligible: No

Prerequisites: ME 123 or CSSE 120 or BE 100 or ENGD 120, and ES 213, and ES 213L or ECE 203 or ENGD 120 or BE 131

Corequisites: There are no corequisites for this course.

Applications of microprocessors and microcontrollers and digital electronics to the design and utilizations of embedded control systems in smart systems and products. Topics include Boolean logic and algebra, system hardware and software development, and interfacing for mechanical applications.

ME 435 Robotics Engineering 3R-3L-4C S

Graduate Studies Eligible: Yes

Prerequisites: ME 430 or ECE 230
Corequisites: There are no corequisites for this course.
Interdisciplinary course in robotics focusing on communication, software development, kinematics, robot GUI design, sensing, control, and system integration. Labs in the course cover MATLAB GUI development with GUIDE, Denavit-Hartenberg parameters, Arduino programming, Arduino to Android communication, Android app development, and OpenCV4Android image recognition. Students in the course will program an Android + Arduino, 6-wheeled mobile robot with 5 DOF servo arm to participate in an outdoor GPS robotics challenge. Cross-listed with CSSE 435.

ME 441 Advanced Modeling and Simulation Techniques 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: ES 205
Corequisites: There are no corequisites for this course.
Covers cross-disciplinary system analysis, modeling, simulation, and control using specialized techniques. Systems to be investigated include linear mechanical, rotational mechanical, electrical, thermal, pneumatic, electro-magnetic, and combinations thereof. Bond graph method for modeling. System simulation and controller design using MATLAB and Simulink. Discussion of modeling, simulation, and control of nonlinear systems. Special topics may be added if time permits.

ME 445 Robot Dynamics and Control 4R-0L-4C W
Graduate Studies Eligible: No
Prerequisites: ME 406 or ECE 320 or BE 350
Corequisites: There are no corequisites for this course.
This course introduces students to the basics of kinematic and dynamic modeling of serial manipulators. Students will also learn joint-space position control and gain familiarity with Cartesian-space control.

ME 447 Visualizing Data 4R-0L-4C Not Offered
Graduate Studies Eligible: No
Prerequisites: Junior class standing
Corequisites: There are no corequisites for this course.
The course is about creating truthful and compelling data visuals. We study elements of statistical analysis, programming in R, human perception, graphic design, and visual rhetoric and ethics. After successfully completing this course, students should be able to design effective and truthful data displays, credibly explain their design rationale, produce publication-quality visuals, and credibly critique a data display. Prior experience with R is not required.

ME 450 Combustion 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: ME 301 or CHE 303
Corequisites: There are no corequisites for this course.
Study of the thermodynamics and kinetics of combustion processes and the underlying chemical processes. Topics covered include deflagration and detonation waves, combustion of solid, liquid, and gaseous fuels, and environmental impacts of combustion. Laboratory experience via in-class, hands-on exercises.

ME 461 Aircraft Design 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: ME 305
Corequisites: There are no corequisites for this course.
Fundamentals of conceptual aircraft design. Aerodynamic analysis, design constraints based on customer requirements, mission profiles, aircraft sizing, optimization, and

presentation of performance capabilities. Oral and written communication emphasized. Design teams.

ME 462 Thermal Design 4R-0L-4C See Department

Graduate Studies Eligible: No

Prerequisites: ES 212, and ME 302

Corequisites: There are no corequisites for this course.

Applications of the thermodynamic, heat transfer, and fluid flow principles to the modeling and design of thermal systems. These systems include pumps, fans, and heat and mass exchangers. A team project which includes the design, construction and testing of a fluid or thermal device or system provides the focus for the course.

ME 470 Capstone Design I 2R-3L-4C F,S

Graduate Studies Eligible: No

Prerequisites: ES 205, and EM 204, and ME 301, and ME 480 (or concurrent registration), and Junior standing.

Corequisites: There are no corequisites for this course.

Students work in teams with three to five members on design projects furnished from clients. The emphasis is on creating design solutions, with appropriate analyses, to meet stakeholders' needs. In addition to regular meetings with their faculty advisors, the teams are expected to maintain close and continuous communications with their clients during the quarter. The ten week projects culminate in interim reports which are submitted to the clients.

ME 471 Capstone Design II 1R-4L-4C F,W

Graduate Studies Eligible: No

Prerequisites: ME 470, and ME 480

Corequisites: There are no corequisites for this course.

This course is a continuation of ME470. Students continue work in teams with three to five members developing the project started in ME470. The emphasis is on detailing design solutions identified in the first quarter. In addition to regular meetings with their faculty advisors, the teams are expected to maintain close and continuous communications with their clients during the quarter. The ten week projects culminate in interim reports which are submitted to the clients. This course is intended to be taken in the quarter immediately following ME470.

ME 472 Capstone Design III 1R-4L-4C W,S

Graduate Studies Eligible: No

Prerequisites: ME 471

Corequisites: There are no corequisites for this course.

This course is a continuation of ME 471. The student teams test their prototype solutions and transfer the project results to their client. Continuous and regular communication with the outside clients, as well as with the faculty advisors, is expected. The course culminates with a final report that documents the design process. This course is intended to be taken in the quarter immediately following ME471.

ME 480 Machine Component Design 4R-0L-4C S,F

Graduate Studies Eligible: No

Prerequisites: EM 204 or BE 222 or EM 203

Corequisites: There are no corequisites for this course.

Applications of fundamentals of engineering mechanics in analysis and synthesis of machine components and systems. Special emphases placed on stress/strength analyses and fatigue failures. Design of mechanical components and systems including threaded fasteners, springs, bearings, gears, shafts, clutches, brakes, belts, chains, and couplings.

ME 490 Directed Research As assigned. Maximum 4 credits per term. See Department
Graduate Studies Eligible: No
Prerequisites: Completion of freshman and sophomore course requirements and approval of adviser and course instructor
Corequisites: There are no corequisites for this course.
Selected projects for student research.
ME 491 Directed Research As assigned. Maximum 4 credits per term. See Department
Graduate Studies Eligible: No
Prerequisites: Completion of freshman and sophomore course requirements and approval of adviser and course instructor
Corequisites: There are no corequisites for this course.
Selected projects for student research.
ME 493 Selected Topics in Design Hours as assigned. Maximum 4 credits per term. See Department
Graduate Studies Eligible: No
Prerequisites: Senior class standing
Corequisites: There are no corequisites for this course.
Selected student design projects. May include testing and/or computer aided design.
ME 497 Special Topics in Mechanical Engineering 4R-0L-4C Arranged See Department
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics of current interests in mechanical engineering.
ME 501 Advanced Thermodynamics 4R-0L-4C See Department
Graduate Studies Eligible: Yes
Prerequisites: ME 301 or equivalent
Corequisites: There are no corequisites for this course.
Study of advanced thermodynamic topics: modeling of transient systems, exergy (availability) analysis, equations of state and thermodynamics relationships for simple, compressible substances.
ME 502 Topics in Heat Transfer 4R-0L-4C See Department
Graduate Studies Eligible: Yes
Prerequisites: ME 302
Corequisites: There are no corequisites for this course.
Course may be repeated for different heat transfer topics.
ME 503 Viscous Fluid Flow 4R-0L-4C See Department
Graduate Studies Eligible: Yes
Prerequisites: ME 401
Corequisites: There are no corequisites for this course.
Material and spatial descriptions of fluid motion. The Reynolds transport equation. The stress tensor and governing equations for the motion of viscous fluids. Newtonian fluids, the Navier-Stokes equations. Asymptotic solutions including fully developed channel flow, oscillating flat plate, wakes and jets. Introduction to boundary layers and turbulent flow including Reynolds averaging.
ME 505 Modeling & Simulation of Dynamic Systems 4R-0L-4C Not Offered
Graduate Studies Eligible: Yes
Prerequisites: ES 205, and MA 222

Corequisites: There are no corequisites for this course.
Modeling and simulation of engineering components and systems. Emphasis on a unified work-energy approach to modeling physical systems, model formulation using a differential-algebraic form of Lagrange's equation, and the numerical solution of the resulting initial-value problem. Applications are explored using modeling and simulation projects.

ME 506 Advanced Control Systems 4R-0L-4C See Department
Graduate Studies Eligible: Yes
Prerequisites: ME 406 or equivalent or consent of instructor
Corequisites: There are no corequisites for this course.
Physical models for control; system response, analysis and design. Time domain; system response, analysis and design. Frequency domain; state variable representation/description; stability, controllability, observability; linear quadratic regulator, pole-placement, state estimation/observers.

ME 507 Applied Nonlinear Control Systems 4R-0L-4C Not Offered
Graduate Studies Eligible: Yes
Prerequisites: ME 406 or equivalent or consent of instructor
Corequisites: There are no corequisites for this course.
Analysis and design of controls for inherently nonlinear systems and the use of nonlinear elements in design. Techniques for analysis and design include, stability by Liaqunov, describing functions, phase plane analysis, sliding control, adaptive control and control of multi-input systems.

ME 510 Gas Dynamics 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: ES 212
Corequisites: There are no corequisites for this course.
Introduction to the dynamics of a compressible flow. Equations of motion for subsonic and supersonic flow. Nozzle flow. Normal and oblique shock waves, Prandtl-Meyer flow. Steady and unsteady, one dimensional gas flow with friction and heat transfer.

ME 511 Numerical Methods for Dynamic Systems Analysis 4R-0L-4C Not Offered
Graduate Studies Eligible: Yes
Prerequisites: ES 205, and ME 323 or ME 327
Corequisites: There are no corequisites for this course.
Applications of approximate numerical solution techniques, including the finite element method, to the analysis of dynamic, continuous systems. Introduction to variational principles in mechanics for purposes of formulating governing equations of motion.

ME 512 Light Weight Structures 4R-0L-4C See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 222, and EM 203 or EM 204
Corequisites: There are no corequisites for this course.
Applies the principles of mechanics to the structural analysis of mechanical and aerospace components. Covers stress tensors, shear flow in open and closed sections, beam columns, unsym-metrical bending. Castigliano's theorem, statically indeterminate structures , thin walled pressure vessels, introduction to elasticity.

ME 513 Environmental Noise 4R-0L-4C See Department
Graduate Studies Eligible: Yes
Prerequisites: Senior class standing
Corequisites: There are no corequisites for this course.
Introduces noise and its sources as a potential public health hazard. Covers the basics of sound propagation relating to noise measurement and analysis. Emphasizes effects

on humans and the environment. Covers methods of noise and vibration control and abatement including absorption, enclosures, vibration isolation, damping, and mufflers. Team projects involving noise measurement and reduction are required.

ME 514 Materials Selection in Mechanical Design 4R-0L-4C See Department

Graduate Studies Eligible: Yes

Prerequisites: Graduate standing or permission of instructor.

Corequisites: There are no corequisites for this course.

Same as ME414, with the requirement that ME514 is only open to graduate students having a graduate project or thesis that the instructor agrees would benefit from the materials selection approach taught in ME414. Students enrolled in ME 514 must complete an experimental, computational, and/or theoretical project related to their graduate work that includes complexities not covered in ME414. Students may not receive credit for both ME414 and ME514.

ME 516 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S

Graduate Studies Eligible: Yes

Prerequisites: Junior or Senior class standing

Corequisites: There are no corequisites for this course.

Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with EP 510, ECE 516, CHE 505, and BE 516.

ME 517 Mechanics of Metal Forming 4R-0L-4C See Department

Graduate Studies Eligible: Yes

Prerequisites: EM 204

Corequisites: There are no corequisites for this course.

Fundamentals of plasticity, 2D and 3D stress and strain tensors, characteristics of yield surfaces, flow rules and constitutive relations for elasto-plastic materials. Modelling of metal forming processes using work balance, slab and upper bound analysis techniques. Friction in metal forming. The mechanics of bulk metal forming processes such as extrusion, sheet metal forming, stamping, rolling, drawing, and stretching. Design forming tool dies.

ME 518 Advanced Kinematics 4R-0L-4C Not Offered

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Considers the analysis, design, and simulation of planar and spatial mechanisms. The mechanisms examined are parallel manipulators, serial manipulators, and compliant mechanisms. These mechanisms are analyzed for position, velocity, acceleration, and workspace. The techniques used for the analysis include vector approaches, homogeneous transformations, and dual number techniques.

ME 519 Advanced MEMS: Modeling & Packaging 3R-3L-4C F

Graduate Studies Eligible: Yes

Prerequisites: EP 410 or equivalent

Corequisites: There are no corequisites for this course.

Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with ECE 519, EP 511, and CHE 519.

ME 520 Computer-Aided Design & Manufacturing (CAD/CAM) 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: EM 104 and Senior class standing
Corequisites: There are no corequisites for this course.
Use and management of computer in engineering for drafting, design management, documentation, and manufacturing. Covers drafting methods and standards, design data management, CNC operations and implementation.

ME 522 Advanced Finite Element Analysis 4R-1L-4C S
Graduate Studies Eligible: Yes
Prerequisites: ME 422
Corequisites: There are no corequisites for this course.
A continuation of ME 422. Includes multi-dimensional extensions of 2-D theory for transient, nonlinear problem statements in engineering. Utilizes Matlab and Ansys for developing and assessing FEA solutions to real world problems via theory developed in ME 422.

