

Electrical Engineering Undergraduate Major
2018-2019 Interdisciplinary Electives

BSEE Degree Requirement: 9 credits (3 classes in any combination)

Advance level 3000/4000 Biological Science Courses (BSC, CHM, PCB or ZOO)

And including CHM2046, CHM2210, CHM2211 and CHM2211L.

AND/OR

Advance level 3000/4000 Physics Courses (See Physics Advisor for details about the physics minor)

AND/OR

Advance level 3000/4000 Mathematics Courses (See Mathematics Advisor for details about the math minor)

AND/OR

Advance level 3000/4000-level course in the College of Engineering (non-ECE) Courses (including EML2023)

COMPUTER AND INFORMATION SCIENCE AND ENGINEERING MINOR (20 credits) - 3 of the courses can be used for the minor and Interdisciplinary electives

A comprehensive list of Engineering Courses are listed below (pgs.1-41)

A comprehensive list of Biological and Chemistry courses below (pgs.42-50)

AGRICULTURAL AND BIOLOGICAL ENGINEERING

ABE 3000C Applications in Biological Engineering

3 Credits

Overview of the research and applications of biological engineering, such as bioprocessing, biotechnology, transport processes, biosensors, bioremediation, biological materials and biomedicine.

Prereq: [BSC 2010](#) or equivalent

ABE 3063L Biological Engineering Laboratory

2 Credits

Quantitative laboratory studies of activities of biological systems, including microbial, plant and animal systems.

Prereq: general biology, general chemistry and differential equations or the equivalent

General Education - Biological Science

ABE 3212C Land and Water Resources Engineering

4 Credits

Introduces hydrology, flow through porous media, flood routing, grade control structures and erosion control.

Prereq: [ENV 3040C](#) and [MAP 2302](#) **Coreq:** [CWR 3201](#) or [EGN 3353C](#)

ABE 3612C Heat and Mass Transfer in Biological Systems

4 Credits

Transport phenomena, steady and unsteady-state heat conduction, radiation, free and forced convection, mass transfer, psychometrics and thermodynamics of biological processes.

Prereq: [EML 3007](#) **Coreq:** [ENV 3040C](#) or [CGN 3421](#) or ESI 4567C

ABE 3652C Physical and Rheological Properties of Biological Materials

3 Credits

Theory and use of physical and rheological properties of biological materials in agricultural engineering applications.

Prereq: [CHM 2045](#), [MAC 2313](#) and [PHY 2048](#)

ABE 4000 Nonpoint Source Pollution Modeling

2 Credits

Concepts, principles, and application of modeling and monitoring for assessment and management of nonpoint source pollution. Design and implementation of monitoring systems. Concepts of modeling agroecosystems and land use impacts on hydrologic/water quality response of upland catchments. Model selection, calibration, validation and application for comparative analysis. Screening models using geographic information systems. Case studies in current watershed management issues with a focus on agricultural waste and nutrient management using existing field and watershed models.

ABE 4033 Fundamentals and Applications of Biosensors

3 Credits

Provides a broad introduction to the field of biosensors, as well as an in-depth and quantitative view of biosensor design and performance analysis. Fundamental application of biosensor theory will be demonstrated, including: recognition, transduction, signal acquisition, and post processing/data analysis.

Prereq: [MAP 2302](#), [BSC 2010](#) and [CHM 2200](#)

ABE 4171 Power and Machines for Biological Systems**3 Credits**

Design and specification of power and machine elements applied to agricultural, biological and land and water resources or food engineering; fundamentals of power units, design of machine elements and power transmission.

Prereq: [EGM 3520](#) and [EML 3007](#)

ABE 4231C Irrigation and Drainage Engineering**4 Credits**

Irrigation and drainage systems design, including pump sizing and specification, water distribution systems, plant water requirement, drainage systems and flood control.

Prereq: [ABE 3212C](#)

ABE 4303C Structural and Environmental Design**3 Credits**

Design and analysis of structures and environmental modification systems used in agricultural production.

Prereq: [ABE 2012C](#) and [ABE 3612C](#)

ABE 4413C Post-Harvest Operations Engineering**3 Credits**

Engineering principles and practices of post-harvest operations for the maintenance of quality of agricultural products. Design of systems and facilities.

Prereq: [ABE 3612C](#)

ABE 4655C Bio-Based Products from Renewable Resources**3 Credits**

Provides the knowledge for the production of fuels, chemicals, and materials from renewable resources; includes the fundamental principles and practical applications of bio-based products: biorefinery and biobased products overview, fundamental concepts in understanding biorefinery and biobased products; materials, chemical platforms, and fuels from biomass.

Prereq: [CHM 2045](#) or [CHM 2095](#) and [CHM 2046](#) or [CHM 2096](#) or equivalent general chemistry courses, or instructor permission

ABE 4660 Applied Microbial Biotechnology**3 Credits**

Principles of microbial biotechnology with emphasis on applications of microorganisms for industrial processes; e.g., energy, environmental, food, pharmaceutical and chemical.

ABE 4932 FUNDAMENTALS AND APPLICATIONS OF SOLAR ENERGY**3 Credits**

The student will be introduced to principles and applications of solar energy in a variety of situations including photovoltaics and solar thermal. After the first two weeks, which will be entirely devoted to theory, the course will combine theory and laboratory work simultaneously. Some emphasis is to be given about the amount of solar energy in the tropics as on latitudes above (and below) 23.5 degrees.

Prereq: Physics, Trigonometry and MAC2311 and MAC2312

BIOMEDICAL ENGINEERING

BME 3012 Clinically-Inspired Engineering Design

3 Credits

Through Exposure to Real Clinical Problems, Learn to Communicate With Medical Professionals in Order to Identify Unmet Needs, to Develop Prototypes and Initial Concepts for Clinical Problems, and to Critically Evaluate Potential Solutions for Clinical Problems.

Prereq: [BME 3060](#) with minimum grade of C **Coreq:** [BME 4409](#)

BME 3053C Computer Applications for BME

2 Credits

Computer programming lab and lecture utilizes Matlab to analyze biomedical measurements.

Prereq: [COP 2271](#) and [COP 2271L](#) or equivalent and [MAC 2312](#), with minimum grades of C

BME 3060 Biomedical Fundamentals

3 Credits

Working specifically within the framework of biomedical engineering applications, provides the engineering fundamentals of the conservation laws of mass, energy, charge, and momentum.

Prereq: [CHM 2046](#) or [CHM 2096](#) and [MAC 2313](#) with minimum grades of C **Coreq:** [PHY 2049](#), [MAP 2302](#), and [BME 1008](#)

BME 3101 Biomedical Materials

3 Credits

Restoration of Physiological Function By Engineering Biomaterials for Biological Environment, Covering Principles Underlying Use and Design of Medical Implants and Matrices/Scaffolds. Strong Emphasis on Transition From Engineering Material to Biological Tissue, Including Molecular and Cellular Interactions With Biomaterials, Tissue and Organ Regeneration, and Design of Intact, Biodegradable, and Bioreplaceable Materials.

Prereq: [BME 3060](#) with minimum grade of C and [CHM 3217](#)

BME 3234 Mechanical Behavior of Biological Tissues and Systems

3 Credits

Focuses on Understanding the Mechanical Behavior of Biological Tissues and Systems By Evaluating Structure-Function Relationships, Stress-Strain Relationships, and the Mechanical Complexity of Biological Systems. In Addition, the Basics of Viscoelastic Behavior Is Introduced as It Applies to Biological Tissues.

Prereq: [BME 3060](#) with minimum grade of C and [EGM 2511](#)

BME 3323L Cellular Engineering Laboratory

3 Credits

The cellular engineering laboratory teaches the fundamentals of cell culture for use in biomedical engineering investigations. Acquire skills in cell culture, quantitative analyses, notebook keeping, report writing, and oral presentation.

Prereq: [BSC 2010](#) and [CHM 2046](#) with minimum grades of C **Coreq:** [BCH 4024](#) and [PCB 3713C](#)

BME 3508 Biosignals and Systems

3 Credits

Basic theory and techniques of biosignals and systems. Topics include sampling, noise in biological signals, signal averaging of noisy biological signals, Fourier analysis and filtering.

Prereq: [MAC 2313](#) with minimum grade of C

BME 4160 Magnetic Biomaterials**3 Credits**

Consists of classroom lectures on fundamental concepts in magnetism and magnetic micro and nano-materials and their applications in biomedicine. Participants present a critical review of recent literature in the field and lead a group discussion on a specific, recent paper.

Prereq: [PHY 2048](#) and [CHM 2046](#) or [CHM 2096](#) with minimum grades of C

BME 4311 Molecular Biomedical Engineering**3 Credits**

Introduces the fundamentals of molecular biology for biomedical engineers. Designed for juniors or seniors majoring in biomedical engineering to learn the nomenclature and current state of knowledge of the eukaryotic cell and its related structures. Topics include protein structure and function, enzymes, the structure and nature of DNA and the cellular structure and function of various cellular organelles. Learn about energy and the function of mitochondria and chloroplast, cellular communication and the function of the extracellular matrix.

Prereq: [BSC 2010](#), [CHM 3217](#) and [PCB 3713C](#) with minimum grades of C

BME 4409 Quantitative Physiology**3 Credits**

A junior/senior level physiology course. Quantitative modeling of organ system physiology of the nervous system, the cardiovascular system and the respiratory system are discussed and students work on quantitative problems.

Prereq: [PCB 3713C](#), [MAP 2302](#), and [BME 3060](#) with minimum grades of C

BME 4621 Biomolecular Thermodynamics and Kinetics**3 Credits**

Principles of thermodynamics and kinetics from a biomolecular perspective. The mathematics, analysis, and applications of classical thermodynamics, statistical thermodynamics, and reaction kinetics are introduced in the context of molecular interactions, binding equilibria, metabolism, and biomolecular transport common to living systems.

Prereq: [BME 3060](#) and [BME 4311](#)

BME 4632 Biomedical Transport Phenomena**3 Credits**

Introduces and applies the concepts of momentum, mass, and thermal energy transport in the context of problems of interest in biomedical sciences and engineering. Macroscopic and microscopic analysis of momentum, mass, and thermal energy transport problems in biomedical systems.