ME 523 Fatigue 4R-0L-4C See Department
Graduate Studies Eligible: Yes
Prerequisites: Permission of instructor.
Corequisites: There are no corequisites for this course.
Same as ME 423, with the additional requirement that students enrolled in ME 523 must complete an experimental, computational, and/or theoretical project including complexities not covered in ME 423. Students may not receive credit for both ME 423 and ME 523.

ME 524 Mechanics of Composites 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: EM 204, and ME 328 and graduate standing, or permission of instructor.
Corequisites: There are no corequisites for this course.
Same as ME 424 with the requirement that ME 524 is only open to graduate students. Students enrolled in ME 524 must complete an additional laboratory project in the course extending the principles developed in the course beyond what is directly covered during the course itself. Students may not receive credit for both ME 424 and ME 524.

ME 526 Turbomachinery 4R-0L-4C See Department
Graduate Studies Eligible: Yes
Prerequisites: ES 205 or equivalent, or permission of instructor
Corequisites: There are no corequisites for this course.
Introduces the theory and issues related to the design of axial and radial flow turbines, compressors and pumps. Euler's equation and vector diagrams are used to evaluate energy transfer and efficiency. Students enrolled in ME 526 must complete a design project including complexities not covered in ME 426. Students may not receive credit for both ME 426 and ME 526

ME 527 Computational Fluid Dynamics 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: ES 212, and ME 323 or ME 327
Corequisites: There are no corequisites for this course.
Covers the key components of a CFD calculation: mesh generation, numerical algorithm and turbulence modeling. Survey of solution strategy includes both the finite volume and the finite difference methods. Issues on formal order of accuracy, dissipation, dispersion, stability and space-time coupling are discussed in detail. Both structured programs and commercial software will be used as vehicles in obtaining a CFD solution.

Students enrolled in ME527 must complete a design project not covered in ME 427. Students may not receive credit for both ME 427 and ME 527.

ME 528 Materials Research and Instrumentation 4R-0L-4C See Department

Graduate Studies Eligible: Yes

Prerequisites: CHEM 111 and graduate standing, or permission of instructor.

Corequisites: There are no corequisites for this course.

Same as ME 428 with the additional requirement that students enrolled in ME 528 must work individually on their research topic. The research topic must also be multifaceted requiring use of several of the instruments discussed during class. Students may not receive credit for both ME 428 and ME 528.

ME 536 Computational Intelligence in Control Engineering 4R-0L-4C See Department

Graduate Studies Eligible: Yes

Prerequisites: ME 406 or equivalent, or consent of instructor

Corequisites: There are no corequisites for this course.

Machine learning and adaptation applied to feedback control, guidance and navigation. Neural Networks for pattern recognition, modeling and control. Radial basis function model identification by recursive least squares. Fuzzy logic controllers. Genetic algorithm for optimization and turning of controllers including fuzzy logic control.

ME 541 Advanced Modeling and Simulation Techniques 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: ES 205

Corequisites: There are no corequisites for this course.

This course is the same as ME 441 with the addition of greater depth on modeling, simulation, and control of nonlinear systems. ME 541 students will also complete a course project not part of ME 441. Students may not receive credit for both ME 441 and ME 541.

ME 545 Robot Dynamics and Control 4R-0L-4C W

Graduate Studies Eligible: Yes

Prerequisites: ME 406 or ECE 320 or BE 350 and graduate standing, or permission of instructor.

Corequisites: There are no corequisites for this course.

This course is the same as ME445 with the additional topic of orientation representation and greater depth on dynamic modeling. ME545 students will also complete a course project. Students may not receive credit for both ME445 and ME545.

ME 547 Visualizing Data 4R-0L-4C Not Offered

Graduate Studies Eligible: Yes

Prerequisites: Graduate standing and instructor consent.

Corequisites: There are no corequisites for this course.

Same as ME 447 with the added requirement that the course is open only to graduate students having a graduate project or thesis generating quantitative data that the course instructor has agreed meets the 500-level course objectives.

ME 550 Combustion 4R-0L-4C S

Graduate Studies Eligible: Yes

Prerequisites: ME 301 or CHE 303

Corequisites: There are no corequisites for this course.

Study of the thermodynamics and kinetics of combustion processes and the underlying chemical processes. Topics covered include deflagration and detonation waves, combustion of solid, liquid, and gaseous fuels, and environmental impacts of combustion. Laboratory experience via in-class, hands-on exercises. Students enrolled

in ME 550 must complete a design project not covered in ME 450. Students may not receive credit for both ME 450 and ME 550.

ME 590 Thesis Research As assigned See Department

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Credits as assigned; however, not more than 12 credits will be applied toward the requirements of an M.S. degree.

ME 597 Selected Topics for Graduate Students As assigned. Maximum 4 credits per term. See Department

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Topics arranged by instructor.

ME 699 Professional Experience 1R-0L-1C See Department

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The work experiences should be informative or integral to the advancement or completion of the student's program requirements. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

Multi-Disciplinary Studies - Course Descriptions

MDS 100 Me, Myself, and Leadership 1R-1L-21 W, S

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Before leading others, you must first understand yourself. This course will focus on developing YOU as a leader through hands-on experiences, lectures, and reflection. Focus will be on learning about your personality, identity, values, and strengths and how those relate to your growth as a leader. In addition, you will explore how a solid understanding of emotional and social intelligence can help a leader motivate and communicate with their team. Leadership is a process, not a position; you can learn to be a leader.

MDS 150 Leading Together 1R-1L-1C F, W

Graduate Studies Eligible: No

Prerequisites: MDS 100

Corequisites: There are no corequisites for this course.

Leading a successful team is more than just working toward a common goal. It takes skill and practice to be a great leader. This course will focus on developing you as a leader of cohesive and effective teams through hands-on experiences and reflections. The focus will be on learning how to motivate and lead a team with members that have a variety of strengths, skills, backgrounds, and values.

MDS 201 Global Engineering and the Social Context 1R-3L-2C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the practice of engineering in a global context. Discusses the nature of global challenges and the context in which those global challenges need to be solved by covering such topics as culture, participant observation, field notes, national character, standards, codes and regulations, community engagement engineering, sustainable engineering, engineering ethics, intercultural communication as well as flexible and adaptable problem solving.

MDS 202 Global Engineering and the Social Context 0R-6L-2C
Graduate Studies Eligible: No
Prerequisites: MDS 201
Corequisites: There are no corequisites for this course.
Examines engineering as practiced in an immersive global context. Contextualizes the design method, standards, codes and regulations by completing an engineering project in the travel country. Explores the impact of the travel country's cultural, political, geographical and social attributes on the practice of engineering. Students enrolled in this course must complete an approved international travel program.

MDS 210 Introduction to Internet of Things 4R-0L-4C S (Even Years)
Graduate Studies Eligible: No
Prerequisites: ECE 160 or CSSE 120 or ENGD 120 or BE 100 or CHE 110 or ME 123
Corequisites: There are no corequisites for this course.
Introduction to the design and development of an Internet of Things (IoT) solution. Provides breadth of knowledge on a broad range of topics, such as sensors, power, communication, cloud storage, data analysis, automation, privacy and security, business considerations, and ethics. Focuses on a multidisciplinary team design project to provide a complete IoT solution for a real-world application. This is a required course for the minor in Internet of Things for all majors except those earning a primary or secondary major in EE, CPE, CS, and SE. Students cannot earn credit for both MDS210 and ECE436.

MDS 220 Introduction to Research Fundamentals 1R-0L-1C F
Graduate Studies Eligible: No
Prerequisites: Permission of instructor and Y1 or Y2 standing. Enrollment in this course will be limited and will require submission of a statement of research interest.
Corequisites: There are no corequisites for this course.
This course focuses on skills required for beginning an undergraduate research project, including formulating research questions, reading the primary literature, documentation practices, research ethics, and professional development.

MDS 221 Conducting and Communicating Research 1R-0L-1C W
Graduate Studies Eligible: No
Prerequisites: MDS 220
Corequisites: There are no corequisites for this course.
The course is designed for current undergraduate researchers and focuses on skills for successfully conducting research and communicating results. Topics include setting project goals and expectations, preparing research proposals, and research communication (oral, written, visual).

MDS 290 Special Topics in Multidisciplinary Studies 1C-4C Variable
Graduate Studies Eligible: No
Prerequisites: TBD
Corequisites: TBD
Special topics courses of current interest in Multidisciplinary Studies at the 200 level.

MDS 301 Global Engineering for Health 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: PH 112
Corequisites: There are no corequisites for this course.
Introduces critical thinking skills, engineering methodology, troubleshooting and debugging skills, and a basic knowledge of how electrical and mechanical systems work in common medical devices. Develops students' social, professional, and global awareness skills needed to live, work, and provide humanitarian need in a developing world. Completion of this course satisfies Engineering World Health training requirements.

MDS 302 Sustainability in Practice 2R-0L-2C
Graduate Studies Eligible: No
Prerequisites: HUM H130, BIO 191, and ECON S151
Corequisites: There are no corequisites for this course.
This is a project-based course to provide hands-on experiences for student teams working on real-world problems related to sustainability. This could include design projects, scientific research, modeling-based projects, or studies to improve campus sustainability. The course instructor will mentor teams with routine assignments that relate to their design or research process through oral and written communication.

MDS 310 Appropriate Technology for Developing Communities 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: MA 113, and PH 112
Corequisites: There are no corequisites for this course.
Prepares students to effectively participate in humanitarian engineering work in developing communities. Introduces multidisciplinary technical topics important in areas with limited infrastructure such as water and sanitation, agriculture, energy, and communication. Emphasis on cross-cultural communication, community support and involvement, long-term maintenance, and minimizing harmful side-effects. Team design project to demonstrate a practical and appropriate system from the course material.

MDS 390 Special Topics in Multidisciplinary Studies 1C-4C Variable
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Special topics courses of current interest in Multidisciplinary Studies at the 300 level.

MDS 401 Independent Project/Research Opportunities Seminar 1R-0L-1C F,W,S
Graduate Studies Eligible: No
Prerequisites: Permission of instructor
Corequisites: There are no corequisites for this course.
Companion seminar for students participating in the Independent Project/Research Opportunities Program. Students attend an organizational seminar, attend one additional IPROP seminar during the quarter, complete first week and tenth week surveys, acknowledge their sponsor, and generate publicity graphics. Students present their work as a poster at a tenth week End of Quarter Symposium. This course may not be used as credit toward any degree program. This course is given Pass/Fail.

MDS 402 Seminar in Sustainability 2R-0L-2C
Graduate Studies Eligible: No
Prerequisites: MDS 302
Corequisites: There are no corequisites for this course.
This course provides students with the opportunity to examine, analyze, and reflect upon sustainability as it related to their project or research work. Course work

includes weekly readings and discussions, individual essays, and in-class and public presentations. Successful completion of this course will require students to have completed the co-curricular requirements.

MDS 410 Multidisciplinary Capstone I 2R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: Senior standing or approval of instructor

Corequisites: There are no corequisites for this course.

This course begins the year-long multidisciplinary capstone design project and continues to investigate the process of design from previous courses. The emphasis of this course includes project scoping, generating design concepts, establishing specifications, planning the project, scheduling, team building, and working within explicit (or implicit) constraints such as social, fiscal, manufacturing, etc. The course culminates with a proposal for next steps. It is expected that each student produces 12 hours of quality work each week including class time.

MDS 420 Multidisciplinary Capstone II 2R-3L-4C W

Graduate Studies Eligible: No

Prerequisites: MDS 410

Corequisites: There are no corequisites for this course.

This course is a continuation of MDS410 by having student teams continue to implement their proposed design plan. This will include development of a test plan, modifications to the design project as needed, and assessment of design performance relative to initial specifications. This course culminates in evaluation of prototype development and plan for project completion. It is expected that each student produces 12 hours of quality work each week including class time.

MDS 430 Multidisciplinary Capstone III 2R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: MDS 420

Corequisites: There are no corequisites for this course.

This course is a continuation of MDS410 and MDS420. The student teams continue to implement their proposed design plan and complete the design project according to stakeholder needs. This course culminates in final product documentation and a formal public showcase to which all campus is invited. It is expected that each student produces 12 hours of quality work each week including class time.

MDS 440 Systems Engineering Capstone 2R-0L-2C

Graduate Studies Eligible: No

Prerequisites: Senior standing

Corequisites: There are no corequisites for this course.

Directed study course with a minor advisor. Student applies concepts from SE courses to an experience in their undergraduate career. Taken in senior year. Culminates in a written report at the end of the quarter. Must attend and report on one monthly INCOSE meeting with practicing systems engineers. Only available to those students who have officially declared their intent to earn the SE Minor.

MDS 442 Applied Computational Modeling 0R-2L-1C S

Graduate Studies Eligible: No

Prerequisites: MA 342 and consent of instructor

Corequisites: There are no corequisites for this course.

Numerical modeling of scientific and engineering problems as practiced by computational scientists. Students will develop, implement, refine, and apply computational models to simulate physical phenomena.

MDS 450 Consulting Engineering Seminar 2R-0L-2C S

Graduate Studies Eligible: No
Prerequisites: Junior class standing
Corequisites: There are no corequisites for this course.
Discusses problems in the field of consulting engineering; includes seminars presented by practicing consulting engineers and project work to practice consulting skills.