Prereq: [BME 3060](#) with minimum grade of C

BME 4760 Biomedical Data Science**3 Credits**

Covers the Biomedical Applications of Data Science Techniques, Which Include Pre-Processing Techniques, Machine Learning Data Analysis, and Data Visualization Techniques.

Prereq: [BME 3053C](#), [COP 2271](#), and COP2271L

CHEMICAL ENGINEERING

BME 3406 Introduction to Biomolecular Engineering

3 Credits

Introduces chemical engineering students interested in bio-related careers to the chemical engineering discipline. Emphasizes the link between biology and chemical engineering and the interface between them.

Prereq: [ABE 2062](#) or ECH 2062

BME 4220 Biomolecular Cell Mechanics

3 Credits

Covers the biomolecular basis of cell mechanics and cell motility, emphasizing quantitative models and systems-biology approaches.

BME 4321 Dynamics of Cellular Processes

3 Credits

Confocal fluorescence microscopy, techniques for imaging macromolecular dynamics and interactions inside living cells, models of intracellular diffusion, models of ligand-receptor binding, interplay between binding and transport, modeling and analysis of experiments. Examples from literature include mRNA transport, nuclear pore dynamics, cytoskeletal dynamics, imaging motor proteins and transcription factor dynamics.

Prereq: a course on kinetics and/or transport, or instructor permission

COT 3502 Computer Model Formulation 4 Credits

Solutions of scientific and engineering problems using digital computers. Formulation of models for describing physical processes, numerical analysis and computer programming. (M)

Prereq: [ECH 3023](#), [MAP 2302](#) and [MAC 2313](#) MR

ECH 3023 Material and Energy Balances 4 Credits

Formulation and solution of material and energy balances utilizing physical/chemical properties of matter as applied to analyzing unit operations systems.

Prereq: [CHM 2046](#), [MAC 2312](#) and [PHY 2048](#) **Coreq:** [PHY 2049](#), [MAC 2313](#) and [MAP 2302](#)

ECH 3101 Process Thermodynamics 3 Credits

Introduces fundamental principles of classical thermodynamics. Applications to modeling and analysis of physical and chemical processes undergoing change.

Prereq: [CHM 4411](#) or [PHY 3513](#), [COT 3502](#) and [ECH 3264](#)

ECH 3203 Fluid and Solid Operations 3 Credits

Characteristics of laminar and turbulent flow, mechanical energy balance, flow through packed beds and fluidization of solids, design of pumping systems and piping networks and metering of fluids.

Prereq: [COT 3502](#) and [ECH 3264](#)

ECH 3223 Energy Transfer Operations**3 Credits**

Steady state conduction in solids and heterogeneous materials, transient conduction, convection heat transfer, heat transfer during boiling and condensation, radiation heat transfer, design of heat-transfer equipment and heat exchange networks.

Prereq: [COT 3502](#) and [ECH 3264](#)

ECH 3264 Elementary Transport Phenomena**3 Credits**

Flux law and conservation equations of mass, energy and momentum; steady and unsteady states as applied to physical and chemical processing; macroscopic and microscopic analysis.

Prereq: [ECH 3023](#), [MAP 2302](#) and [MAC 2313](#)

ECH 4123 Phase and Chemical Equilibria**3 Credits**

Application of thermodynamic principles to systems of variable composition including the study of phase and chemical equilibria.

Prereq: [ECH 3101](#), [ECH 3203](#) and [ECH 3223](#)

ECH 4224L Fluid and Energy Transfer Operations Laboratory**2 Credits**

Laboratory work in unit operations involving heat and momentum transfer. (WR)

Prereq: [ECH 3101](#), [ECH 3203](#), [ECH 3223](#) and [ENC 3246](#) Coreq: ECH 4714L WR6

ECH 4323 Process Control Theory**3 Credits**

The analysis and automatic control of process systems in chemical engineering.

Prereq: [COT 3502](#) or [ECH 3023](#) or [MAP 2302](#) Coreq: [ECH 4323L](#)

ECH 4323L Chemical Engineering Laboratory 5**1 Credit**

Laboratory work associated with [ECH 4323](#). Coreq: [ECH 4323](#)

ECH 4403 Separation and Mass Transfer Operations**3 Credits**

Theory, design and evaluation of diffusional and staged mass transfer processes including distillation, absorption and extraction, leaching and membrane separations. Computer-aided design methods.

Prereq: [ECH 3101](#), [ECH 3203](#) and [ECH 3223](#)

ECH 4404L Separation and Mass Transfer Operations Laboratory**2 Credits**

Laboratory work in unit operations involving mass transfer. (WR)

Prereq: [ECH 4403](#), [ECH 4224L](#) and ECH 4714L WR6

ECH 4504 Chemical Kinetics and Reactor Design**4 Credits**

Homogeneous and heterogeneous reaction kinetic modeling and data analysis. Analysis and design of ideal batch, mixed, plug and recycle reactors. Heterogeneous catalysis and reactor design.

Prereq: [ECH 3264](#) and [ECH 4123](#)

ECH 4524 Heterogeneous Chemical Kinetics Reactor Design **2 Credits**

Theories of catalytic reactions of adsorbed species at solid surfaces, development of rate expressions with heat and mass transport properties through porous catalyst materials for design of heterogeneous chemical reactors.

Prereq: [ECH 4504](#)

ECH 4604 Process Economics and Optimization **3 Credits**

Introduces the principles of process economics including specifications and costing of equipment, operations costing and economic evaluation of processes.

Prereq: [ECH 3203](#) and [ECH 3223](#) **Coreq:** [ECH 4403](#)

ECH 4644 Process Design **3 Credits**

Preliminary design of conventional chemical processes including process specifications, siting and layout, equipment sizing, utility and manpower needs, safety and hazard analysis, environmental considerations and economic evaluation. Planning techniques for detailed engineering, construction and startup.

Prereq: [ECH 4403](#), [ECH 4504](#), [ECH 4604](#) and [ECH 4824](#)

ECH 4714 Chemical Process Safety **3 Credits**

Laboratory and Process Safety Analysis With Emphasis on Prevention and Mitigation. Application of chemical engineering principles to assessing hazards and risk. Integrated with [ECH 4224L](#).

ECH 4824 Materials of Chemical Engineering **2 Credits**

Relations between microscopic structure and macroscopic mechanical, thermal and electrical properties of organic and inorganic solids. Engineering applications, including corrosion.

Prereq: [ECH 4123](#)

ECH 4827 Processing of Complex Fluids **3 Credits**

The principles involved in quantitative adoption of chemical engineering unit operations and unit processes for the analysis and design of systems involving complex fluids.

Prereq: [ECH 3203](#), [ECH 3223](#), [ECH 4123](#) and [ECH 4824](#), or instructor permission **Prereq:** senior standing

CIVIL AND COASTAL ENGINEERING

CCE 4015 Civil Engineering Estimating

3 Credits

Design of systems for estimating and cost control of man-machine productivity for civil engineering projects. Analysis of cost factors required for optimization of engineering-investment efficiency.

Prereq: [CCE 4204](#) and 3EG classification

CCE 4204 Construction Equipment, Methods and Management

3 Credits

Theory and practice of construction operations, equipment utilization and construction methods. Analysis of costs. Optimizing crew and equipment. Heavy equipment costs. New emphasis on planning and executing a construction project.

Prereq: junior or senior standing, or instructor permission **Coreq:** [CGN 4101](#)

CCE 4811 Construction Engineering Design

3 Credits

Simulation of comprehensive construction project involving all phases of planning, scheduling and control from start to finish, which involves making major decisions. Oral presentation at the end of course.

Prereq: [CCE 4204](#), CGN 4102 and CES 4034

CEG 4011 Soil Mechanics

4 Credits

Physical properties of soils, compaction, flow of water through soil, distribution of stress within soil and consolidation. Laboratory.

Prereq: [EGM 3520](#)

CEG 4012 Geotechnical Engineering

3 Credits

Subsurface exploration settlements analysis, slope stability, earth pressure and an introduction to foundation design.

Prereq: [CEG 4011](#)

CEG 4104 Retaining Wall and Embankment Design

3 Credits

The application of soil mechanics to the design and analysis of various types of retaining structures and earthen embankments.

Prereq: [CEG 4012](#)

CEG 4111 Foundation Engineering Design

3 Credits

Comprehensive design of geotechnical system, focusing on design of complete project and utilizing CAD programs. Designs, drawings and oral presentations through group effort.

Prereq: [CEG 4012](#)

CES 3102 Mechanics of Engineering Structures

4 Credits

Introduces structural load, equilibrium, shear and bending moment diagrams, structural analysis software, classical methods for displacement determination, method of consistent deformations, slope deflection method, moment distribution method.

Prereq: [EGM 3520](#)

CES 4141 Matrix Structural Analysis**3 Credits**

Determining structural loads, solving matrix equations, direct stiffness method, formulation of element matrices, transformations, modeling realistic frame and truss systems, introduces the finite element method, determining convergence, interpretation of results, model validation.

Prereq: [CES 3102](#) and [CGN 3421](#); EG classification or instructor permission

CES 4605 Analysis and Design in Steel**3 Credits**

Elastic and plastic theories of design, design of members subjected to tension, compression, flexure and torsion. Design of connections and rigid frames.

Prereq: [CES 3102](#) and CGN 3501; EG classification

CES 4608 Advanced Steel Design**3 Credits**

Advanced topics in the design of steel structural building systems, advanced column and beam design, base plate design, moment amplification, second-order analysis, bracing considerations, beam-columns, interaction equations, connection design, composite design, plate girders.

Prereq: [CES 4605](#) and EG classification

CES 4702 Analysis and Design in Reinforced Concrete**3 Credits**

Ultimate strength analysis and design of reinforced beams and columns, working stress design for flexure, design of footings and retaining walls.

Prereq: [CES 3102](#) and [CGN 3501C](#); EG classification

CES 4704 Advanced Reinforced Concrete Design**3 Credits**

Advanced topics in the design of concrete building systems. Long columns and frames, floor and roof systems, including two-way slabs, continuous beams, spandrel beams, torsion, foundations, introduces pre-stressed concrete.

Prereq: [CES 4702](#) and EG classification

CGN 3421 Computer Methods in Civil Engineering**4 Credits**

Computer programming, use of computers, numerical methods as applied to civil engineering problems, and civil engineering software.

Prereq: 3EG classification

CGN 3501C Civil Engineering Materials**4 Credits**

Studies the principal materials used for engineering purposes with special attention to mechanical properties and their importance to the engineer. Hands-on experience in testing of civil engineering materials.

Coreq: [EGM 3520](#)

CGN 3510 Introduction to Sustainable Engineering**3 Credits**

Overview of the principles of sustainability as they relate to civil and environmental engineering issues. Discussions and projects facilitate a basic understanding of the production-consumption model and life cycle assessment.

Prereq: EG standing

CGN 3710 Experimentation and Instrumentation in Civil Engineering**3 Credits**

Fundamentals and applications of measuring systems commonly used in civil engineering. Topics include recording techniques, strain, force, displacement, flow, temperature, humidity and PH measurements.

Prereq: [PHY 2049](#)

CGN 4101 Civil Engineering Cost Analysis**3 Credits**

Analysis of civil engineering proposals, utilizing time-value and related factors. Feasibility and optimum life comparisons. Utility rate derivation, utility/cost method.

Prereq: 3EG classification or instructor permission

CGN 4160 Civil Engineering Practice**4 Credits**

Fundamentals of civil engineering professional practice: project management, construction delivery processes, business concepts, public policy, administration and leadership.

Prereq: EGM2511 or equivalent **Coreq:** [CGN 2328](#)

CGN 4503 Pavement Design**3 Credits**

Function and material requirements of different elements of flexible and rigid pavement systems; characterization of soils, materials, traffic loads, and environment for design; flexible and rigid pavement design; new developments.

Prereq: [CGN 3501C](#)

CGN 4600 Public Works Engineering and Management Practices**3 Credits**

Public works profession, organization, administration and management of operating divisions with emphasis on role of engineer.

CGN 4806 Transportation-Water-Materials Design**3 Credits**

Simulation of a design project experience through the completion and presentation of a comprehensive roadway project design. Students work in multi-disciplinary groups to complete a system design that includes traffic, materials, hydrologic and geotechnical considerations.

Prereq: senior standing

CGN 4910 Structures-Geotechnical-Construction Comprehensive System Design 3 Credits

Simulation of a design office experience through the completion and presentation of a comprehensive building design. Students work in multi-disciplinary groups to complete a system design that includes structural, geotechnical and construction management considerations.

Prereq: instructor permission

CWR 3201 Hydrodynamics 4 Credits

Classification and properties of fluids, hydrostatics, and conservation of mass, momentum and energy in fluid flow. Potential flow, similitude and physical modeling. Laminar and turbulent pipe flow. Introduces turbomachines.

Prereq: [EGM 3400](#) and [MAP 2302](#)

CWR 4114 Surface Hydrology 3 Credits

Occurrence and distribution of water by natural processes, including atmospheric thermodynamics, precipitation, runoff, infiltration, water losses, flood routing and catchment characteristics, analysis and methods of runoff prediction.

Prereq: [CWR 4202](#)

CWR 4120 Groundwater 3 Credits

Introduces groundwater hydraulics, including hydrologic cycle, Darcy's equation, Dupuit assumption, well hydraulics, regional flow, freshwater-saltwater interface, flow in the unsaturated zone, fate and transport of contaminants and contaminant plume model.

Prereq: [CWR 4202](#)

CWR 4202 Hydraulics 3 Credits

Fundamental equations for pipe and open conduit flow. Development of design oriented formulas for pipes and open channels. Introduces hydrology.

Prereq: [CWR 3201](#) or instructor permission

CWR 4306 Urban Stormwater Systems Design 3 Credits

Surface-water system design including: time of concentration, peak runoff rate, open-channel flow, gravity storm sewer, culvert, stormwater pumping, filtration systems, hydrograph generation, flood routing, site layout, site grading and permitting.

Coreq: [CWR 4202](#)

CWR 4542 Water Resources Engineering 3 Credits

Study of water resources engineering applications including hydrology and statistics, groundwater, hydraulic machinery, dams and reservoirs, water quality, water quality modeling, water and waste-water treatment and water law and institutions.

Prereq: [CWR 4202](#)

ENV 4514C Water and Wastewater Treatment 3 Credits

Design of water and wastewater treatment units.

TTE 4004C Transportation Engineering**4 Credits**

Overview of the significance of highway transportation to the social and economic underpinnings of society. Introduces road vehicle performance, geometric design of highways, traffic flow and queuing theory, highway capacity and level of service analysis, traffic control and analysis at signalized intersections, and travel demand and traffic forecasting.

Prereq: 3EG classification

TTE 4106 Urban Transportation Planning**3 Credits**

Overview of the four-step urban transportation planning process; includes analytical techniques for estimating future travel demand and state-of-the-art approaches.

Prereq: [TTE 4004C](#)

TTE 4201 Traffic Engineering**3 Credits**

General review of the fundamentals of traffic engineering with emphasis on field studies and data analysis.

Prereq: [TTE 4004C](#)

TTE 4203 Highway Capacity Analysis**3 Credits**

Provide students with detailed instruction on the procedures defined within the 2010 Highway Capacity Manual (HCM), including analytical chapters for uninterrupted and interrupted flow.

Prereq: [TTE 4004C](#)

TTE 4300 Transportation Systems Analysis**3 Credits**

Systems analysis in transportation planning and engineering, including supply, demand, equilibrium, evaluation and decision analysis.

Prereq: [TTE 4004C](#)

TTE 4824 Transportation Facility Design**3 Credits**

Simulates a comprehensive design of a transportation facility, specifically an arterial-freeway interchange. Utilizes state and national-level design manuals in preparation of standard plans. Applies the theoretical background gained in supporting classes, in areas such as traffic analysis, roadway design, roadway drainage and pavement design. Some review of this material is provided, as well as introduction of several new concepts. Emphasizes teamwork skills and technical communication skills.

Prereq: [SUR 4201](#) and [TTE 4004C](#)

COMPUTER AND INFORMATION SCIENCE AND ENGINEERING

CAP 3020 Theory and Practice of Multimedia Production **3 Credits**

Combines the traditional media production pipeline and software engineering processes to synthesize an approach geared for the production of works incorporating both artistic and computational elements.

Prereq: [CAP 3027](#)

CAP 3027 Introduction to Digital Arts and Sciences **3 Credits**

Synergy between art and computing through a programming-oriented exploration of fundamental concepts in multimedia.

Prereq: [COP 3504](#) or [COP 3503](#)

CAP 3032 Interactive Modeling and Animation 1 **3 Credits**

Introduces programming and data structures for interactive two-dimensional multimedia applications. Representing form and transforms in two dimensions, capturing user actions and driving application behavior interactively. Graphical interfaces, image processing, automata and basic artificial intelligence.

Prereq: [MAC 1147](#) or equivalent

CAP 3034 Introduction to Computer-Aided Animation **3 Credits**

Introduces topics related to computer-aided animation. Rigging for forward and inverse kinematics. Skin weighting. Morph targets. Expression-driven animation, rigid-body and particle simulation.

Prereq: [MAC 1147](#) or equivalent

CAP 3220 Introduction to Computer-Aided Modeling **3 Credits**

Introduces topics related to computer-aided modeling. Polygonal mesh, NURBS and subdivision surface meshes. Materials and shading networks. Lighting, shadows and rendering.

Prereq: [MAC 1147](#) or equivalent

CAP 4053 Artificial Intelligence for Computer Games **3 Credits**

Examines the use of A.I. in computer games. Topics include general A.I. knowledge, path finding, movement, tactics and planning, strategy, state machines, learning, dialogue, and emotions.

Prereq: [COP 3530](#)

CAP 4403 Introduction to Aesthetic Computing **3 Credits**

Basic concepts of applying aesthetics to the representation of formal discrete structures found in computing, as well as to their operational behaviors.

Prereq: [COP 3530](#)

CAP 4621 Artificial Intelligence and Heuristics**3 Credits**

Introduces artificial intelligence concepts. Heuristic search, clause form logic, knowledge representation, reasoning and inference, overview of computer vision, planning, natural language, Lisp and Prolog. (M)

Prereq: [COP 3530](#) MR

CAP 4680 Knowledge-Based System: Theory and Practice**3 Credits**

Concepts, theory and various applications for knowledge-based (expert) systems, reasoning schemes, knowledge representation, knowledge-based system tools, building knowledge bases, knowledge acquisition, reasoning under certainty and inexact reasoning.

Prereq: [COP 3530](#)

CAP 4730 Computational Structures in Computer Graphics**3 Credits**

Studies the major topics in computer graphics: display and output technology, two and three dimensional manipulations; space curves and surfaces, hidden surface removal and shading models.

Prereq: [COP 3530](#)

CAP 4770 Introduction to Data Science**3 Credits**

Introduces the basics of data science including programming for data analytics, file management,

Prereq: [COP 3530](#)

CAP 4800 Systems Simulation**3 Credits**

Simulation methodology and practice. Covers basic concepts in modeling and analysis for both continuous and discrete systems. Combined simulation methods including integrated qualitative/quantitative system modeling. Uses in-house simulation software. (M)

Prereq: [COP 3530](#) MR

CDA 3101 Introduction to Computer Organization**3 Credits**

Organization of computing systems. Logical basis of computer structure. Machine representation of instructions and data, flow of control, and basic machine instructions. Assembly language programming. (M)

Prereq: [COP 3504](#) or [COP 3503](#); and [MAC 2233](#), [MAC 2311](#) or [MAC 3472](#) MR

CDA 4102 Computer Architecture**3 Credits**

Introduces computer architecture and system organization including virtual memory supports cache, pipeline, vector processing, multiprocessor and RISC architecture.

Prereq: [CDA 3101](#) and [COP 3530](#)

CDA 4630 Embedded Systems**3 Credits**

Embedded Systems.

CEN 3031 Introduction to Software Engineering**3 Credits**

Topics include software planning, specifications, coding, testing and maintenance. Gain experience in the team approach to large system development. (M)

Prereq: [COP 3530](#) MR

CEN 4072 Software Testing and Verification**3 Credits**

Concepts, principles and techniques of software testing and verification. Strengths and limitations of black-box and white-box testing methods; techniques for proving the correctness of programs.