MDS 490 Special Topics in Multidisciplinary Studies 1C-4C Variable
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Special topics courses of current interest in Multidisciplinary Studies at the 400 level.

NOTE: In courses which include a laboratory, satisfactory completion of the laboratory work is required in order to pass the course.

Optical Engineering - Course Descriptions

OE 171 Photography and Holography 2R-0L-2C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduce students to basic knowledge of optics, principles and operation of a camera, shutters, films, and film development, color photography. Basic understanding of interference of waves, concept of holography, properties of various holograms, application of holography, and each student makes an individual hologram that can be seen in sunlight.

OE 172 Lasers and Fiber Optics 2R-0L-2C S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Light, optics, image formation, and optical instruments. Introduction to the properties, physics of operation, types, and applications of lasers. Characteristics of optical fibers and optical communication systems. Applications of lasers and fibers in industry, medicine, and consumer products. Laser safety.

OE 199 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student’s academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as “S” satisfactory, or “U” unsatisfactory based on the written report of the professional experience.

OE 280 Geometrical Optics 3.5R-1.5L-4C W
Graduate Studies Eligible: No
Prerequisites: PH 113
Corequisites: There are no corequisites for this course.
First-order optics including graphical ray tracing, Gaussian methods, y-nu ray tracing, cardinal points, apertures, stops, pupils, vignetting, and obscuration. Optical invariant, dispersion, chromatic aberrations, glass selection, exact ray tracing, third-order

monochromatic aberrations, introduction to computer-aided design and analysis. Relevant laboratory experiments.

OE 290 Directed Research Arranged

Graduate Studies Eligible: No

Prerequisites: Consent of instructor

Corequisites: There are no corequisites for this course.

Research for freshmen and sophomore students under the direction of a physics and optical engineering faculty member. May earn up to a maximum of 2 credits for meeting the graduation requirements. The student must make arrangements with the faculty member for the research project prior to registering for this course.

OE 295 Photonic Devices & Systems 3.5R-1.5L-4C S

Graduate Studies Eligible: No

Prerequisites: PH 113, and MA 221

Corequisites: There are no corequisites for this course.

Optical radiation, radiometry, and photometry. Blackbody radiation and thermal sources. Introduction to optoelectronic devices. Light emitting diodes and other optical sources. Optical detectors (thermal, photoemissive, and semiconductor detectors). Sources/effects of noise and SNR. Flux transfer in optical systems. Relevant laboratory experiments.

OE 360 Optical Materials 4R-0L-4C W (every other year)

Graduate Studies Eligible: No

Prerequisites: PH 255, and PH 316

Corequisites: There are no corequisites for this course.

Electromagnetic waves in dielectrics/metals and complex refractive index. Optical, thermal, and mechanical properties of materials. Thin film interference, optical coatings, and design of multilayer films. Optical characterization of materials. Electromagnetic waves in anisotropic materials, double refraction, optical activity, and polarization devices.

OE 392 Linear Optical Systems 4R-0L-4C W (every other year)

Graduate Studies Eligible: No

Prerequisites: PH 292, and MA 222

Corequisites: There are no corequisites for this course.

Propagation of light and scalar diffraction theory. Fraunhofer and Fresnel diffraction, coherence, Fourier series and transforms, convolution and correlation. Linear system theory, impulse and step response, transfer functions. Coherent and incoherent image formation, optical transfer function (OTF), modulation transfer function (MTF). Image quality assessment methods. Optical information processing applications.

OE 393 Fiber Optics & Applications 3.5R-1.5L-4C S

Graduate Studies Eligible: No

Prerequisites: PH 113, and either PH 316 or ECE 340

Corequisites: There are no corequisites for this course.

Step-index and graded-index fibers; single-mode and multi-mode fibers; numerical aperture; attenuation and dispersion; fabrication of optical fibers and cables; fiber measurements; source coupling, splices and connectors; point-to-point links; selected applications such as fiber optic sensors and fiber optic system components. Slab and cylindrical dielectric waveguides, silicon waveguides, mode cutoff conditions; effective index of propagating mode, examples of silicon passive and active devices. Relevant laboratory experiments.

OE 395 Optomechanics & Optical Engineering Lab 2R-6L-4C F

Graduate Studies Eligible: No

Prerequisites: PH 292, and OE 280, and OE 295
Corequisites: There are no corequisites for this course.
Design, assembly, and alignment of bench top optical systems. Introduction to experimental techniques in optics. Data collection and analysis. Relevant lecture topics including principles of opto-mechanical design, fold mirrors and prisms, lens and mirror mounting, kinematic mounts, precision adjustments and control.

OE 415 Optical Engineering Design I 2R-6L-4C S
Graduate Studies Eligible: No
Prerequisites: OE 280 and Junior/Senior standing
Corequisites: ENGL H290 *Prerequisite or concurrent registration
Principles of design. Codes of ethics appropriate to engineers. Case studies related to optical engineering and engineering physics professional practice, teamwork, contemporary issues, patents and intellectual property. Team-oriented design project work on selected topics in optical engineering and engineering physics. Introduction to product development practices, product research, planning and project management. Preliminary design of a product and product specifications. Deliver a design document specific to customer needs and constraints. Cross-listed with EP 415.

OE 416 Optical Engineering Design II 2R-6L-4C F
Graduate Studies Eligible: No
Prerequisites: OE 415
Corequisites: There are no corequisites for this course.
Team-based capstone design project following structured design processes and utilizing knowledge gained from prior coursework. Project planning and budgeting, development of product/process specifications, application of engineering standards, system design and prototyping subject to multiple realistic constraints (cost, schedule, and performance). Formal midterm design review. Deliver initial statement of work and interim technical report. Laboratory activities supporting the formal design process. Cross-listed with EP 416.

OE 417 Optical Engineering Design III 2R-6L-4C W
Graduate Studies Eligible: No
Prerequisites: OE 416
Corequisites: There are no corequisites for this course.
Continuation of OE 416. System design and prototyping, performance testing, and data analysis. Formal midterm design review. Demonstration of a functional prototype. Deliver oral presentation and final technical report. Cross-listed with EP 417.

OE 434 Non-Imaging Optics 4R-0L-4C S (every other year)
Graduate Studies Eligible: Yes
Prerequisites: OE 295
Corequisites: There are no corequisites for this course.
Lighting, illumination, and solar concentration systems. Radiometry and photometry for illumination, etendue, and concentration. Color coordinates, color vision, and color measurements. Sources, light transfer components, and systems evaluation. Introduction to design methods (edge-ray, compound parabolic concentrator, tailored reflector). Design examples and case studies.

OE 435 Biomedical Optics 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: PH 113, and MA 222
Corequisites: There are no corequisites for this course.
Optical techniques for biomedical applications and health care; imaging modalities; laser fundamentals, laser interaction with biological cells, organelles and

nanostructures; laser diagnostics and therapy, laser surgery; microscopes; optics-based clinical applications; imaging and spectroscopy; biophotonics. Cross-listed with BE 435.

OE 437 Introduction to Image Processing 3R-3L-4C W

Graduate Studies Eligible: Yes

Prerequisites: MA 222

Corequisites: There are no corequisites for this course.

Basic techniques of image processing. Discrete and continuous two dimensional transforms such as Fourier and Hotelling. Image enhancement through filtering and histogram modification. Image restoration through inverse filtering. Image segmentation including edge detection and thresholding. Introduction to image encoding. Relevant laboratory experiments.

OE 450 Laser Systems & Applications 3.5R-1.5L-4C S

Graduate Studies Eligible: Yes

Prerequisites: PH 292, and MA 222

Corequisites: There are no corequisites for this course.

Ray transfer matrix methods, Gaussian beam propagation, and beam quality. Optical resonators and stability, longitudinal and transverse modes. Stimulated emission, population inversion, rate equations, gain and threshold. Q-switching and mode-locking. Applications and types of lasers. Laser safety and relevant laboratory experiments.

OE 460 SILICON PHOTONIC DEVICES AND APPLICATIONS 3.5R-1.5L-4C F

Graduate Studies Eligible: Yes

Prerequisites: PH 292

Corequisites: There are no corequisites for this course.

Energy bands in semiconductors, minority and majority carriers and n/p-type doping. PN-junction in semiconductors, free-carrier absorption and recombination, forward and reverse bias pn-junction diodes. Thermo-optic effect, Franz-Keldysh effect, and plasma dispersion effect in semiconductors. TE/TM-mode propagation in semiconductor waveguides. Modeling passive and active silicon photonic (SiPh) devices. Examples of photonic integrated circuits (PICs) and applications. Fabrication of passive and active SiPh devices and PICs. Laboratory experiments will cover performance characterization of passive and active SiPh devices and PIC systems.

OE 470 Special Topics in Optical Engineering 2-4C

Graduate Studies Eligible: Yes

Prerequisites: Consent of instructor

Corequisites: There are no corequisites for this course.

Lectures on special topics in optics.

OE 480 Optical System Design 4R-0L-4C F

Graduate Studies Eligible: Yes

Prerequisites: OE 280

Corequisites: There are no corequisites for this course.

Review of geometrical optics and exact ray tracing. Chromatic and monochromatic aberrations. Image quality assessment, spot size, point spread function, Strehl ratio, and modulation transfer function. Classical lens design and design of various imaging, non-imaging, and diffractive optical systems. First-order layout, computer-based optimization, tolerancing, and manufacturing considerations.

OE 490 Directed Research 1-4C

Graduate Studies Eligible: Yes

Prerequisites: Consent of instructor

Corequisites: There are no corequisites for this course.

Research for junior and senior students under the direction of a physics and optical engineering faculty member. May earn a maximum of 8 credits between PH/OE 290 and PH/OE 490 for meeting graduation requirements. Maximum of 4 credits per term. The student must make arrangements with the faculty member for the research project prior to registering for this course.

OE 493 Fundamentals of Optical Fiber Communications 3.5R-1.5L-4C S (every other year)

Graduate Studies Eligible: Yes

Prerequisites: OE 393

Corequisites: There are no corequisites for this course.

Analysis and design of common fiber optic communication systems and optical networks. Transmission penalties: dispersion, attenuation. Optical transmitters and receivers: fundamental operation and noise. Intensity and phase modulation. Optical amplification: types of amplifiers, noise and system integration. Point-to-point links: power budget and rise-time analysis. Performance analysis: BER and eye diagrams. WDM concepts and components: multiplexers, filters, common network topologies. Non-linear effects in fibers. Relevant laboratory experiments.

OE 495 Optical Metrology 3.5R-1.5L-4C W

Graduate Studies Eligible: Yes

Prerequisites: OE 280, and PH 292

Corequisites: There are no corequisites for this course.

Geometrical test methods (refractometers, knife edge, Ronchi, Wire, Hartmann). Review of interference and coherence. Third-order aberrations, Zernike polynomials, and fringe analysis. Interferometers (Newton, Fizeau, Twyman-Green, and shearing), fringe localization, and phase shifting. Holographic, Moire, photoelastic and speckle interferometry. Applications of optical metrology. Relevant laboratory experiments.

OE 497 Senior Thesis 1-2C F

Graduate Studies Eligible: No

Prerequisites: Consent of PHOE faculty

Corequisites: There are no corequisites for this course.

Literature search, research proposal preparation, and laboratory project work. This sequence is designed to result in a completed senior thesis or initiation of research to be completed in an MSOE degree at Rose-Hulman.

OE 498 Senior Thesis 1-2C W

Graduate Studies Eligible: No

Prerequisites: Consent of PHOE faculty

Corequisites: There are no corequisites for this course.

Literature search, research proposal preparation, and laboratory project work. This sequence is designed to result in a completed senior thesis or initiation of research to be completed in an MSOE degree at Rose-Hulman.

OE 499 Senior Thesis 1-2C S

Graduate Studies Eligible: No

Prerequisites: Consent of PHOE faculty

Corequisites: There are no corequisites for this course.

Literature search, research proposal preparation, and laboratory project work. This sequence is designed to result in a completed senior thesis or initiation of research to be completed in an MSOE degree at Rose-Hulman.

OE 520 Principles of Optics 2R-0L-2C F

Graduate Studies Eligible: Yes

Prerequisites: Graduate standing

Corequisites: There are no corequisites for this course.
Introduction to optics for incoming graduate students. Geometric optics; wave optics; sources and detectors. Students progressing towards or holding a bachelor's degree in Optical Engineering may not receive credit for OE 520.

OE 535 Biomedical Optics 4R-0L-4C W
Graduate Studies Eligible: Yes
Prerequisites: PH 113 and and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Optical techniques for biomedical applications and health care; imaging modalities; laser fundamentals, laser interaction with biological cells, organelles and nanostructures; laser diagnostics and therapy, laser surgery; microscopes; optics-based clinical applications; imaging and spectroscopy; biophotonics. Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both OE 435 and OE 535. Cross-listed with BE 535.

OE 537 Advanced Image Processing 3R-3L-4C S
Graduate Studies Eligible: Yes
Prerequisites: CSSE 120 or ME 123 and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Introduction to image segmentation and recognition. Use of neural networks, fuzzy logic and morphological methods for feature extraction. Advanced segmentation, detection, recognition and interpretation. Relevant laboratory experiments and required project. Cross-listed with ECE 582.