Prereq: [CEN 3031](#)

CEN 4721 Human-Computer Interaction**3 Credits**

Studies the major topics in the study, planning and design of the interaction between people and computers. Topics include interface design (principles, theories and guidelines), virtual environments, interactive devices and collaboration.

Prereq: [COP 3530](#)

CEN 4722 User Experience Design**3 Credits**

Introduces methods and tools used in User Experience Design (UXD): the early stages of software design focused on meeting user needs. Key concepts include user research, contextual design, design thinking, ideation, iterative design, prototyping, and design documentation. Projects utilize software tools used in the industry.

Prereq: [COP 3530](#)

CEN 4725 Natural User Interaction**3 Credits**

Introduces the design, development and evaluation of Natural User Interaction (NUI) technologies (e.g., non-keyboard and mouse technologies such as touchscreen interaction, gesture interaction, speech interaction, etc.). Discussion of the hardware-to-software NUI pipeline and key considerations when developing NUI software, including existing platforms, toolkits and APIs used to create NUI software.

Prereq: [COP 3530](#) with minimum grade of C

CGS 3063 Computers and Modern Society**3 Credits**

Impact of computers on society. Discussion includes specific cases from many areas, but does not include problem solution. Does not teach how to use the computer but gives an understanding of the implications of computers. (S) (WR)

General Education - Social Science WR6

CGS 3065 Legal and Social Issues in Computing**3 Credits**

Explores the history, the myth, the ethics, the law and the risks of computer-based technology in modern society. Emphasizes critical analysis of hypotheticals and case studies. Published material is supplemented with online references.

Prereq: previous experience in Unix environment

CIS 4204 Penetration Testing: Ethical Hacking**3 Credits**

Introduces principles and techniques associated with the cybersecurity practice known as.

Prereq: [COP 3530](#)

CIS 4301 Information and Database Systems 1**3 Credits**

First part of a two-course sequence that studies the essential concepts, principles and techniques of modern database systems. Topics include modeling and querying of data using conceptual data models as well as the development of a database application. (M)

Prereq: [COP 3504](#), or [COP 3503](#) and [COT 3100](#) MR

CIS 4360 Computer and Information Security**3 Credits**

Covers systematic threat and risk assessment; programmed threats and controls in hardware, software, and human procedures; security policies, models, and mechanisms; theoretical limitations and practical implementations; certification and accreditation standards; and case study reviews. Includes projects.

Prereq: [COP 4600](#) or equivalent

CIS 4362 Introduction to Cryptology**3 Credits**

Introduces classical and modern cryptography and cryptanalysis, including symmetric and asymmetric (public key) ciphers. Covers cryptographic hash functions, block and stream ciphers, as well as differential and linear cryptanalysis. Reviews applications of cryptography, cryptographic standards and protocols, and analyzes case studies of failed implementations.

Prereq: [COT 3100](#) or the equivalent

CNT 4007C Computer Network Fundamentals**4 Credits**

Fundamental concepts, principles and standards of computer networks. Topics are introduced in bottom-up approach, starting from physical layer in OSI system architecture with a stronger focus on data link, mac, network and transport layers. (M)

Prereq: [COP 4600](#) MR

CNT 4409 Network and System Security**3 Credits**

Examines networked threats and vulnerabilities; trust, identification, authentication, and authorization in networked and distributed systems; secure network protocols and standards; certification of network products; firewall configurations, intrusion detection, and anomaly detection; security flaws in network protocols and distributed applications. Includes projects.

Prereq: [CNT 4007C](#) and [COP 4600](#) or equivalent

COP 3229 Computer Programming Using C++**3 Credits**

In-depth treatment of the C++ programming language. Introduces Windows programming using Visual C++.

Prereq: [COP 3504](#) or [COP 3503](#)

COP 3502 Programming Fundamentals 1**3 Credits**

First course of a two-semester introductory sequence for those planning further study in computer science, digital arts and sciences or computer engineering. Concepts of computer science and the process of computer programming, including object-oriented programming, procedural and data abstraction and program modularity.

Coreq: [MAC 2311](#)

COP 3503 Programming Fundamentals 2**3 Credits**

Second course of a two-semester introductory sequence for those planning further study in computer science, digital arts and sciences or computer engineering. Concepts of computer science and the process of computer programming, including object-oriented programming, procedural and data abstraction and program modularity.

Prereq: [COP 3502](#) with a minimum grade of C or an AP exam in computer science with a minimum grade of 4; and [MAC 2311](#) with a minimum grade of C

COP 3530 Data Structures and Algorithm**4 Credits**

Algorithm development using pseudo languages, basic program structures, program design techniques, storage and manipulation of basic data structures like arrays, stacks, queues, sorting and searching and string processing. Linked linear lists. Trees and multilinked structures. (M)

Prereq: [COP 3504](#) or [COP 3503](#) with minimum grade of C, [COT 3100](#), and [MAC 2234](#), [MAC 2312](#), [MAC 3473](#) or MAC 3512 MR

COP 4020 Programming Language Concepts**3 Credits**

Introduces programming language principles, including language constructs, design goals, run-time structures, implementation techniques and exposure to a wide variety of programming paradigms.

Prereq: [COP 3530](#)

COP 4331 Object-oriented Programming**3 Credits**

Fundamental conceptual models for programming languages illustrated with specific programming languages and application problems. Specific topics include class and object models, inheritance among classes, objects and static and dynamic systems and implementations.

Prereq: [COP 3530](#)

COP 4600 Operating Systems**3 Credits**

Design and implementation of various components of a modern operating system, including I/O programming, interrupt handling, process and resource management, computer networks and distributed systems. (M)

Prereq: [CDA 3101](#) and [COP 3530](#); knowledge of C or C++ recommended MR

COP 4620 Translators and Translator Writing Systems**3 Credits**

Translation of languages, scanning and parsing techniques. Translator writing systems. The implementation of a compiler. (M) **Prereq:** [COP 3530](#) MR

COP 4720 Information and Database Systems 2**3 Credits**

Part two of a two-course sequence. Provides a basic understanding of the internals of a modern database system. Topics include data storage, indexing, query processing and advanced concepts such as database tuning, alternate data models and emerging applications. (M)

Prereq: [CIS 4301](#) and COP 3530 MR

COT 3100 Applications of Discrete Structures**3 Credits**

Covers the mathematics of discrete events; i.e., events that involve distinct elements, finite structures of distinct elements or finite sampled versions of continuous phenomena (such as movement). (M)

Prereq: [MAC 2233](#) or [MAC 2311](#) or [MAC 3472](#) **Coreq:** [COP 3504](#) or [COP 3503](#) General Education – Mathematics MR

COT 4501 Numerical Analysis: a Computational Approach**3 Credits**

Numerical integration, nonlinear equations, linear and nonlinear systems of equations, differential equations and interpolation.

Prereq: [COP 3504](#) or [COP 3503](#) and [MAS 3114](#)

Engineering

EGM 3400 Elements of Dynamics

2 Credits

Dynamics of particles and rigid bodies for rectilinear translation, curvilinear motion, rotation and plane motion. Also includes principles of work and energy, and impulse and momentum.

Prereq: EGM 2511, and MAC 2313 with a minimum grade of C

EGN 4641 Engineering Entrepreneurship

3 Credits

Engineering Entrepreneurship introduces engineering students to the concepts and practices of technological entrepreneurial thinking and entrepreneurship. Using lectures, case studies, business plans and student presentations, the course teaches life skills in entrepreneurial thought and action that students can utilize when starting technology companies or executing research and development projects in large companies.

Prereq: junior or senior standing

EGN 4643 Engineering Innovation

3 Credits

Engineering Innovation introduces students to the concepts of innovative thinking and innovation practices. Using lectures, case studies, team exercises and guest speakers, the course teaches life skills in innovative thought and action that students can use in careers ranging from starting companies to executing research and development projects in large companies.

Prereq: junior or senior standing

EGN 4932 Special Topics

1-4 Credits

Covers selected, rotating topics in engineering.

EGN 4940 NSF Fellowship Preparation

1 Credit

Overview of fellowship preparation pertaining to intellectual merit and broader impacts.

EGS 4034 Engineering Ethics and Professionalism

1 Credit

Provides students with an interactive study of ethical theory and the development of professionalism. Students review case studies of ethical conflicts in engineering practice. Course covers engineering codes of ethics and requires students to resolve theoretical situations through application of ethical codes.

Prereq: junior level standing

EGS 4038 Engineering Leadership**3 Credits**

Engineering Leadership introduces engineering graduate students to the concepts, theory and practice of engineering leadership; effective written and oral communications and presentations; engineering leadership characteristics, individual differences and self-awareness; developing and building teams; managing change, conflicts, and crises; and understanding real-world ethics and core values.

Prereq: junior or senior standing

EGS 4100 Divergent Thinking**3 Credits**

Acquire divergent thinking skills to support the engineering design process. Emphasizes the importance of practices such as observing, questioning, learning, and experimenting; Stresses cultivating an openness to new experiences In order to generate ideas and devise solutions to complex design problems.

Prereq: junior or senior level standing

EGS 4625 Fundamentals of Engineering Project Management**3 Credits**

Provides a Comprehensive Understanding of How to Plan, Optimize, and Efficiently Manage Projects (Or Tasks) to Implement Products, Services, or Developments. Includes Building the Structure, Processes, Components, and Linkages With a Team for Successful Project Delivery Within Schedule, Budget, and Quality Requirements.

Prereq: junior or senior level standing

EGS 4627 Applied Engineering Project Management**3 Credits**

Applied Engineering Project Management expands on foundational project management practices to include complex as well as new project delivery concepts. Topics include project acquisition; negotiation skills; advanced risk planning and management; program management; project life cycle models and their applicability; and diagnostics and remedies for problem projects.

EGS 4680 Advanced Engineering Leadership Development**3 Credits**

Further Develops the Leadership Framework and Capabilities; Involves a Case Study-Based Instructional Approach That Reviews and Applies Strategic Leadership Concepts and Knowledge Critical to the Success of Engineering-Based Companies That Operate in a Highly Uncertain and Volatile Business Environment.

Prereq: EGS 4038 or instructor permission

EML 3007 Elements of Thermodynamics and Heat Transfer**3 Credits**

Applications of first and second laws of thermodynamics to closed and open systems. Steady one-dimensional conduction, lumped parameter analysis, convection, radiation. Intended for non-mechanical engineering students.

Prereq: CHM 2045, MAC 2313 and PHY 2048

ENVIRONMENTAL ENGINEERING SCIENCES

EES 3008 Energy and Environment

3 Credits

Consideration of the energy basis for man and nature including principles of energy analysis, systems ecology and public policy. (P)

General Education - Physical Science

EES 4005C Ecological Engineering

3 Credits

Application of ecological and engineering principles to natural resource management and problem solving.

Prereq: CHM 2046or [CHM 2096](#) **Coreq:** [EES 4203](#)

EES 4050 Environmental Planning and Design

3 Credits

Principles and practices of environmental planning. Planning for and designing sustainable communities and regions. Exploration of quantitative methods for the evaluation of environmental impacts and analysis of carrying capacity of economic development. Exploration of theories of spatial and temporal organization of systems of humanity and nature.

EES 4102 Wastewater Microbiology

2 Credits

General concepts in microbiology and cell biology with major emphasis on the role of microorganisms in polluted environments. (B)

Prereq: [CHM 2046](#) General Education - Biological Science

EES 4102L Environmental Biology Laboratory

1 Credit

Focuses on the biota (microorganisms, algae, zooplankton, fish, and plants) found in natural (lakes and wetlands) and engineered systems, ecological engineering approach to management of surface waters and ecological modeling.

EES 4103 Applied Ecology

2 Credits

Application of ecological principles to technological resource management and problem solving. (B)

General Education - Biological Science

EES 4201 Water Chemistry

3 Credits

Kinetics and equilibrium of aqueous chemistry including acid-base, complexation, precipitation and redox equilibria. (P)

Prereq: [CHM 2046](#) or [CHM 2096](#) and [MAC 2311](#) or [MAC 2233](#) General Education - Physical Science

EES 4203 Phase Partitioning in the Environment

4 Credits

A study of the fate of organic pollutants in the environment through application of principles of organic chemistry and chemical thermodynamics, including phase partitioning between environmental media.

Prereq: [CHM 2046](#) or [CHM 2096](#)

EES 4316 Industrial Ecology**3 Credits**

Linkage of industrial activity with environmental and social sciences. Corporate environmental management and environmental ethics. Resources, laws and economics. Environmental account. Industrial products and processes and life cycle assessments. Case studies of corporate environmental policies.

EES 4401 Public Health Engineering**3 Credits**

Application of engineering principles to protect public health. Areas covered include water supply, waste treatment, air pollution, radiological health, occupational health, milk and food sanitation, vector control, solid wastes, and housing hygiene. (P)

General Education - Physical Science

EMA 4535 Sustainable Nanotechnology**3 Credits**

Increase in production and use of engineered nanomaterials (ENMs) raises concerns on their potential impacts on the environment and human health. The sustainable development of nanotechnology requires knowledge of life cycle and environmental fate/implications of ENMs. Focuses on linkages between ENM properties and environmental implications.

Prereq: [CHM 2046](#) or [CHM 2047](#) or [CHM 2096](#)

ENV 3040C Computational Methods in Environmental Engineering**3 Credits**

Numerical modeling techniques and their application to environmental engineering. Use of personal computers and spreadsheets to solve numerical models. Solution techniques include numerical methods and their implementation using Excel and Visual Basic for Applications (VBA).

Prereq: [MAC 2313](#) **Coreq:** [MAP 2302](#)

ENV 3930 Environmental Engineering Ethics Seminar**1 Credit**

Intended for undergraduates majoring in environmental engineering. Lectures and discussion on ethics topics in environmental engineering sciences. (H)

General Education – Humanities

ENV 4041C Environmental Analysis**3 Credits**

Theory and laboratory techniques for the analysis of air and water pollutants and basic concepts of ecosystems structure and analysis.

Prereq: [CHM 2046](#) or [CHM 2096](#) and [STA 3032](#) or [STA 2023](#)

ENV 4101 Elements of Atmospheric Pollution**3 Credits**

Sources, effects and regulation of air pollutants. Meteorology and dispersion of pollutants. Sampling and analysis of gaseous and particulate air pollutants. Photochemical air pollution and mobile sources. (P)

Prereq: [EES 4203](#) and [PHY 2049](#) General Education - Physical Science

ENV 4121 Air Pollution Control Design**3 Credits**

Principles of particulate and gaseous emission control; design and operation of particulate and gas control equipment to meet federal emission standards.

Prereq: [ENV 4101](#)

ENV 4122 Design of Air Pollution Control System**3 Credits**

Design of a complete air pollution control system including the industrial ventilation system needed to capture, transport and condition the hot, corrosive gases from an industrial process.

Prereq: [ENV 4101](#) and [ENV 4121](#)

ENV 4212 Nuclear Power Radioactive Waste Technology**3 Credits**

Characterization and description of low and high level radwastes, regulatory requirements and method of treatment. Transportation, burial and surveillance of radwaste. Decommissioning of nuclear facilities.

Prereq: refer to the department

ENV 4300 Solid Waste Containment Design**3 Credits**

Design fundamentals of solid and hazardous waste landfills, waste piles, monofills and surface impoundments. Regulations, site requirements, sizing, liner design, leachate and gas management system design, operations and closure.

Prereq: [ENV 4351](#) **Coreq:** [ENV 4561](#) or [CWR 4202](#)

ENV 4351 Solid and Hazardous Waste Management**4 Credits**

Generation of solid and hazardous wastes. Collection, methods, equipment, costs and disposal. Rules, regulations and management systems for proper control of solid and hazardous wastes. Evaluation of engineering systems to minimize costs and regulatory problems. (P)

Prereq: [EES 4201](#) General Education - Physical Science

ENV 4405 Nutrient Control and Water Reuse**3 Credits**

Biological and physicochemical processes for advanced treatment of municipal wastewater. Reuse guidelines and applications.

ENV 4411 Stormwater Control Systems**3 Credits**

Chemical, physical, biological and hydrologic aspects of rainfall runoff and control through unit operations and processes (UOPs). Stormwater physical and chemical loads. Interactions between hydrologic processes, water chemistry, sediment transport, infrastructure materials and UOPs for treatment and reuse.

Prereq: [EES 4201](#) or instructor permission

ENV 4430 Water Treatment Process Design**3 Credits**

Design of selected water treatment processes including disinfection, air stripping, adsorption, ion exchange and membrane processes.

Prereq: [ENV 4514C](#) and [EES 4201](#)

ENV 4501 Environmental Hydrology 1**3 Credits**

Surface and atmospheric hydrology. Hydrologic processes controlling streamflow events. Practical application to stormwater management.

Prereq: [ENV 3040C](#) and [STA 3032](#) or [STA 2023](#); [CWR 3201](#), or [EGN 3353C](#)

ENV 4506 Environmental Hydrology 2**3 Credits**

Subsurface hydrology. Properties of porous media governing flow and chemical transport in the subsurface. Environmental site evaluation methods.

Prereq: [ENV 3040C](#) or [CWR 3201](#) or [EGN 3353C](#)

ENV 4532 Wastewater System Design**3 Credits**

Detailed design and layout of gravity wastewater collection systems, pumping facilities, force mains, and a wastewater treatment plant. Emphasis on the preparation of design drawings and estimating costs.

Prereq: [ENV 4514C](#) **Coreq:** [ENV 4561](#) or [CWR 4202](#)

ENV 4561 Hydraulic Systems Design**3 Credits**

Hydraulic design of water distribution systems, wastewater collection and disposal systems, and water and wastewater treatment plants.

Prereq: [CWR 3201](#)

ENV 4601 Environmental Resources Management**2 Credits**

Theory and application of engineering economics and systems analysis to the design of environmental management systems.

Prereq: [ENV 3040C](#)

Industrial Systems Engineering

EGN 4930 Sales Engineer Seminar

1 Credit

Intended for those interested in pursuing a career in sales engineering (required for students enrolled in the sales engineering certificate program). Lectures and discussions on practice-oriented sales engineering topics. (S-U)

EIN 3101C Introduction to Industrial and Systems Engineering

2 Credits

Introduction and overview of the profession, including career planning, professionalism and communication, ethics, teamwork, industry site visits, industrial speakers, and selected solution methods for problems in coordination and planning.

Prereq: [ENC 3254](#) with a minimum grade of C

EIN 4321 Industrial Energy Management

3 Credits

Introduces energy conservation. Supply-demand data, energy economics, investment analysis and energy legislation. Audits, waste heat recovery, cogeneration and computerized energy management systems.

Prereq: [EIN 4354](#) and [PHY 2049](#) with minimum grades of C

EIN 4343 Inventory and Supply Chain Systems

3 Credits

Develops analytic abilities to formulate and solve inventory and logistics problems faced by today's firms. Learn to take a comprehensive view of complex inventory and supply-chain systems; develop abilities to model, optimize and design such systems.

Prereq: ESI 4321 and [ESI 4313](#) with minimum grades of C

EIN 4354 Engineering Economy

3 Credits

Basic principles and applications of economic decision-making between alternatives encountered in engineering systems projects. Analysis includes methodologies of economics and finance in addition to engineering fundamentals.

Prereq: [MAC 2312](#) with a minimum grade of C

EIN 4360C Facility Planning and Work Design⁴ Credits

Introduces fundamental concepts in several main areas of industrial engineering such as facility planning, material handling systems, work analysis and design. Covers topics such as analysis and design of work space and flow, facility location and layout, material handling systems, motion and time studies and work sampling.

Prereq: [ENC 3250](#) or [ENC 3254](#) and [EML 2023](#) or equivalent with minimum grades of C **Coreq:** [EIN 4354](#)

EIN 4451 Lean Production Systems**3 Credits**

Design of flow line, cellular and flexible manufacturing systems. Design and control of lean manufacturing systems. Continuous improvement, small lot production, setup-time reduction, equipment improvement and maintenance. Principles and control of push and pull manufacturing systems. Production planning and operations scheduling.