OE 570 Special Topics in Optics 2 or 4C F,W,S
Graduate Studies Eligible: Yes
Prerequisites: Consent of instructor and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Lectures on contemporary topics in optical science, optical engineering, and photonics.

OE 580 Optical System Design 4R-0L-4C F
Graduate Studies Eligible: Yes
Prerequisites: OE 280 and and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Review of geometrical optics and exact ray tracing. Chromatic and monochromatic aberrations. Image quality assessment, spot size, point spread function, Strehl ratio, and modulation transfer function. Classical lens design and design of various imaging, non-imaging, and diffractive optical systems. First-order layout, computer-based optimization, tolerancing, and manufacturing considerations. Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both OE 480 and OE 580.

OE 584 Medical Imaging Systems 4R-0L-4C S
Graduate Studies Eligible: Yes
Prerequisites: OE 392* or ECE 300 * with a grade of B or better or Graduate standing or consent of instructor
Corequisites: There are no corequisites for this course.
Engineering principles of major imaging techniques/modalities for biomedical applications and health care including diagnostic x-ray, computed tomography, nuclear techniques, ultrasound, and magnetic resonance imaging. Topics include general characteristics of medical images; physical principles, signal processing to generate an image, and instrumentation of imaging modalities. Clinical applications of these technologies are also discussed. Cross-listed with ECE 584 and BE 541.

OE 585 Electro-Optics and Applications 3R-3L-4C F

Graduate Studies Eligible: Yes
Prerequisites: PH 292, and PH 316 and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Optical wave propagation in anisotropic media. Normal surface and the index ellipsoid. Double refraction. Optical activity and Faraday rotation. Pockels and Kerr effects. Electrooptic modulators. Acousto-optic effect. Modulators and scanners. Introduction to nonlinear optics. Second-harmonic generation and frequency doubling. Relevant laboratory experiments.

OE 592 Fourier Optics & Applications 3.5R-1.5L-4C S
Graduate Studies Eligible: Yes
Prerequisites: OE 392 and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Two-dimensional linear systems. Scalar diffraction theory, Fresnel & Fraunhofer diffraction. Coherent optical systems analysis. Frequency analysis of optical imaging systems. Spatial filtering and analog optical information processing. Wavefront reconstruction and holography. Relevant laboratory experiments.

OE 593 Fundamentals of Optical Fiber Communications 3.5R-1.5L-4C S (every other year)
Graduate Studies Eligible: Yes
Prerequisites: OE 393 and Senior or Graduate Standing
Corequisites: There are no corequisites for this course.
Analysis and design of common fiber optic communication systems and optical networks. Transmission penalties, dispersion, attenuation. Optical transmitters and receivers: fundamental operation and noise. Intensity and phase modulation. Optical amplification: types of amplifiers, noise and system integration. Point-to-point links: power budget and rise-time analysis. Performance analysis: BER and eye diagrams. WDM concepts and components: multiplexers, filters, common network topologies. Non-linear effects in fibers. Relevant laboratory experiments. Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both OE 493 and OE 593.

OE 594 Integrated Silicon Photonics 3.5R-1.5L-4C W
Graduate Studies Eligible: Yes
Prerequisites: OE 393 and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Dispersion properties of silicon waveguides, coupled-mode theory, mode propagation and confinement, effective index of TE and TM modes. Modeling silicon passive devices: directional coupler, Y-branch, Mach-Zehnder interferometer, ring resonators, I/O grating couplers. Modeling silicon active devices: thermo-optic phase-shifters, pn-junction modulators, electro-absorption modulators, and photodetectors. Modeling and simulation of integrated silicon photonics circuits and applications. Laboratory experiments: Fabrication and characterization of a silicon passive device.

OE 595 Optical Metrology 3.5R-1.5L-4C W
Graduate Studies Eligible: Yes
Prerequisites: OE 280, OE 392 or Senior or Graduate standing or consent of instructor
Corequisites: OE 480
Geometrical test methods (refractometers, knife edge, Ronchi, Wire, Hartmann). Review of interference and coherence. Third-order aberrations, Zernike polynomials, and fringe analysis. Interferometers (Newton, Fizeau, Twyman-Green, and shearing), fringe localization, and phase shifting. Holographic, Moire, photoelastic and speckle interferometry. Applications of optical metrology. Relevant laboratory experiments.

Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both OE 495 and OE 595.

OE 599 Thesis Research 1-4C

Graduate Studies Eligible: Yes

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Graduate students only. Credits as arranged; however not more than 12 credits will be applied toward the requirements for the MS (OE) degree.

OE 699 Professional Experience 1R-0L-1C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The work experiences should be informative or integral to the advancement or completion of the student's program requirements. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

NOTE: In courses which include a laboratory, satisfactory completion of the laboratory work is required in order to pass the course.

Physics - Course Descriptions

PH 090 College Preparatory Physics 4R-0L-4C

Graduate Studies Eligible: No

Prerequisites: College Algebra II

Corequisites: There are no corequisites for this course.

Topics covered include: Units, significant figures, vectors, 1 and 2 dimensional motion; kinematic equations, objects in free-fall, motion in a circle, projectile motion, Newton's Laws, contact forces, non-contact forces: gravity, Coulomb's Law, magnetic force; centripetal force; collisions, linear momentum, rotational kinematics, torques, angular momentum, mechanical equilibrium - static equilibrium. The credits from this course cannot be counted toward any degree completion at Rose-Hulman.

PH 111 Physics I 3.5R-1.5L-4C F,W

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: MA 111 or MA 105

Kinematics, Newton's laws of motion, gravitation, Coulomb's law, Lorentz force law, strong and weak nuclear forces, conservation of energy and momentum, relevant laboratory experiments.

PH 112 Physics II 3.5R-1.5L-4C W,S,F

Graduate Studies Eligible: No

Prerequisites: PH 111, and MA 111 or MA 105*

Corequisites: MA 112 or MA 106

Torque and angular momentum, oscillations, one-dimensional waves, electric fields and potentials, electric current and resistance, DC circuits, capacitance, relevant laboratory experiments.

PH 113 Physics III 3.5R-1.5L-4C S,F,W

Graduate Studies Eligible: No
Prerequisites: PH 112, and MA 112
Corequisites: MA 113
Sources of magnetic fields, Faraday's law, inductance electromagnetic waves, reflection and polarization, geometric and physical optics, introduction to relativity, relevant laboratory experiments.

PH 199 Professional Experience 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

PH 200 Career Preparation 1R-0L-1C W,S
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course is for physics majors to be taken in the second year. The course addresses career choices, summer opportunities, employment and graduate school preparation, and curriculum vitae and resumes preparation. This course is cross-listed with CHEM200, MA200 and SV200.

PH 215 Introduction to CHAOS 2R-0L-2C W
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
What constitutes chaotic behavior, detection of chaos in real systems using phase space plots, Poincare sections, bifurcation plots, power spectra, Lyupunov exponents, and computer simulation of chaotic systems.

PH 231 Observational Astronomy 1R-3L-2C F
Graduate Studies Eligible: No
Prerequisites: MA 111, and PH 111 or EM 120
Corequisites: There are no corequisites for this course.
Celestial coordinates; basics of celestial mechanics; electromagnetic radiation, atomic structure, spectra, blackbody radiation; telescopes and detectors; quantitative observational work using modern telescopes and detectors.

PH 235 Many-Particle Physics 3.5R-1.5L-4C F
Graduate Studies Eligible: No
Prerequisites: PH 111
Corequisites: MA 112
Dynamics of rigid body, harmonic motion; mechanics of fluids; heat, kinetic theory, thermodynamics. Alternate week laboratories.

PH 241 Physics of Stars 4R-0L-4C W
Graduate Studies Eligible: No
Prerequisites: MA 111, and PH 111 or EM 120
Corequisites: There are no corequisites for this course.
Binary stars and stellar parameters; stellar spectra; stellar atmospheres; stellar interiors; star formation; stellar evolution; star death; stellar remnants; black holes and binary stars.

PH 250 Planets and Galaxies 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: MA 111, and PH 111 or EM 120
Corequisites: There are no corequisites for this course.
Overview of planets and planetary science; origin and evolution of the solar system; structure and evolution of galaxies; origin and evolution of the universe; introduction to cosmology.

PH 255 Foundations of Modern Physics 3.5R-1.5L-4C W
Graduate Studies Eligible: No
Prerequisites: PH 113
Corequisites: MA 221
Wave-particle nature of matter and radiation, Bohr model, Schrodinger equation, quantum description of the hydrogen atom, atomic and molecular spectra, and introduction to statistical physics.

PH 265 Fundamentals of Nuclear Physics & Radiation 3R-3L-4C S
Graduate Studies Eligible: No
Prerequisites: PH 112, and MA 221
Corequisites: There are no corequisites for this course.
Relativity, black-body radiation, the Bohr model, physics of the nucleus, fission and fusion, reactors, nuclear radiation, radiation damage, medical applications.

PH 270 Special Topics in Physics 1-4C
Graduate Studies Eligible: No
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Lectures on special topics in physics. Maximum of 4 credits per term.

PH 290 Directed Research 1-4C
Graduate Studies Eligible: No
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Research for freshmen and sophomore students under the direction of a physics and optical engineering faculty member. May earn up to a maximum of 2 credits for meeting the graduation requirements. The student must make arrangements with a faculty member for the research project prior to registering for this course.

PH 292 Physical Optics 3.5R-1.5L-4C F
Graduate Studies Eligible: No
Prerequisites: PH 113
Corequisites: There are no corequisites for this course.
The wave equation; electromagnetic waves; phase and group velocities; complex refractive index; dispersion, interference; interferometers and applications, optical interferometry; coherence; polarized light; Jones vectors/matrices; production of polarized light; birefringence, Fraunhoffer diffraction; diffraction gratings.

PH 302 Biophysics 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: PH 113 or consent of instructor
Corequisites: There are no corequisites for this course.
Biological examples of the interaction of radiation and matter; medical uses of x-rays, nuclear medicine, magnetic resonance imaging, and current applications in biophysics.

PH 310 Introduction to Special Relativity 2R-0L-2C F
Graduate Studies Eligible: No
Prerequisites: PH 113 or Consent of instructor

Corequisites: There are no corequisites for this course.
Experimental background of the special theory of relativity, the structure of the theory and its consequences in measurements involving space, time and motion. Relativistic mechanics, relativity and electromagnetism, and applications in modern physics.

PH 314 Theoretical Mechanics I 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: PH 112, and MA 222
Corequisites: There are no corequisites for this course.
Statics and dynamics of particles and systems of particles, including rigid bodies. Conservation of energy, linear and angular momentum. Central forces. Lagrangian and Hamiltonian equations of motion. Vibrations.

PH 315 Theoretical Mechanics II 4R-0L-4C W
Graduate Studies Eligible: No
Prerequisites: PH 314
Corequisites: There are no corequisites for this course.
Statics and dynamics of rigid bodies. Lagrangian treatment of rigid body dynamics. Euler method of rigid body dynamics. Small oscillations about positions of equilibrium and about steady motion. Statics and dynamics of deformable bodies. Computational analysis of mechanical systems.

PH 316 Electric & Magnetic Fields 4R-0L-4C F
Graduate Studies Eligible: No
Prerequisites: PH 113, and MA 222
Corequisites: There are no corequisites for this course.
Maxwell's equations in integral and point form, vector calculus; electric field and potential, electric fields in matter, boundary conditions; the magnetic field.

PH 317 Electromagnetism 4R-0L-4C W
Graduate Studies Eligible: No
Prerequisites: PH 316
Corequisites: There are no corequisites for this course.
Further methods in electrostatics, Poisson's equation; magnetostatics, the vector potential; electromagnetic induction; magnetic properties of matter; further applications of Maxwell's equations, properties of electromagnetic radiation.

PH 322 Celestial Mechanics 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: PH 112 or PH 265
Corequisites: There are no corequisites for this course.
Dynamics of point masses; the two-body problem; the restricted three-body problem; orbital position as a function of time; orbits in three dimensions; preliminary orbit determination; orbital maneuvers; interplanetary trajectories.

PH 325 Advanced Physics Laboratory I 2R-6L-4C S
Graduate Studies Eligible: No
Prerequisites: PH 113
Corequisites: There are no corequisites for this course.
Introduction to the methods of experimental physics; topics may include error analysis, component fabrication, transducers, ac circuits, operational amplifiers, electrical signal conditioning, and automated data acquisition.

PH 327 Thermodynamics & Statistical Mechanics 4R-0L-4C S
Graduate Studies Eligible: No
Prerequisites: PH 235 or consent of instructor
Corequisites: There are no corequisites for this course.

First, second, and third laws of thermodynamics. Ideal gases, real gases, liquids, solids, change of phase. The Joule-Thompson effect, adiabatic demagnetization. Kinetic theory of gases, classical and quantum statistical mechanics.

PH 401 Introduction to Quantum Mechanics 4R-0L-4C W

Graduate Studies Eligible: No

Prerequisites: PH 255 or PH 113, and PH 265

Corequisites: There are no corequisites for this course.

Review of wave-particle experiments, atomic model, Bohr theory, deBroglie's hypothesis. Uncertainty principle, Schroedinger equation, quantum mechanical operators and stationary states, quantization and role of angular momentum.