Prereq: [ESI 4312](#) and [STA 4321](#)

EIN 4937 Industrial and Systems Engineering Seminar**1 Credit**

Lectures and discussions on general and specific engineering problems. Individual investigations and research reports on assigned topics. Orientation for an industrial career. (S-U)

Prereq: 3EG or 4EG standing in industrial and systems engineering

ESI 4221C Industrial Quality Control**3 Credits**

Factors affecting variation in product quality; use of control charts to evaluate and control manufacturing processes. Techniques for acceptance and reliability testing. Laboratory exercises illustrate the operation and control of manufacturing processes and hazard function. Typical failure distributions, redundant systems, models of repair and maintenance.

Prereq: [STA 4321](#) and [STA 4322](#) with minimum grades of C

ESI 4312 Operations Research 1**4 Credits**

Introduces optimization modeling, algorithms and software to aid in the analysis and solution of decision-making problems.

Prereq: [ESI 4327C](#) with minimum grade of C

ESI 4313 Operations Research 2**4 Credits**

Introduces stochastic models and methodologies for analyzing and providing solutions to decision-making problems with uncertainties.

Prereq: [ESI 4327C](#) and [STA 4321](#) with minimum grades of C

ESI 4327C Matrix and Numerical Methods in Systems Engineering**4 Credits**

Theory and application of vector, matrix and other numerical methods to systems problems. Simultaneous linear equations, characteristic values, quadratic forms, error analysis, use of series, curve fitting, nonlinear equations, discrete methods. Laboratory emphasize numerical solutions using MATLAB.

Prereq: [MAC 2313](#) and [MAP 2302](#) with minimum grades of C

ESI 4356 Decision Support Systems for Industrial and Systems Engineers**4 Credits**

Applications of decision support systems in industrial and systems engineering; developing and implementing decision support systems arising in industrial and systems engineering using popular database management and spreadsheet software.

Prereq: [COP 2271](#) and [ESI 4312](#) with minimum grades of C

ESI 4357 Web-Based Decision Support Systems for Industrial and Systems Engineers**4 Credits**

Introduces the Internet and e-commerce; Internet tools and technologies necessary for the development of web-based decision support systems; designing and implementing web-based decision support systems arising in the practice of industrial and systems engineering using popular software packages.

Prereq: [COP 2271](#) and [ESI 4312](#) with minimum grades of C

ESI 4523 Industrial Systems Simulation**3 Credits**

Simulation methodology and languages (such as General Purpose Simulation System - GPSS). Design and analysis of simulation experiments as well as applications to solutions of industrial and service system problems.

Prereq: [COP 2271](#), [STA 4322](#) and [ESI 4313](#) with minimum grades of C

MATERIALS SCIENCE AND ENGINEERING

EMA 3010 Materials

3 Credits

Conceptual perspective for origin of materials behavior and the interrelationships of structure/property/performance. Materials selection and use of familiar material (metals, ceramics, polymers, electronic materials and composites) in electronics and structural and other engineering applications.

Prereq: [CHM 2045](#)

EMA 3011 Fundamental Principles of Materials

3 Credits

Covers the fundamental principles of structure, reactivity and energies describing materials systems, directly relating individual principles to specific materials properties or functions.

Prereq: [CHM 2046](#) or [CHM 2096](#)

EMA 3013C Materials Laboratory 2

2 Credits

General undergraduate materials laboratory. (WR)

Prereq: [EMA 3080C](#) WR2

EMA 3050 Introduction to Inorganic Materials

3 Credits

Uses, structure, processing and properties of inorganic materials, including metals, alloys and ceramics. Scientific principles are introduced through discussion of developed inorganic materials for high technology applications.

Prereq: [EMA 3010](#)

EMA 3066 Introduction to Organic Materials

3 Credits

Uses, structure, processing and properties of organic materials, including polymers, biomacromolecules and small molecule organic materials. Scientific principles are introduced through discussion of developed organic materials for high technology applications.

Prereq: [EMA 3010](#) and one of the following: [EMA 3011](#), [CHM 2200](#) or [CHM 2210](#)

EMA 3080C Materials Laboratory 1

2 Credits

First part of the general undergraduate materials laboratory. (WR)

Prereq: [EMA 3010](#) and [EMA 3800](#) WR4

EMA 3123 Metallurgical Engineering**3 Credits**

Preparation, structure, properties and applications of metals and alloys.

Prereq: [EMA 3010](#)

EMA 3413 Electronic Properties of Materials**3 Credits**

Atomistic and quantum-mechanical description of the electrical, optical, magnetic and thermal properties of materials. Deals with metals, alloys, semiconductors, polymers, dielectrics and amorphous materials with special emphasis given to high technology applications of electronic materials.

Prereq: [EMA 3010](#)

EMA 3513C Analysis of the Structure of Materials**4 Credits**

Laboratory fundamentals of crystallography, x-ray and electron diffraction, scanning and transmission electron microscopy, surface analysis and microprobe techniques.

Prereq: [EMA 3010](#)

EMA 3800 Error Analyses and Optimization Methodologies in Materials Research **3 Credits**

Statistical approach for materials research, basic and relevant statistical concepts, error analyses, factorial matrices, reducing the variance, nested designs and sampling plans, mixture designs, optimization technology, response surface method and Taguchi.

Coreq: [EMA 3010](#)

EMA 4020L Metallurgy Laboratory**1 Credit**

Concepts, skills, and techniques required for an understanding of metals and metallurgy processing.

Prereq: [EMA 3050](#) Coreq: [EMA 4120](#)

EMA 4041L Advanced Ceramics Laboratory 1**1 Credit**

Forming, drying, firing and testing of traditional ceramics.

Coreq: [EMA 4645](#)

EMA 4042L Advanced Ceramics Laboratory 2**1 Credit**

Part two of the advanced ceramics laboratory in forming, drying, firing and testing of advanced ceramics.

Prereq: [EMA 3050](#)

EMA 4061 Biomaterials: Structure and Properties**3 Credits**

Materials commonly used for biomedical application, such as their properties from a biocompatibility or medical device perspective. In addition, materials interactions with biological systems are examined from the molecular (e.g., protein), cellular, tissue and systemic (whole body) perspective. This is the foundation for the second biomaterials class, which applies these principles toward the application of biomaterials in medical implants, prostheses and devices, along with the regulatory issues associated with biomaterials development.

Coreq: [EMA 3066](#)

EMA 4061L Biomaterials Laboratory**1 Credit**

Hands-on laboratory experience in the processing and characterization of biomaterials for use in medical applications.

Coreq: [EMA 4061](#)

EMA 4062 Biopolymers: Manufacture, Stability and Biocompatibility**3 Credits**

Polymer manufacturing processes and biochemical/biophysical behavior are considered from the perspective of achieving those properties needed for the engineering of polymeric implants and devices. Unique economic, ethical and regulatory issues are also presented.

Prereq: [EMA 3066](#)

EMA 4120 Physical Metallurgy 1**3 Credits**

In-depth discussion of fundamentals of physical metallurgy and principles of microstructure evolution.

Prereq: [EMA 3050](#)

EMA 4121 Interfacial Engineering**3 Credits**

Correlation of properties, structural and mechanical history, thermal history and service behavior of various interfaces.

Prereq: [EMA 3050](#), [EMA 3066](#) and [EMA 3413](#)

EMA 4125 Transport Phenomena in Materials Processing**3 Credits**

Science and application of momentum, heat and mass transport in materials and materials processing.

Prereq: [EMA 3010](#) and [MAP 2302](#)

EMA 4144 Physical Ceramics 1**3 Credits**

Structure of complex ceramic compounds and glasses. Influence of structural imperfections and stoichiometry on physical characteristics, surface and interfacial phenomena, diffusion and phase transformations in ceramic systems.

Prereq: [EMA 3050](#)

EMA 4145 Physical Ceramics 2**3 Credits**

Influence of ceramic microstructure on processing. Chemical bonds, surface phenomena, forming energetics, drying and firing kinetics. Diffusion, nucleation, crystal growth, solid-solid and solid-liquid reactions.

Prereq: [EMA 3050](#)

EMA 4161 Physical Properties of Polymers**3 Credits**

Molecular structure and the physical property relationships for polymers: viscoelastic behavior, the glass transition, thermomechanical and rheological properties, the crystalline and amorphous molecular solid state. Correlation of properties with design engineering of polymer applications. Laboratory section included.

Prereq: [EMA 3066](#) and [EMA 3513C](#)

EMA 4161L Polymers Laboratory**1 Credit**

Concepts, skills, and techniques required for an understanding of polymer and polymer composite processing.

Coreq: [EMA 4161](#)

EMA 4223 Mechanical Behavior of Materials**3 Credits**

Plastic deformation and fracture of metals and alloys, ceramics and polymers.

Prereq: [EGM 3520](#)

EMA 4224 Physical Metallurgy 2**3 Credits**

In-depth discussion of fundamentals of alloy design, mechanical properties and failure mechanisms.

Prereq: [EMA 4120](#) and [EMA 4223](#)

EMA 4314 Energetics and Kinetics in Materials Science**3 Credits**

Foundations of energetics and kinetic theory with applications to processes in materials science.

Prereq: [EMA 3010](#)

EMA 4324 Stability of Materials**3 Credits**

Mechanisms, energetics and kinetics of corrosion and degradation of engineering materials. Economic solutions to degradation problems based upon design and materials selection.

Prereq: [EMA 4314](#)

EMA 4414L Electronic Materials Laboratory**1 Credit**

Hands-on experience for those specializing in electronic materials. Laboratory topics include characterization of optical and electronic properties of semiconductor materials, electronic devices characterization and semiconductor processing.

Coreq: [EMA 4614](#)

EMA 4462 Polymer Characterization**3 Credits**

Use of a broad variety of spectroscopic and other scattering phenomena in polymer research.

Prereq: [EMA 3066](#) or equivalent

EMA 4614 Production of Electronic Materials**3 Credits**

Production of materials for use in solid state electronic devices; nucleation and growth kinetics, solidification of single phase alloys, segregation, dynamics of crystal growth, selection of materials and growth techniques, characterization.

Prereq: [EMA 3413](#)

EMA 4615 Compound Semiconductor Materials**3 Credits**

Physical properties of technologically important compound semiconductor materials. Epitaxial growth and practical application of compound semiconductor heterostructures.

Prereq: [EEE 3396](#)

EMA 4623 Process Metallurgy**3 Credits**

Engineering aspects of mineral processing, including unit operations and flow sheets. Science and technology of metal extraction with applications to specific ferrous and non-ferrous metals.