PH 402 Introduction to Atomic Physics 4R-0L-4C S (odd years)

Graduate Studies Eligible: No

Prerequisites: PH 401

Corequisites: There are no corequisites for this course.

Solutions of Schroedinger equation, perturbation theory, applications to one electron system. Quantum numbers, spin and magnetic moments, multi-electron systems including LS coupling. Zeeman effect, transition rates, hyperfine structure, X-rays.

PH 404 Acoustics 4R-0L-4C W (odd years)

Graduate Studies Eligible: No

Prerequisites: PH 113, and MA 222

Corequisites: There are no corequisites for this course.

Harmonic motion, waves on strings, membranes, eigenfunctions and eigenvalues; waves in rods and fluids; behavior of waves at interfaces; radiation from vibrating piston; resonators, absorption.

PH 405 Semiconductor Materials & Applications 3R-3L-4C F

Graduate Studies Eligible: Yes

Prerequisites: PH 113 or PH 255 or PH 265

Corequisites: There are no corequisites for this course.

Material structure electronic levels and energy bands; semiconductor doping; optical and electronic material characteristics; p-n junction and diode characteristics; bipolar junction transistor; basics of device fabrication. Laboratories on X-ray and Scanning Electron Microscope investigations, device characteristics and a three-week design project on production and testing of thin films. Cross-listed with PH 505.

PH 407 Solid State Physics 4R-0L-4C S (even years)

Graduate Studies Eligible: Yes

Prerequisites: PH 255 or PH 265

Corequisites: There are no corequisites for this course.

Selected topics in the field are discussed in detail; e.g., crystal structures, lattice vibrations and electronic band structure; electrical, optical and thermal properties of solids and semi-conductors; and the properties of materials at very low temperatures.

PH 410 General Relativity 4R-0L-4C W (odd years)

Graduate Studies Eligible: Yes

Prerequisites: PH 310, and MA 421

Corequisites: There are no corequisites for this course.

An in-depth study of Einstein’s theory of General Relativity. Gravity as geometry and curved space-time, metrics, and geodesics. Orbits and light paths around spherical masses. Detailed study of Einstein’s equation in vacuum and with sources of space-time curvature.

PH 425 Advanced Physics Laboratory II 0R-8L-4C W

Graduate Studies Eligible: Yes

Prerequisites: PH 325
Corequisites: There are no corequisites for this course.
Selected experiments in various areas of physics, with primary emphasis on nuclear physics and a significant independent student project

PH 431 Advanced Observational Astronomy 1R-3L-2C S
Graduate Studies Eligible: No
Prerequisites: PH 231, and either PH 241 or PH 250
Corequisites: There are no corequisites for this course.
Students will conduct astronomical observations with telescopes and learn to process and interpret astronomical data. They will learn astronomical data processing, statistical analysis, image processing, observational bias, data interpretation, and scientific writing skills.

PH 440 X-rays and Crystalline Materials 2R-6L-4C S (even years)
Graduate Studies Eligible: Yes
Prerequisites: PH 255 or PH 265
Corequisites: There are no corequisites for this course.
X-ray emission, absorption, fluorescence, and diffraction. Methods of analyzing crystalline solid materials. Applications in solid-state physics, materials science, chemistry, metallurgy, and biology.

PH 460 Directed Study 1-4C
Graduate Studies Eligible: Yes
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Permits study in an area of physics not available in regular course offerings. Maximum of 4 credits per term.

PH 470 Special Topics in Physics 2-4C
Graduate Studies Eligible: Yes
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Lectures on special topics in physics.

PH 480 Seminar 0C
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Lectures by staff, students, and outside speakers on topics of special interest.

PH 490 Directed Research 1-2 C
Graduate Studies Eligible: Yes
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Research for junior and senior students under the direction of a physics and optical engineering faculty member. May earn a maximum of 8 credits between PH 290 and PH 490 for meeting graduation requirements. Maximum of 2 credits per term. The student must make arrangements with a physics and optical engineering faculty member for the research project prior to registering for this course.

PH 496 Senior Thesis 2-4C
Graduate Studies Eligible: No
Prerequisites: Consent of PHOE faculty
Corequisites: There are no corequisites for this course.

Literature search, research proposal preparation, and laboratory project work with a total number of 8 credit hours over the three quarter sequence. This sequence is designed to result in a completed senior thesis.

PH 497 Senior Thesis 2-4C F

Graduate Studies Eligible: No

Prerequisites: Consent of PHOE faculty

Corequisites: There are no corequisites for this course.

Literature search, research proposal preparation, and laboratory project work with a total number of 8 credit hours over the three quarter sequence. This sequence is designed to result in a completed senior thesis.

PH 498 Senior Thesis 2-4C W

Graduate Studies Eligible: No

Prerequisites: Consent of PHOE faculty

Corequisites: There are no corequisites for this course.

Literature search, research proposal preparation, and laboratory project work with a total number of 8 credit hours over the three quarter sequence. This sequence is designed to result in a completed senior thesis.

PH 499 Physics Ethics and Communication 1R-0L-1C S

Graduate Studies Eligible: No

Prerequisites: PH 497, PH 498 or PH 425

Corequisites: There are no corequisites for this course.

Guidelines will be discussed to encourage ethical reporting and conduct of research performed by individuals. Situations in physics research and publication will be presented and discussed in regards to ethical reporting and conduct. As the final component of the students' Senior Thesis, students will prepare oral and written presentations of their research and present them at a public forum held near the end of the spring term. Students not in the thesis track will present (in both oral and written form) the projects conducted in PH425 Advanced Physics Lab II.

PH 505 Semiconductor Materials & Devices I 3R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: PH 113 or PH 255 or PH 265

Corequisites: There are no corequisites for this course.

Material structure electronic levels and energy bands; semiconductor doping; optical and electronic material characteristics; p-n junction and diode characteristics; bipolar junction transistor; basics of device fabrication. Laboratories on X-ray and Scanning Electron Microscope investigations, device characteristics and a three-week design project on production and testing of thin films. Students must do additional project work on a topic selected by the instructor. Cross-listed with PH 405.

PH 512 Methods of Mathematical Physics 4R-0L-4C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Ordinary and partial differential equations, linear vector spaces, matrices, tensors. Strum-Liouville theory and eigenvalue problems, special functions, function of a complex variable, theory of groups, linear integral equations.

PH 514 Quantum Mechanics 4R-0L-4C

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Development of quantum mechanical theory to the present time. Examples from spectroscopy, chemistry, nuclear physics.

PH 530 Advanced Acoustics 4R-0L-4C
Graduate Studies Eligible: No
Prerequisites: PH 404
Corequisites: There are no corequisites for this course.
Waves in solids, electrodynamics and piezoelectric sound transducers, ultrasonics. Architectural acoustics. Underwater sound.

PH 538 Introduction to Neural Networks 3R-3L-4C
Graduate Studies Eligible: No
Prerequisites: Senior or Graduate Standing
Corequisites: There are no corequisites for this course.
Classifiers, linear separability. Supervised and unsupervised learning. Perceptrons. Back-propagation. Feedback networks. Hopfield networks. Associative memories. Fuzzy neural networks. Integral laboratory.

PH 540 Computer Physics 3R-3L-4C
Graduate Studies Eligible: No
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Exploration of physics by simulation including planetary motion, waves, chaos, cellular automata and fractals; application of numerical methods of differentiation and integration; computer hardware and machine language as it affects laboratory use; curve fitting and smoothing of data.

ROTC-Air Force - Course Descriptions

AS 101 Heritage and Values I 1R-2L-1C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This is a survey course designed to introduce students to the Department of the Air Force (DAF) and provides an overview of the basic characteristics, missions, communications and organization of the Air and Space Forces

AS 101L Leadership Laboratory - F,W,S
Graduate Studies Eligible: No
Prerequisites: AS 101* or AS 102* or AS 103* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 2 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 102 Heritage and Values II 1R-2L-1C W
Graduate Studies Eligible: No
Prerequisites: AS 101 or consent of instructor
Corequisites: There are no corequisites for this course.
This is a survey course designed to introduce students to the Department of the Air Force (DAF) and provides an overview of the basic characteristics, missions, communications and organization of the Air and Space Forces

AS 102L Leadership Laboratory - F,W,S
Graduate Studies Eligible: No
Prerequisites: AS 101* or AS 102* or AS 103* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 2 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 103 Heritage and Values III 1R-2L-1C W
Graduate Studies Eligible: No
Prerequisites: AS 102 or consent of instructor
Corequisites: There are no corequisites for this course.
This is a survey course designed to introduce students to the Department of the Air Force (DAF) and provides an overview of the basic characteristics, missions, communications and organization of the Air and Space Forces

AS 103L Leadership Laboratory - F,W,S
Graduate Studies Eligible: No
Prerequisites: AS 101* or AS 102* or AS 103* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 2 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 201 The Evolution of Air and Space Power I 2R-3L-2C F
Graduate Studies Eligible: No
Prerequisites: AS 103 or consent of instructor
Corequisites: There are no corequisites for this course.
This course designed to examine the general aspects of air and space power through a historical perspective. Utilizing this perspective, the course covers a time period from the first balloons and dirigibles to the space-age global positioning systems of the Persian Gulf War. Historical examples are provided to extrapolate the development of Air Force capabilities (competencies), and missions (functions) to demonstrate the evolution of what has become today's USAF air and space power. Furthermore, the course examines several fundamental truths associated with war in the third dimension: e.g. Principles of War and Tenets of Air and Space Power. As a whole, this course provides the cadets with a knowledge level understanding for the general element and employment of air and space power, from an institutional doctrinal and historical perspective. In addition, the students will continue to discuss the importance of the Air Force Core Values, through the use of operational examples and historical Air Force leaders, and will continue to develop their communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences.

AS 201L Leadership Laboratory 0 F,W,S
Graduate Studies Eligible: No
Prerequisites: AS 201* or AS 202* or AS 203* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.

Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 202 The Evolution of Air and Space Power II 2R-3L-2C W

Graduate Studies Eligible: No

Prerequisites: AS 201 or consent of instructor

Corequisites: There are no corequisites for this course.

This course is a continuation of the fall quarter course designed to examine the general aspects of air and space power through a historical perspective.

AS 202L Leadership Laboratory 0 F,W,S

Graduate Studies Eligible: No

Prerequisites: AS 201* or AS 202* or AS 203* *Enrollment in one of the three courses

Corequisites: There are no corequisites for this course.

Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 203 The Evolution of Air and Space Power III 2R-3L-2C S

Graduate Studies Eligible: No

Prerequisites: AS 202 or consent of instructor

Corequisites: There are no corequisites for this course.

This course is a continuation of the winter quarter course designed to examine the general aspects of air and space power through a historical perspective.

AS 203L Leadership Laboratory 0 F,W,S

Graduate Studies Eligible: No

Prerequisites: AS 201* or AS 202* or AS 203* *Enrollment in one of the three courses

Corequisites: There are no corequisites for this course.

Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 301 Leading People and Effective Communication I 3R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: Enrollment in Professional Officer Corps

Corequisites: There are no corequisites for this course.

This course utilizes student's field training experience to take a more in-depth look at leadership. Special emphasis is placed on enhancing communication skills, and why that is important as a leader. Students have an opportunity to try out these leadership and management skills techniques in a supervised environment as juniors and seniors.

AS 301L Leadership Laborator - F,W,S

Graduate Studies Eligible: No

Prerequisites: AS 301* or AS 302* or AS 303* *Enrollment in one of the three courses

Corequisites: There are no corequisites for this course.

Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 302 Leading People and Effective Communication II 3R-3L-4C W

Graduate Studies Eligible: No

Prerequisites: AS 301

Corequisites: There are no corequisites for this course.

This course utilizes student's field training experience to take a more in-depth look at leadership. Special emphasis is placed on enhancing communication skills, and why that is important as a leader. Students have an opportunity to try out these leadership and management skills techniques in a supervised environment as juniors and seniors.

AS 302L Leadership Laborator - F,W,S

Graduate Studies Eligible: No

Prerequisites: AS 301* or AS 302* or AS 303* *Enrollment in one of the three courses

Corequisites: There are no corequisites for this course.

Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 303 Leading People and Effective Communication III 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: AS 302

Corequisites: There are no corequisites for this course.

This course utilizes student's field training experience to take a more in-depth look at leadership. Special emphasis is placed on enhancing communication skills, and why that is important as a leader. Students have an opportunity to try out these leadership and management skills techniques in a supervised environment as juniors and seniors.

AS 303L Leadership Laborator - F,W,S

Graduate Studies Eligible: No

Prerequisites: AS 301* or AS 302* or AS 303* *Enrollment in one of the three courses

Corequisites: There are no corequisites for this course.

Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 401 National Security Affairs and Preparation for Active Duty I 3R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: AS 303

Corequisites: There are no corequisites for this course.

This course is designed for college seniors and provides them the foundation to understand their role as military officers and how they are directly tied to our National Security Strategy. It is an overview of the complex social and political issues facing the

military profession and requires a measure of sophistication commensurate with the senior college level.

AS 401L Leadership Laboratory - F,W,S

Graduate Studies Eligible: No

Prerequisites: AS 401* or AS 402* or AS 403* *Enrollment in one of the three courses

Corequisites: There are no corequisites for this course.

Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 402 National Security Affairs and Preparation for Active Duty II 3R-3L-4C W

Graduate Studies Eligible: No

Prerequisites: AS 401

Corequisites: There are no corequisites for this course.

This course is designed for college seniors and provides them the foundation to understand their role as military officers and how they are directly tied to our National Security Strategy. It is an overview of the complex social and political issues facing the military profession and requires a measure of sophistication commensurate with the senior college level.

AS 402L Leadership Laboratory - F,W,S

Graduate Studies Eligible: No

Prerequisites: AS 401* or AS 402* or AS 403* *Enrollment in one of the three courses

Corequisites: There are no corequisites for this course.

Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 403 National Security Affairs & Preparation for Active Duty III 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: AS 402

Corequisites: There are no corequisites for this course.

This course is designed for college seniors and provides them the foundation to understand their role as military officers and how they are directly tied to our National Security Strategy. It is an overview of the complex social and political issues facing the military profession and requires a measure of sophistication commensurate with the senior college level.

AS 403L Leadership Laboratory - F,W,S

Graduate Studies Eligible: No

Prerequisites: AS 401* or AS 402* or AS 403* *Enrollment in one of the three courses

Corequisites: There are no corequisites for this course.

Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

Academic Electives

In order to fulfill commissioning requirements, cadets in the Military Science program must take and successfully complete one college undergraduate course to satisfy the Professional Military Education (PME) requirement for American Military History. This should be taken during the course of the student's four years of academic studies and completed prior to graduation and commissioning. A complete listing of all applicable PME courses is available through the ROTC department.

ROTC-Army - Course Descriptions

MS 101 Introduction to the Army and Critical Thinking 1R-3L-1C F
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
MS 101 introduces Cadets to the personal challenges and competencies that are critical for effective leadership. Cadets learn how the personal development of life skills such as critical thinking, time management, goal setting, stress management, and comprehensive fitness relate to leadership, and the Army profession.

MS 102 Adaptive Leadership & Professional Competence 1R-3L-1C W
Graduate Studies Eligible: No
Prerequisites: MS 101 or consent of instructor
Corequisites: There are no corequisites for this course.
MS 102 introduces Cadets to the personal challenges and competencies that are critical for adaptive leadership. Cadets learn the basics of the communications process and the importance for leaders to develop the essential skills to effectively communicate in the Army. Students will examine the Army Profession and what it means to be a professional in the U.S. Army.

MS 103 Basic Tactical leadership 1R-3L-1C S
Graduate Studies Eligible: No
Prerequisites: MS 101, and MS 102 or consent of instructor
Corequisites: There are no corequisites for this course.
MS 103 continues the exploration of leadership fundamentals and examines the leadership process as affected by individual differences and styles, group dynamics, and personality behavior of leaders. Students will experience an introduction of fundamental leadership concepts, and examine factors that influence leader and group effectiveness. Students will fully explore the basic soldier skills and squad level tactical operations. Students participate in briefings and hands-on practical exercises. Attention is devoted to development of leadership potential through practical exercises both in and out of the classroom.

MS 201 Leadership and Decision Making 2R-3L-2C F
Graduate Studies Eligible: No
Prerequisites: MS 101, and MS 102, and MS 103 or consent of instructor
Corequisites: There are no corequisites for this course.
MS 201 explores the dimensions of creative and innovative tactical leadership strategies and styles by examining team dynamics and two historical leadership theories that form the basis of the Army leadership framework. Aspects of personal motivation and team building are practiced planning, executing and assessing team exercises.

MS 202 Army Doctrine & Team Development 2R-3L-2C W

Graduate Studies Eligible: No
Prerequisites: MS 201 or consent of instructor
Corequisites: There are no corequisites for this course.
MS 202 examines the challenges of leading teams in the complex operational environment. The course highlights dimensions of terrain analysis, patrolling, and operation orders. Further study of the theoretical basis of the Army Leadership Requirements Model explores the dynamics of adaptive leadership in the context of military operations. Cadets develop greater self awareness as they assess their own leadership styles and practice communication and team building skills.

MS 203 Foundations of Tactical Leadership II 2R-3L-2C S
Graduate Studies Eligible: No
Prerequisites: MS 201, and MS 202 or consent of instructor
Corequisites: There are no corequisites for this course.
MS203 continues the examination of the challenge of leading tactical teams in the complex contemporary operational environments. Dimensions of the cross-cultural challenges of leadership in a constantly changing world are highlighted and applied to practical Army leadership tasks and situations. Cadets develop greater self-awareness as they practice communication and team building skills. Contemporary Operational Environment case studies give insight into the importance and practice of teamwork and tactics in real world scenarios.

MS 206 ROTC Cadet Initial Entry Training Course -
Graduate Studies Eligible: No
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Covering a training period of approximately thirty days, the Department of Military Science ROTC battalion provides travel to and from Fort Knox. Students may attend to access their desire to continue and contract into the ROTC Advanced Course. While in the course, you will meet students from all over the nation while earning $700 in pay and receive free room and board. You may apply for a two-year Full-tuition scholarship and receive up to $1200 annually for books and earn a monthly stipend of over $450 per month for 10 months per year. The Cadet Initial Entry Training Course is a way to catch up on missed Military Science courses in order to qualify the student for progression as a contracted Advanced Course ROTC cadet.

MS 301 Training Management and the Warfighting Functions 3R-3L-4C F
Graduate Studies Eligible: No
Prerequisites: MS 206 or completion of Basic Course requirements, or prior military service (contact Military Science Department for specific requirements established in Army Regulations)
Corequisites: There are no corequisites for this course.
MS 301 Cadets will study, practice, and apply the fundamentals of Army Leadership, Officership, Army Values and Ethics, Personal Development, and small unit tactics at the platoon level. At the conclusion of this course, Cadets will be capable of planning, coordinating, navigating, motivating and leading a squad and platoon in the execution of a mission during a classroom PE, a Leadership Lab, or during a Leader Training Exercise (LTX).

MS 302 Applied Leadership in Small Unit Operations 3R-3L-4C W
Graduate Studies Eligible: No
Prerequisites: MS 301
Corequisites: There are no corequisites for this course.

MS 302 uses increasingly intense situational leadership challenges to build cadet awareness and skills in leading small units. Skills in decision-making, persuading and motivating team members when under fire are explored, evaluated, and developed. Aspects of military operations are reviewed as a means of preparing for the ROTC Cadet Leader Course (CLC). Cadets are expected to apply basic principles of the Law of Land Warfare, Army training, and motivation to troop leading procedures. Emphasis is also placed on conducting military briefings and developing proficiency in garrison operation orders. Cadets are evaluated on what they know and do as leaders.

MS 303 Leadership under Fire II 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: MS 302

Corequisites: There are no corequisites for this course.

MS 303 continues development in decision making, persuading, and motivating team members in operational situations are explored, evaluated and developed. Aspects of military operations are reviewed as a means of preparing for CLC. Cadets are expected to apply basic principles of Law of the Land Warfare, Army training, and motivation to troop leading procedures. Emphasis is also placed on conducting military briefings and developing proficiency in garrison operations orders. Cadets are evaluated on what they know and do as leaders.

MS 401 Mission Command & Ethics 3R-3L-4C F

Graduate Studies Eligible: No

Prerequisites: MS 303

Corequisites: There are no corequisites for this course.

MS 401 is an advanced course that places primary emphasis on Officership with our MS IV cadets who are our educational main effort; MS 401 and 402 together refine and ultimately completes the Cadet-tocommissioned officer transition. In MS 401 Mission Command and ethics is stressed in order to assist the Cadet in further embracing their future role as an Army officer.

MS 402 Mission Command and the Army 3R-3L-4C W

Graduate Studies Eligible: No

Prerequisites: MS 401

Corequisites: There are no corequisites for this course.

MS 402 and MS 403 are the culmination of a four-year sequential, progressive, challenging developmental leadership experience. It is during this quarter and MSL 403 that the Cadet is undergoing final preparation for the duties and responsibilities of a commissioned officer along with their integration into the Army. The emphasis is placed on critical knowledge, skills, abilities and competencies skills newly commissioned officers will need to succeed in their first unit of assignment, and the modern operating environment where they will be expected to plan, prepare, execute, and assess platoon-level training strategies and more to enable mission accomplishment.

MS 403 Leadership in a Complex World II 3R-3L-4C S

Graduate Studies Eligible: No

Prerequisites: MS 401

Corequisites: There are no corequisites for this course.

MS 403 continues the exploration of the dynamics of leading in the complex situations of current military operations from MS 402. Cadets examine differences in customs and courtesies, military law, principles of war, and rules of engagement in the face of international terrorism. Aspects of interacting with non-government organizations, civilians on the battlefield, and host nation support are examined and evaluated.

Significant emphasis is placed on preparing cadets for their first unit of assignment as Second Lieutenants.

MS 497 Military Science Independent Study Variable Credit

Graduate Studies Eligible: No

Prerequisites: MS 301, and MS 302, and MS 303 and consent of instructor

Corequisites: There are no corequisites for this course.

MS 497 provides ROTC cadets who have completed their Cadet Leader Course the opportunity to conduct detailed research and independent study on a current problem or topic associated with the military. Program of study will be arranged individually with the Professor of Military Science.

Overview of CLC Cadet Leader Course - S

Graduate Studies Eligible: No

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

The purpose of the course is to train U.S. Army ROTC Cadets to Army standards, to develop their leadership skills, and to evaluate their officer potential. The 29-day course starts with individual training and leads to collective training, building from simple to complex tasks. This building-block approach permits integration of previously-learned skills into follow-on training. This logical, common-sense training sequence is maintained for each training cycle. Every day at CLC is a day of training.

SOFTWARE ENGINEERING - COURSE DESCRIPTIONS

CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

An introduction to programming with an emphasis on problem solving. Problems may include visualizing data, interfacing with external hardware or solving problems from a variety of engineering disciplines. Programming concepts covered include data types, variables, control structures, arrays, and data I/O. Software development concepts covered include testing, debugging, incremental development, understanding requirements, and version control systems.

CSSE 132 Introduction to Systems Programming 3R-3L-4C F,S

Prerequisites: CSSE 120

Corequisites: There are no corequisites for this course.

Provides students with understanding of computer system level issues and their impact on the design and use of computer systems. Students will study low-level programming (assembly) and memory operations, representation of various types of data and programs in memory, and resource/efficiency trade-offs. System requirements such as resource management, security, communication and synchronization are studied and basic systems tools for these tasks are implemented. Course topics will be explored using a variety of hands-on assignments and projects.

CSSE 140 Practical Security I 0R-1L-1C F

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

This is an entry-level introduction to exploiting and securing computer systems, networks, and web sites. This shallow introduction exposes students to various applied cybersecurity topics including Firewalls, SSH, passwords, web security, and basic unix system administration. Through a series of hands-on exercises, students will relate these topics to practical ways to secure computers.

CSSE 141 Practical Security II 0R-1L-1C W
Prerequisites: CSSE 140
Corequisites: There are no corequisites for this course.
A second-level introduction to exploiting and securing computer systems, networks, and web sites. This class continues the introduction to applied cybersecurity topics including basic Cryptography, network protocol analysis, reverse engineering, steganography, forensics, and more unix system administration. Students are also introduced to capture-the-flag exercises, which are widely practiced cybersecurity skill competitions.

CSSE 142 Practical Security III 2L-2C Term F
Prerequisites: CSSE 141
Corequisites: There are no corequisites for this course.
A third-level class on exploiting and securing computer systems, networks, and web sites. This class continues the introduction to applied cybersecurity topics and focus on applying concepts learned in CSSE140/141 to security competitions such as capture-the-flag events. This class exposes students to strategy used in security competitions, teamwork skills for effective competition, and construction of set of exercises used for running a CTF event. Students will work in teams to solve security-oriented problems, apply their skills to create competition challenges/exercises for use in CSSE 141 and for competition training, practice for security competitions, and participate in or run a few security competitions.

CSSE 145 Cybersecurity Seminar 2R-0L-2C Varies
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course provides exposure to leading-edge industrial and academic experts in Cybersecurity and Digital Privacy. Topics including the societal, economic, scientific, and psychological impacts of modern areas of cybersecurity and privacy are examined from both practical and theoretical points of view. Students in this class will attend live and view remote or recorded talks from industry/academic experts, read emergent papers on Cybersecurity and Digital Privacy, participate in discussions or debate about the topics, and reflect on the impacts these topics have on their major area of study. May be repeated for credit with approval from the course instructor when topics are different.

CSSE 199 Professional Experience 1R-0L-1C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

CSSE 212 Hardware-oriented Programming 3R-3L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Simple computer architecture. Special hardware-oriented programming. Introduction to the C programming language, especially the use of pointers. Interrupt programming. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S
Prerequisites: CSSE 120
Corequisites: There are no corequisites for this course.

Object-oriented programming concepts, including the use of inheritance, interfaces, polymorphism, abstract data types, and encapsulation to enable software reuse and assist in software maintenance. Recursion, GUIs and event handing. Use of common object-based data structures, including stacks, queues, lists, trees, sets, maps, and hash tables. Space/time efficiency analysis. Testing. Introduction to UML.

CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C

Prerequisites: A score of 4 or 5 on the APCS A exam or permission of instructor

Corequisites: There are no corequisites for this course.