Coreq: [EMA 4120](#)

EMA 4630C Metals Casting**2 Credits**

Melting and solidification of metals and alloys including heat flow, solute redistribution, casting defects, micro- and macrosegregation. Foundry techniques including sand casting, permanent mold casting, investment casting and die casting.

Prereq: [EMA 3123](#)

EMA 4645 Processing of Ceramic Materials**3 Credits**

Introduces the technology and science of processing ceramic materials, including traditional clay-based ceramics, modern technical ceramics and glasses. Topics include the nature of fine particles, forming methods and consolidation by heat.

Prereq: [EMA 3050](#)

EMA 4666 Polymer Processing**3 Credits**

Major processing methods for polymers and polymeric composites as related to the rheological behavior of these systems. Synthesis of polymers via industrial processes.

Prereq: [EMA 3066](#)

EMA 4714 Materials Selection and Failure Analysis**3 Credits**

Philosophy and practice of engineering selection of materials. Case studies in product liability and failure analysis.

Prereq: [EMA 4223](#) and [EMA 4324](#)

EMA 4740 Ceramic Engineering Design**2 Credits**

Molecular composition, design of ceramic bodies and glazes, design use histories and computer-based design projects.

Prereq: [EMA 4144](#)

EMA 4760 Plastics Engineering Design**3 Credits**

Utilizes knowledge of processing and properties of plastics for the proper design of products, molds, etc.

Prereq: EMA 4666C Coreq: EMA 4666C

MECHANICAL AND AEROSPACE ENGINEERING

EAS 3020C Introduction to Flight

3 Credits

Introduction to the science and engineering of aircraft. Overview of applied aerodynamics, performance, stability, propulsion and structures. Includes lab sessions flying and making measurements in a general aviation aircraft.

Prereq: [PHY 2048](#) or [PHY 2053](#), [MAC 2311](#), or instructor permission

EAS 4101 Aerodynamics

3 Credits

Incompressible aerodynamics, integral and differential governing equations, potential flow, boundary layers,

Prereq: [EAS 2011](#) or [EAS 3020C](#) or [EGN 3353C](#) and [COP 2271](#), [EML 3100](#), [MAC 2313](#) and [MAP 2302](#) with minimum grades of C

EAS 4132 Compressible Flow

3 Credits

One-dimensional and quasi one-dimensional compressible fluid flows. Includes mach waves, normal shocks, oblique shocks, Prandtl-Meyer expansions, isentropic flow with area change, Fanno flow and Rayleigh flow.

EAS 4200C Aerospace Structures

3 Credits

Review of plane states of stress and strain. Includes analysis of thin-walled beams with open and closed section, unsymmetrical bending of wing sections, torsion of skin-stringer and multi-cell sections, flexural shear in open and closed sections, Shear Center and failure criteria. Also includes introduction to composite materials and demonstration of behavior of some simple structural elements.

Prereq: [EGM 3520](#)

EAS 4240 Aerospace Structural Composites 1

3 Credits

Various types and applications of structural composites used in flight structures. Also includes an introduction to analysis of structural composites.

Prereq: [EGM 3520](#)

EAS 4300 Aerospace Propulsion

3 Credits

Basics of air-breathing and rocket engines used in flight systems.

EAS 4400 Stability and Control of Aircraft

3 Credits

Static stability and control, equations of motion, stability derivatives, stability of longitudinal and lateral motion of aircraft.

Prereq: [EAS 4101](#) and [EML 4312](#)

EAS 4412 Dynamics and Control of Space Vehicles

3 Credits

Review of aerospace applications in current guidance and control systems. Includes synthesis of open and closed loop guidance and control systems using classical and modern control theory.

EAS 4510 Astrodynamics**3 Credits**

Introduction to the solar system. Includes study of two-body motion, Hohmann transfer, patched conics for interplanetary and lunar trajectories, and the restricted three-body problem. Also includes an introduction to powered flights and artificial satellite orbits.

EAS 4530 Space Systems Design**3 Credits**

A discussion of the component systems of a spacecraft and a typical mission's requirements. The operation and character of different spacecraft hardware is presented as well as typical mission timelines from early conception to final operations. Topics include the space environment, guidance/control/navigation systems, spacecraft sensors and actuators, propulsion systems, thermal systems, power systems, launch systems, communication systems, structural systems and mission operations. This course is useful to engineers, scientists, computer scientists and any profession that uses data.

Prereq: [EAS 4510](#)

EAS 4700 Aerospace Design 1**3 Credits**

Applications of the principles of analysis and design to aerospace vehicles. Emphasizes astronautics.

Prereq: [EAS 4510](#) and [EML 4312](#)

EAS 4710 Aerospace Design 2**3 Credits**

Applications of the principles of analysis and design to aerospace vehicles. Emphasizes aeronautics.

Prereq: [EAS 4101](#) and [EAS 4400](#)

EAS 4810C Aerospace Sciences Lab and Design**3 Credits**

Experimental investigations of aerospace engineering systems. Wind tunnel testing. Design project with experimental validation.

Prereq: [EAS 4101](#) and [EML 3301C](#)

EGM 3344 Introduction to Numerical Methods of Engineering Analysis**3 Credits**

Methods for numerical solution of mathematical problems with emphasis on engineering applications using MATLAB. Includes roots, optimization, linear algebraic equations, matrices, curve fitting, differentiation, integration and ordinary differential equations.

Prereq: [MAC 2313](#) and [COP 2271](#) Coreq: MAP2302

EGM 3401 Engineering Mechanics: Dynamics**3 Credits**

Continues the dynamics sequence begun in [EGM 3400](#) plus extended coverage of three-dimensional rigid-body dynamics and orbital motion.

Prereq: [EGM 2511](#) or EGM 2500, and [MAC 2313](#)

EGM 3520 Mechanics of Materials**3 Credits**

Stress and strain at a point, stress-strain-temperature relations and mechanical properties of materials. Systems subject to axial load, torsion and bending. Design concepts, indeterminate structures and applications.

Prereq: [EGM 2511](#) (not EGM 2500) and [MAC 2313](#)

EGM 4313 Intermediate Engineering Analysis**3 Credits**

Ordinary differential equations, systems of ordinary differential equations, partial differential equations, Fourier series and complex analysis. Also includes equations of heat conduction, wave propagation and Laplace.

Prereq: [MAP 2302](#) and [EGM 3344](#)

EGM 4590 Biodynamics**3 Credits**

Dynamic analysis of the human musculoskeletal system. Includes development of lumped mass, planar rigid body and 3-D rigid body models of human movement. Also includes calculation of internal forces in muscles and joints and analysis of muscle function using dynamics principles and musculoskeletal geometry.

Prereq: [EGM 3400](#) or [EGM 3401](#), or instructor permission

EGM 4592 Bio-Solid Mechanics**3 Credits**

Introduction to solid and fluid mechanics of biological systems. Includes rheological behavior of materials subjected to static and dynamic loading, the mechanics of cardiovascular, pulmonary and renal systems, and the mathematical models and analytical techniques used in biosciences.

Prereq: [EGM 3520](#)

EGM 4853 Bio-Fluid Mechanics and Bio-Heat Transfer**3 Credits**

A study of biothermal fluid sciences with an emphasis on the physiological processes occurring in human blood circulation and the underlying mechanisms from an engineering prospective.

Prereq: [EGN 3353C](#)

EGN 3353C Fluid Mechanics**3 Credits**

Statics and dynamics of incompressible fluids. Application to viscous and inviscid flows. Dimensional analysis. Compressible flow.

Prereq: [MAC 2313](#), [EGM 2511](#) and [EML 3100](#), or [EML 3007](#)

EML 2023 Computer Aided Graphics and Design**3 Credits**

Sketching, descriptive geometry, computer graphics, computer aided drafting and design projects.

EML 3100 Thermodynamics**3 Credits**

Application of the first and second laws of thermodynamics to closed and open systems and to cyclic heat engines. Includes the development of procedures for calculating the properties of multiphase and single-phase pure substances.

Prereq: [CHM 2045](#), [MAC 2313](#) and [PHY 2048](#)

EML 3301C Mechanics of Materials Laboratory**3 Credits**

Experimental characterization of the mechanical properties of engineering materials, precision instruments, computer-based data acquisition, statistical uncertainty analysis, preparation of engineering reports. (WR)

Prereq: [EGM 3520](#), [EGM 3344](#), and [ENC 2210](#) or [ENC 3254](#) WR6

EML 4140 Heat Transfer**3 Credits**

Steady state and transient analysis of conduction and radiation heat transfer in stationary media. Also discusses heat transfer in fluid systems, including forced and free convection.

Prereq: [MAP 2302](#) with minimum grade of C and [EAS 4101](#) or [EGN 3353C](#)

EML 4147C Thermo-Heat Transfer Design and Laboratory**3 Credits**

Thermodynamics and heat transfer integrated with design and laboratory, including heat exchange design, phase-change heat transfer, thermodynamics of mixtures, psychometry, mass transfer and sensible heat recovery.

Prereq: [EML 3100](#), [EML 3301C](#) and [EML 4140](#)

EML 4220 Vibrations**3 Credits**

Single and multiple degree of freedom systems, including application to mechanical systems with problems employing computer techniques.

Prereq: [EGM 3344](#), [EGM 3401](#), [EGM 3520](#) and [MAP 2302](#) with minimum grades of C

EML 4304C Thermo/Fluid Design and Laboratory**3 Credits**

Design and laboratories for turbomachinery, compressible flow, chemical reactions and thermodynamic cycles.

Prereq: [EGN 3353C](#), [EML 3100](#) and [EML 3301C](#)

EML 4312 Control of Mechanical Engineering Systems**3 Credits**

Theory, analysis and design of control systems, including mechanical, electromechanical, hydraulic, pneumatic and thermal components and systems.

Prereq: [EGM 3401](#), [EGM 3344](#) and [MAP 2302](#) with minimum grades of C

EML 4314C Dynamics and Controls System Design Laboratory**3 Credits**

Experiments on dynamic systems in mechanical and aerospace engineering and design of relevant control systems.

Prereq: [EML 3301C](#) and [EML 4312](#)

EML 4321 Manufacturing Engineering**3 Credits**

Descriptive and analytical treatment of manufacturing processes and production equipment automation computer control and integrated systems. Applications of mechanics stress analysis vibrations controls heat transfer. Discrete time simulation.