This course is intended for students who have sufficient programming experience to warrant placement in an accelerated course covering the topics from CSSE 120 and CSSE 220. This course will satisfy the prerequisite requirements for courses that have CSSE 220 as a prerequisite.

CSSE 225 Programming 3 3R-3L-4C

Prerequisites: ICS major

Corequisites: There are no corequisites for this course.

Differences between Java and C++. C++ concepts of object-oriented programming (classes, objects, inheritance, polymorphism). Storage management. Multiple inheritance, operator overloading, friend-concept, exception handling, I/O. Error analysis of programs. Generic programming and introduction to C++ - standard library. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S

Prerequisites: MA 112, and CSSE 220, with a grade of C or better

Corequisites: There are no corequisites for this course.

This course reinforces and extends students' ability to independently design, develop, and debug object-oriented software that uses correct, clear, and efficient algorithms and data structures. Students study and implement classical data structures such as list, stack, queue, tree, priority queue, hash table, graph, set, and dictionary. Formal efficiency analysis is used to evaluate the complexity of algorithms for these data structures. Students gain proficiency in writing recursive methods. Students design and implement software individually.

CSSE 232 Computer Architecture I 3R-3L-4C F,W

Prerequisites: ECE 233, and CSSE 120

Corequisites: There are no corequisites for this course.

Computer instruction set architecture and implementation. Specific topics include historical perspectives, performance evaluation, computer organization, instruction formats, addressing modes, computer arithmetic, ALU design, floating-point representation, single-cycle and multi-cycle data paths, and processor control. Assembly language programming is used as a means of exploring instruction set architectures. The final project involves the complete design and implementation of a miniscule instruction set processor.

CSSE 240 Principles of Cybersecurity 4R-0L-4C W

Prerequisites: CSSE 120, and HUM H190

Corequisites: There are no corequisites for this course.

This course introduces ethical, theoretical, and practical issues of information security in interconnected systems of computers. Implications of relevant professional codes of ethics are a recurring theme of the course, as are societal and human impacts on computer system security. Foundational topics include access control matrices and standard system models, as well as policies for security, confidentiality, and integrity. Implementation issues include key management, cipher techniques, authentication,

principles of secure design, representation of identity, access control mechanisms, information flow, life cycle issues, and formal evaluation and certification techniques. Additional topics include malicious logic, vulnerability analysis, and auditing. Computer system attack techniques are observed and evaluated in a closed environment to motivate and inform discussion and exploration of computer network defense techniques.

CSSE 241 Computing in a Global Society 2R-6L-4C

Prerequisites: CSSE 220 or CSSE 221

Corequisites: There are no corequisites for this course.

The ability to work with colleagues from other cultures and to work on international projects are key assets in today's job market. The centerpiece of this course is a real-world computing project that students develop in cooperation with peers from an institution of higher education in a foreign country. Exposes students to the procedures and complexities of working on projects that span many time-zones and cultures. Additionally, students examine the use and impact of computing in a global community. International travel is required; students will be expected to incur additional expenses (will vary depending on the project, institution, and country). May be repeated once (for free elective credit only) if the country involved is different.

CSSE 242 Programming in the Community Variable Credit (1 or 2 credits) F, W, S

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Programming in the Community is a unique course where Rose-Hulman students learn how to become teachers in Computer Science for younger students. As the name suggests, students will go teach CS material to K-12 students at their local school. Students will be assigned to a teaching team to take turns leading and helping follow along projects for the K-12 students. Students are expected to join a weekly instructor meeting on Teams, then take two teaching trips into the community per week (40 to 50 minute lessons). Transportation can be arranged for students unable to travel to the school. Students of any major are welcome to join. This class is a very real-world experience. It is a great way to learn leadership and teaching skills while doing great community service. May be repeated up to 12 credit hours.

CSSE 252 Computer Game Design 4R-OL-4C

Prerequisites: ENGL H290

Corequisites: There are no corequisites for this course.

An introduction to computer game design. Topics include game concepts, game settings and worlds, storytelling and narrative, character development, creating the user experience, gameplay, game balancing, and game genres. Working in teams, students will design their own game and produce several design documents for that game.

CSSE 280 Introduction to Web Programming 3R-3L-4C F, W

Prerequisites: CSSE 220 or CSSE 221

Corequisites: There are no corequisites for this course.

Introduction to the client-side and server-side mechanisms for creating dynamic web applications with persistent data storage. Browser-server interaction via HTTP. Static web page creation using current markup and styling languages. Client-side programming with modern scripting languages and the DOM. Server-side programming with emerging web programming languages and frameworks. Persistent data storage with a state-of-the-art database management system. Asynchronous client-server communication via HTTP requests. Development and consumption of REST APIs. Deployment of web applications to cloud platforms or platform as a service providers. Security considerations. This course provides breadth of knowledge of many tools/

technologies rather than deep knowledge of any particular tool/technology. No previous experience with Web development is required.

CSSE 286 Introduction to Machine Learning 4R-0L-4C

Prerequisites: Prior programming experience

Corequisites: There are no corequisites for this course.

An introduction to machine learning (ML) systems, with a focus especially on Artificial Intelligence-based systems, versus statistical ones. The course is designed to be useful to students with a basic knowledge of programming and software systems, whether or not they are computer science majors. During the course, students try different machine learning algorithms on data from problems in a domain of interest to them, comparing results with that of other students taking the class, as well as comparing the outcomes of the different algorithms on their own data. A goal of the course is learning how to gain real predictive value from “big data.”

CSSE 290 Special Topics in Computer Science 4C

Prerequisites: Arranged prerequiste - permission of instructor

Corequisites: There are no corequisites for this course.

Selected topics of current interest. May be repeated for credit if topic is different.

CSSE 304 Programming Language Concepts 4R-0L-4C F,W

Prerequisites: CSSE 230, and CSSE 280

Corequisites: There are no corequisites for this course.

Syntax and semantics of programming languages. Grammars, parsing, data types, control flow, parameter passing, run-time storage management, binding times, functional programming and procedural abstraction, syntactic extensions, continuations, language design and evaluation. Students will explore several language features by writing an interpreter that implements them.

CSSE 332 Operating Systems 4R-0L-4C W,S

Prerequisites: CSSE 220 or CSSE 221, and CSSE 132 or CSSE 232

Corequisites: There are no corequisites for this course.

Students learn fundamental concepts of modern operating systems by studying how and why operating systems have evolved. Topics include CPU scheduling, process synchronization, memory management, file systems, I/O systems, privacy and security, and performance evaluation. Students implement parts of an operating system as a means of exploring the details of some of these topics.

CSSE 333 Database Systems 3R-3L-4C W,S

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

Relational database systems, with emphasis on entity relationship diagrams for data modeling. Properties and roles of transactions. SQL for data definition and data manipulation. Use of contemporary API's for access to the database. Enterprise examples provided from several application domains. The influence of design on the use of indexes, views, sequences, joins, and triggers. Physical level data structures: B+ trees and RAID. Survey of object databases.

CSSE 335 Introduction to Parallel Computing 4R-0L-4C S

Prerequisites: MA 221 and programming experience

Corequisites: There are no corequisites for this course.

Principles of scientific computation on parallel computers. Algorithms for the solution of linear systems and other scientific computing problems on parallel machines. Course includes a major project on RHIT's parallel cluster. Same as MA 335.

CSSE 340 Foundations of Cybersecurity 4R-0L-4C W

Prerequisites: CSSE 132, and CSSE 280

Corequisites: There are no corequisites for this course.
This course introduces ethical, theoretical, and practical issues of information security in interconnected systems of computers. Implications of relevant professional codes of ethics are a recurring theme of the course, as are societal and human impacts on computer system security. Foundational topics include access control matrices and standard system models, as well as policies for security, confidentiality, and integrity. Implementation issues include key management, cipher techniques, authentication, principles of secure design, representation of identity, access control mechanisms, information flow, life cycle issues, and formal evaluation and certification techniques. Additional topics include malicious logic, vulnerability analysis, and auditing. Computer system attack techniques are discussed and explored in a closed environment to motivate and inform discussion and exploration of computer network defense techniques.

CSSE 343 Cybercrime and Digital Forensics 2R-2L-4C

Prerequisites: ENGL H100, and either CSSE 132, or Senior Class Standing
Corequisites: There are no corequisites for this course.
This course introduces students to “cybercrime,” how police investigate these crimes, and what forensics techs use to uncover digital evidence. Students will examine the laws, technologies, tools, and procedures used in the investigation and prosecution of computer crimes through case studies, discussions, ethical debates, and hands-on laboratory exercises that uncover and analyze digital evidence. This class covers topics including: basics of criminal law, collection and chain of evidence, search & seizure procedures, digital trail discovery, data recovery, and smartphone investigation.

CSSE 351 Computer Graphics 4R-0L-4C F

Prerequisites: MA 221, and either CSSE 220 or CSSE 221
Corequisites: There are no corequisites for this course.
Computer graphics algorithms, hardware and software. Line generators, affine transformations, line and polygon clipping, interactive techniques, perspective projection, solid modeling, hidden surface algorithms, lighting models, shading, and graphics standards. Programming assignments and a final project are required.

CSSE 352 Computer Game Development 4R-0L-4C

Prerequisites: CSSE 230
Corequisites: There are no corequisites for this course.
An introduction to designing and developing computer games. Topics include game genres, game design, sprites, game physics, collisions, characters, scripting, graphics, and sound. Students will design and implement their own game using an available game engine.

CSSE 371 Software Requirements Engineering 3R-3L-4C F

Prerequisites: CSSE 230, and ENGL H290, and CSSE 333 and Junior standing
Corequisites: There are no corequisites for this course.
Basic concepts and principles of software requirements engineering, its tools and techniques, and methods for modeling software systems. Topics include requirements elicitation, prototyping, functional and non-functional requirements, object-oriented techniques, and requirements tracking.

CSSE 372 Software Project Management 4R-0L-4C F

Prerequisites: There are no prerequisites for this course.
Corequisites: CSSE 230
Major issues and techniques of project management. Project evaluation and selection, scope management, team building, stakeholder management, risk assessment, scheduling, quality, rework, negotiation, and conflict management. Professional issues

including career planning, lifelong learning, software engineering ethics, and the licensing and certification of software professionals.

CSSE 373 Formal Methods in Specification and Design 4R-0L-4C S

Prerequisites: CSSE 230, and MA 276

Corequisites: There are no corequisites for this course.

Introduction to the use of mathematical models of software systems for their specification and validation. Topics include finite state machine models, models of concurrent systems, verification of models, and limitations of these techniques.

CSSE 374 Software Design 3R-3L-4C W

Prerequisites: CSSE 230 and Junior standing

Corequisites: There are no corequisites for this course.

Introduction to the architecture and design of complete software systems, building on components and patterns. Topics include architectural principles and alternatives, design documentation, and relationships between levels of abstraction.

CSSE 375 Software Construction and Evolution 3R-3L-4C S

Prerequisites: CSSE 374

Corequisites: There are no corequisites for this course.

Issues, methods and techniques associated with constructing software. Topics include detailed design methods and notations, implementation tools, coding standards and styles, peer review techniques, and maintenance issues.

CSSE 376 Software Quality Assurance 4R-0L-4C S

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

Theory and practice of determining whether a product conforms to its specification and intended use. Topics include software quality assurance methods, test plans and strategies, unit level and system level testing, software reliability, peer review methods, and configuration control responsibilities in quality assurance.

CSSE 386 Data Mining with Programming 4R-0L-4C

Prerequisites: CSSE 220, and CSSE 280, and MA 221, and either MA 223 or MA 381

Corequisites: There are no corequisites for this course.

An introduction to data mining for large data sets, including data preparation, exploration, aggregation/reduction, and visualization. Elementary methods for classification, association, and cluster analysis are covered. Significant attention will be given to presenting and reporting data mining results. Students may not get credit for both this course and also the MA 384 Data Mining course.

CSSE 400 CSSE Seminar 4R-0L-4C

Prerequisites: ICS major

Corequisites: There are no corequisites for this course.

This course presents an overview of current application areas within computer science and software engineering through the use of practical case studies. Students will undertake their own preparation of one or more case studies and present their results. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 402 Theory and Practice of Garbage Collection 4R-0L-4C

Prerequisites: CSSE 332

Corequisites: There are no corequisites for this course.

Garbage collection (GC) is a method of automatically reclaiming dynamically allocated storage that anapplication no longer needs. In this course, students will explore the classical problems of garbagecollection such as detecting unused objects and reclaiming the space allocated to them. Students willsurvey the GC literature to become

familiar with the current state of the art and future researchdirections. Students will explore techniques used to implement state-of-the-art garbage collectionalgorithms and will design and implement garbage collectors for a memory-managed language (e.g.,Java, C#, php, or Python).

CSSE 403 Programming Language Paradigms 4R-0L-4C F (even years)

Prerequisites: CSSE 304

Corequisites: There are no corequisites for this course.

A survey of some current and emerging programming languages, focusing on unique language paradigms-ways of structuring solutions or manipulating data. Examples of paradigms include dynamic programming languages, object-oriented programming, highly parallelizable code, and functional programming. Emphasizes developing independent learning techniques that will allow students to acquire skills in new languages quickly. Students will develop basic skills in at least three different languages representing distinct paradigms. They will also be exposed to a selection of other languages. Includes a substantial team project.

CSSE 404 Compiler Construction 4R-0L-4C S (odd years)

Prerequisites: CSSE 232, and CSSE 304, and CSSE 474

Corequisites: There are no corequisites for this course.

Theory and practice of programming language translation. Lexical analysis, syntax analysis, parser generators, abstract syntax, symbol tables, semantic analysis, intermediate languages, code generation, code optimization, run-time storage management, error handling. Students will construct a complete compiler for a small language.

CSSE 413 Artificial Intelligence 4R-0L-4C F

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

Students investigate how to model and implement intelligent behavior using computers. Topics are chosen from how machines can: solve problems; reason and use knowledge; learn from experience; and perceive and act. Students explore these topics by implementing many of the ideas in software. Readings are drawn both from a textbook and from technical papers in recent conferences and journals.

CSSE 415 Machine Learning 4R-0L-4C S

Prerequisites: MA 221, and either MA 223 or MA 381, and either CHE 310 or CSSE 220 or ECE 230 or MA 332 or MA 386 or ME 323

Corequisites: There are no corequisites for this course.

An introduction to machine learning. Topics include: error metrics, accuracy vs interpretability trade-off, feature selection, feature engineering, bias-variance trade-off, under-fitting vs. overfitting, regularization, cross-validation, the bootstrap method, the curse of dimensionality and dimensionality reduction using the singular value decomposition. Both parametric and nonparametric methods are covered including: k-nearest neighbors, linear and logistic regression, decision trees and random forests, and support vector machines. Same as MA415.

Prerequisite Notes:
Prerequisite Clarification for CSSE415:
Junior Standing and MA221,
and either MA223 or MA381,
and one of CHE310, CSSE220, ECE230, MA332, MA386 (or ME323 or ME327).

CSSE 416 DEEP LEARNING 4R-0L-4C See Dept

Prerequisites: See below
Corequisites: There are no corequisites for this course.
An introduction to deep learning using both fully-connected and convolutional neural networks. Topics include: least squares estimation and mean square error, maximum likelihood estimation and cross-entropy, convexity, gradient descent and stochastic gradient descent algorithms, multivariate chain rule and gradient computation using back propagation, linear vs nonlinear operations, convolution, over-fitting vs under-fitting and hyper-parameter optimization, L2, early stopping and dropout regularization, data augmentation and transfer learning. Same as MA416.

Prerequisite Notes:

MA 212 or MA 221, and either MA 223 or MA 381, and either CHE 310 or CSSE 220 or ECE 230 or MA 332 or MA 386 or ME 327

CSSE 432 Computer Networks 4R-0L-4C S
Prerequisites: CSSE 220 or CSSE 221
Corequisites: There are no corequisites for this course.
Organization, design, and implementation of computer networks, especially the Internet. Network protocols, protocol layering, flow control, congestion control, error control, packet organization, routing, gateways, connection establishment and maintenance, machine and domain naming, security. Each of the top four layers of the Internet protocol stack: application (FTP, HTTP, SMTP), transport (TCP, UDP), network (IP), link (Ethernet).
CSSE 433 Advanced Database Systems 4R-0L-4C S
Prerequisites: CSSE 333
Corequisites: There are no corequisites for this course.
This course covers advanced topics in the design and development of database management systems and their modern applications. Topics to be covered include query processing and, in relational databases, transaction management and concurrency control, eventual consistency, and distributed data models. This course introduces students to NoSQL databases and provides students with experience in determining the right database system for the right feature. Students are also exposed to polyglot persistence and developing modern applications that keep the data consistent across many distributed database systems.
CSSE 434 Introduction to the Hadoop Ecosystem 4R-0L-4C
Prerequisites: CSSE 230 *Some Experience with SQL recommended
Corequisites: There are no corequisites for this course.
This advanced course examines emergent Big Data techniques through hands-on introductions to the various technologies and tools that make up the Hadoop ecosystem. Topics covered include internals of MapReduce and the Hadoop Distributed File system (HDFS), internals of the YARN distributed operating system, MapReduce for data processing, transformation & analysis tools for data at scale (processing terabytes and petabytes of information quickly), scheduling jobs using workflow engines, data transfer tools & real time engines for data processing.
CSSE 435 Robotics Engineering 3R-3L-4C S
Prerequisites: ME 430 or ECE 230
Corequisites: There are no corequisites for this course.
Interdisciplinary course in robotics focusing on communication, software development, kinematics, robot GUI design, sensing, control, and system integration. Labs in the course cover MATLAB GUI development with GUIDE, Denavit-Hartenberg parameters,

Arduino programming, Arduino to Android communication, Android app development, and OpenCV4Android image recognition. Students in the course will program an Android + Arduino, 6-wheeled mobile robot with 5 DOF servo arm to participate in an outdoor GPS robotics challenge. Cross-listed with ME 435.

CSSE 443 Distributed Systems & IT Security 3R-3L-4C

Prerequisites: ICS major

Corequisites: There are no corequisites for this course.

Building complex distributed information systems requires a systematic approach. This course covers the analysis of existing distributed information systems and provides the ability to model simple new distributed applications with special attention to the trustworthiness, reliability and security of information systems. Topics covered include the main architectural models of distributed systems, describing simple distributed applications according to architecture and function, defining simple communication protocols, the benefits of using middleware, the risks of using distributed systems, and safety measures. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 444 Real-time Systems 3R-3L-4C

Prerequisites: ICS major

Corequisites: There are no corequisites for this course.

Students will learn the features and specifications of real-time systems. Topics covered include real-time operating systems and programming languages, design patterns for real-time systems, scheduling, synchronization, hybrid task sets, and applications of real-time systems. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 451 Advanced Computer Graphics 4R-0L-4C W (even years)

Prerequisites: CSSE 351

Corequisites: There are no corequisites for this course.

Advanced topics in computer graphics. Topics will be drawn from current graphics research and will vary, but generally will include ray tracing, radiosity, physically-based modeling, animation, and stereoscopic viewing. Programming assignments and a research project are required.

CSSE 453 Topics in Artificial Intelligence 4R-0L-4C

Prerequisites: CSSE 413

Corequisites: There are no corequisites for this course.

Advanced topics in artificial intelligence. Topics will vary. Past topics have included machine game playing and machine learning. May be repeated for credit if topic is different.

CSSE 461 Computer Vision 4R-0L-4C S (odd years)

Prerequisites: MA 221, and either CSSE 220 or CSSE 221 *Also recommended (but not required) either MA371 or MA373.

Corequisites: There are no corequisites for this course.

An introduction to 3D computer vision techniques. Both theory and practical applications will be covered. Major topics include image features, camera calibration, stereopsis, motion, shape from x, and recognition.

CSSE 463 Image Recognition 4R-0L-4C W

Prerequisites: MA 221 Junior standing and programming experience

Corequisites: There are no corequisites for this course.

Introduces statistical pattern recognition of visual data; low-level visual feature extraction (color, shape, edges); clustering and classification techniques. Applies knowledge to various application domains through exercises, large programming

projects in Matlab, and an independent research project. Familiarity with probability distributions will be helpful, but not required.

CSSE 473 Design and Analysis of Algorithms 4R-0L-4C W

Prerequisites: CSSE 230, and MA 276, and MA 374

Corequisites: There are no corequisites for this course.

Students study techniques for designing algorithms and for analyzing the time and space efficiency of algorithms. The algorithm design techniques include divide-and-conquer, greedy algorithms, dynamic programming, randomized algorithms and parallel algorithms. The algorithm analysis includes computational models, best/average/worst case analysis, and computational complexity (including lower bounds and NP-completeness). Same as MA 473.

CSSE 474 Theory of Computation 4R-0L-4C S

Prerequisites: CSSE 230, and MA 276, and MA 374

Corequisites: There are no corequisites for this course.

Students study mathematical models by which to answer three questions: What is a computer? What limits exist on what problems computers can solve? What does it mean for a problem to be hard? Topics include models of computation (including Turing machines), undecidability (including the Halting Problem) and computational complexity (including NP-completeness). Same as MA 474.

CSSE 477 Software Architecture 4R-0L-4C F

Prerequisites: CSSE 374 or consent of instructor

Corequisites: There are no corequisites for this course.

This is a second course in the architecture and design of complete software systems, building on components and patterns. Topics include architectural principles and alternatives, design documentation, relationships between levels of abstraction, theory and practice of human interface design, creating systems which can evolve, choosing software sources and strategies, prototyping and documenting designs, and employing patterns for reuse. How to design systems which a team of developers can implement, and which will be successful in the real world.

CSSE 479 Cryptography 4R-0L-4C S

Prerequisites: MA 276, and either CSSE 220 or CSSE 221

Corequisites: There are no corequisites for this course.

Introduction to basic ideas of modern cryptography with emphasis on mathematical background and practical implementation. Topics include: the history of cryptography and cryptanalysis, public and private key cryptography, digital signatures, and limitations of modern cryptography. Touches upon some of the societal issues of cryptography. Same as MA 479.

CSSE 480 Cross-Platform Development 3R-3L-4C F

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

Programming cross-platform mobile applications that target Android, iOS, and web mobile devices using programmatic UIs, layouts, reusable components, and data persistence via cloud backends. Emphasis is on hands-on use of these components in application development. Includes a substantial team project including UI mockups, design, development, testing, and presentation.

CSSE 481 Web-Based Information Systems 4R-0L-4C F (odd years)

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

In this course, students learn about several aspects of research: thinking creatively about interesting research problems, researching existing work in a chosen area, and

keeping current in a field. Students are exposed to the process of research by writing a pre-proposal for a project that advances the web. Projects either develop new web-technologies or applications or investigate a topic of importance. Based on feedback received, groups of students write a research proposal which goes through a formal peer review process. Approved projects are pursued for the remainder of the quarter. Students present current research as well as give a final presentation of their group project. Selected web-technologies are introduced; in the past, these have included CGI programming and XML technologies.

CSSE 483 Android Application Development 4R-0L-4C

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

An introduction to programming mobile applications using the Android stack. Topics include the activity lifecycle, resources, layouts, intents for multiple activities, menus, fragments and dialogs, adapters, data persistence via shared preferences, SQLite, and web backends. Emphasis is on hands-on use of these components in application development. Includes a substantial team project (UI mockups, user stories, UML design, development, testing, and presentation).

CSSE 484 iOS Application Development 3R-3L-4C W

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

An introduction to programming mobile applications using the iOS stack. Topics include using X-Code for Swift and Objective-C app development, UI components, Storyboards, view controller actions and outlets, table views, navigation controllers, Core Data, and APIs for backend communication. Emphasis is on hands-on use of these components in application development. Includes a substantial team project (UI mockups, user stories, development, testing, and presentation).

CSSE 487 Senior Research Project I 4C

Prerequisites: ENGL H290 and senior standing

Corequisites: There are no corequisites for this course.

Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 488 Senior Research Project II 4C

Prerequisites: CSSE 487

Corequisites: There are no corequisites for this course.

Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 489 Senior Research Project III 4C

Prerequisites: CSSE 488

Corequisites: There are no corequisites for this course.

Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 490 Special Topics in Computer Science 1-4C

Prerequisites: Instructor consent

Corequisites: There are no corequisites for this course.

Selected topics of current interest. May be repeated for credit if topic is different.

CSSE 491 Directed Independent Studies 1-4C

Prerequisites: Consent of instructor and department head

Corequisites: There are no corequisites for this course.
Independent study of an advanced subject not included in regularly offered courses. May be repeated for credit if topic or level is different.

CSSE 492 Undergraduate Research in Computer Science 1-4C
Prerequisites: Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Research under direction of a faculty member. Presentation of preliminary and final results to departmental seminar. Presentation of work at professional meetings or by publication in professional journals is strongly encouraged. May be repeated for credit if topic or level is different.

CSSE 493 Undergraduate Research in Software Engineering 1-4C
Prerequisites: Consent of instructor and department head
Corequisites: There are no corequisites for this course.
The Computer Science curriculum prepares students for careers in all areas of the computer industry as well as for graduate studies in computer science and computer related fields. Students have also found a computer science major to be excellent preparation for careers in law, medicine, business administration, industrial engineering, biomedical engineering, and other technical and non-technical fields.

CSSE 494 Senior Thesis I 4C
Prerequisites: ENGL H290 Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 495 Senior Thesis II 4C
Prerequisites: CSSE 494 Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 496 Senior Thesis III 4C
Prerequisites: CSSE 495 Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 497 Senior Capstone Project I 4C F
Prerequisites: CSSE 371, CSSE 374* and senior standing
Corequisites: There are no corequisites for this course.
For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions,

recording the investigation experience in a research report, and delivering the research artifacts to the client.

CSSE 498 Senior Capstone Project II 4C W

Prerequisites: CSSE 371, CSSE 374, and CSSE 497

Corequisites: There are no corequisites for this course.

For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions, recording the investigation experience in a research report, and delivering the research artifacts to the client.

CSSE 499 Senior Capstone Project III 4C S

Prerequisites: CSSE 371, CSSE 374, and CSSE 498

Corequisites: There are no corequisites for this course.

For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions, recording the investigation experience in a research report, and delivering the research artifacts to the client.

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