Prereq: [EMA 3010](#), [EML 2322L](#), and [EGM 3520](#) with minimum grade of C

EML 4410 Combustion Engineering**3 Credits**

Fundamentals of combustion processes and systems; including thermochemistry, rates and mechanisms, pollutant analysis, premixed and diffusion flames and applications to engines and turbomachinery.

EML 4450 Energy Conversion**3 Credits**

Thermomechanical and thermoelectric energy conversion, conventional and unconventional techniques and analysis of energy systems interactions.

EML 4500C Reengineering Historic Machinery**3 Credits**

Studies historic commercial machine or vehicle, including theory of operation, embedded engineering principles, and design. Reengineering and design of enhancements. Laboratory includes disassembly, observation of characteristics and conditions, implementation of enhancements, and rebuilding.

Prereq: [EML 2322L](#), [EML 3005](#), and [EML 3100](#) with minimum grade of C

EML 4507 Finite Element Analysis and Design**3 Credits**

Stress-strain analysis and design of machine elements and finite element analysis.

Prereq: [EGM 3344](#), [EGM 3520](#) and [MAP 2302](#) with minimum grades of C

EML 4600 Refrigeration and Air Conditioning Fundamentals**3 Credits**

Fundamentals of refrigeration theory, vapor compression and absorption, refrigeration components and systems, psychrometric theory, analysis of cooling and dehumidifying coils.

Prereq: [EML 3100](#)

EML 4601 Heating and Air Conditioning System Design**3 Credits**

Heating and air conditioning systems: equipment selection, system arrangement, load calculations, advanced psychrometrics, duct and piping system design, air distribution system design and indoor air quality.

Prereq: [EML 3100](#)

EML 4737 Hydronics and Pneumatics for Building Systems**3 Credits**

Applications, design, maintenance and operations of various pneumatic, hydronic and other process systems. Includes in-depth design concepts and techniques as well as preparation of specifications and cost estimates.

Prereq: [EGN 3353C](#)

EML 4738 Hydraulic and Mechanical Power Transmission**3 Credits**

Transmission of power in machines by hydraulic and mechanical means, including analytical design of components and their functions.

Prereq: EML 3005C

NUCLEAR AND RADIOLOGICAL ENGINEERING

ENU 4001 Nuclear Engineering Analysis 1

4 Credits

Four one-hour lectures discussing continuous and discrete variable solution methods for the statistical, algebraic, differential and integral equations important in nuclear engineering. Problems involving neutron, photon, fluid and temperature distributions in configuration, time and velocity are mathematically modeled, solved and interpreted.

Prereq: [MAP 2302](#) **Coreq:** [COP 2271](#)

ENU 4103 Reactor Analysis and Computation 1: Statics

4 Credits

Three one-hour lectures discussing neutron reactions, fission chain and criticality and neutron transport/diffusion for nuclear reactors. Neutron thermalization and thermal scattering kernels. Dynamic analysis of reactors including point and space-time models. Feedback and reactor dynamics and control. Short-term transient analysis and long-term time-dependence.

Prereq: [ENU 4001](#) and [ENU 4605](#) with minimum grades of C

ENU 4104 Reactor Analysis and Computation 2: Dynamics

3 Credits

A continuation of [ENU 4103](#). Three one-hour lectures discussing neutron thermalization and thermal scattering kernels. Treatment of resonances and Doppler broadening. Dynamic analysis of reactors including point model and space-time models. Feedback and reactor dynamics and control. Short-term transient analysis and long-term time dependence.

Prereq: [ENU 4103](#)

ENU 4133 Reactor Thermal Hydraulics 1

3 Credits

Fundamentals of thermodynamics, fluid mechanics and heat transfer with application to design and safety of nuclear power plants. Thermal hydraulic characteristics of nuclear power plants, energy conversion cycles, applications of first and second law of thermodynamics, nuclear heat generation, fluid mechanics, conservation laws and governing equations for inviscid and viscous single-phase flow, conduction and convection heat transfer and thermal design of fuel elements.

Prereq: [EML 3100](#)

ENU 4134 Reactor Thermal Hydraulics

4 Credits

Nuclear applications of fluid mechanics, heat transfer and thermodynamics. Two-phase flow and boiling heat transfer. Heat transfer mechanisms in reactor core and sub-channel thermal hydraulics. Steam generator, power cycles, and balance of plant. Introduction to thermal design for reactors.

Prereq: [EML 4140](#), and [ENU 4133](#) or [EGN 3353C](#)

ENU 4144 Nuclear Power Plant Reactor Systems 1

3 Credits

Three one-hour lectures discussing the basis for light water reactor (LWR) design; the NRC design criteria for LWRs. Study of the major systems, components and performance characteristics of LWRs including fuels, primary and secondary coolant systems, emergency and auxiliary systems.

Prereq: [EML 3100](#), [ENU 4605](#) and [ENU 4001](#) with minimum grades of C

ENU 4145 Risk Assessment for Radiation Systems**3 Credits**

Three one-hour lectures discussing the study of radiation management systems, including reliability and probabilistic risk assessment.

Prereq: [ENU 4144](#) and [STA 3032](#)

ENU 4194 Control of Nuclear Reactors and Power Plants**3 Credits**

Three one-hour lectures discussing the analysis of the control and dynamic characteristics of nuclear reactors, including the effects of feedback. Analysis of the control and dynamic characteristics of the integrated nuclear power plant.

Prereq: [ENU 4104](#)

ENU 4505L Nuclear and Radiological Engineering Laboratory 1**3 Credits**

Two one-hour lectures discussing experimental procedures used in reactor operation, personnel monitoring, radiation detection devices and the statistics of nuclear counting systems. Also includes a four-hour laboratory experience that integrates practical applications of radiation sources, radiation interactions, radiation transport and radiation detection. (WR)

Prereq: [ENU 4612](#) WR4

ENU 4605 Radiation Interactions and Sources 1**4 Credits**

Three one-hour lectures discussing interaction of ionizing radiation with matter; cross sections and radiation fields with emphasis on photons, heavy charged particles and electrons.

ENU 4606 Radiation Interactions and Sources 2**3 Credits**

Continuation of [ENU 4605](#). Three one-hour lectures discussing the study of photon-charged particle and electron interactions with matter, attenuation, energy transfer and energy absorption in matter. X-ray production, accelerators and neutron sources, and applications in nuclear and radiological engineering.

Prereq: [ENU 4001](#) with a minimum grade of C and [ENU 4605](#)

ENU 4612 Nuclear Radiation Detection and Instrumentation**3 Credits**

Three one-hour lectures discussing the physics and electronics of radiation detection and instrumentation systems for application to nuclear energy, radiological sciences, radiation protection, medical physics and imaging, and industrial safety and control systems.

Prereq: [ENU 4605](#) with a minimum grade of C and [EEL 3003](#)

ENU 4612L Nuclear Radiation Detection and Instrumentation Laboratory**1 Credit**

Laboratory experiments related to the physics and electronics of radiation detection and instrumentation systems for application to nuclear energy, radiological sciences, radiation protection, medical physics and imaging, and industrial safety and control systems.

Prereq: [ENU 4605](#) with a minimum grade of C and [EEL 3003](#) **Coreq:** [ENU 4612](#)

ENU 4630 Fundamental Aspects of Radiation Shielding**3 Credits**

Three one-hour lectures discussing basic principles of radiation shielding. Study of radiation sources and shielding design for radiation facilities.

Prereq: [ENU 4605](#) with a minimum grade of C

ENU 4641C Applied Radiation Protection**2 Credits**

Two one-hour lectures of introduction to practical radiation protection techniques and practices, including laboratory experiences. Examination of pertinent regulations, current practice, ethics and instrumentation/measurement practices. Design of facilities and controls to optimize benefits of radiation applications and minimize exposure risks. (WR)

Prereq: [ENU 4605](#) with a minimum grade of C and [ENU 4630](#) WR2

ENU 4800 Introduction to Nuclear Reactor Materials**3 Credits**

Provides a comprehensive knowledge on the types of materials used in nuclear reactors, their response to the reactor environments and most of the materials problems encountered in the operation of nuclear power reactors for energy production.

Prereq: [EMA 3010](#)

ENU 4934 Fundamentals of Nuclear and Radiological Engineering**1 Credit**

Presentations and discussions on topics of current and continuing interest in nuclear engineering sciences.

Prereq: junior/senior standing in NES

ENV 4212 Nuclear Power Radioactive Waste Technology**3 Credits**

Characterization and description of low and high level radwastes, regulatory requirements and method of treatment. Transportation, burial and surveillance of radwaste. Decommissioning of nuclear facilities.

Prereq: refer to the department

Advance level 3000/4000 Biological Science Courses (BSC, CHM, PCB or ZOO) and including CHM2046, CHM2210, CHM2211 and CHM2211L.

Department of Biology

College of Liberal Arts and Sciences

BOT 3151C Local Flora of North Florida

Credits: 3.

Laboratory observation of the gross features of vascular plants and practice in the use of keys to identify plants. Elementary ecology of principal types of plant communities in northern Florida. Field trips.

BOT 3503 Physiology and Molecular Biology of Plants

Credits: 3; Prereq: BOT 2010C or BSC 2005 or BSC 2010; and CHM 2046C. Coreq: BOT 3503L (laboratory may be taken in subsequent term).

The chemical organization, cellular organization, metabolism, nutrition, growth and molecular biology of the higher plants.

BOT 3503L Physiology and Molecular Biology of Plants Laboratory

Credits: 2; Coreq: BOT 3503.

Laboratory experiments to accompany BOT 3503.

BOT 4053 Practical Experience in Teaching Botany

Credits: 2; can be repeated with change in content or course up to 4 credits; Prereq: generally, senior standing with recommendations from two faculty members, including the course instructor.

Participation in teaching one 3000-level botany course with practical experience in instructional procedures, testing and grading, course and laboratory preparation and laboratory assistance.

BOT 4621 Plant Geography

Credits: 2; Prereq: BSC 2010/2010L and BSC 2011/2011L with minimum grades of C, or instructor permission.

Patterns in the distribution of plants around the earth and factors that influence plant geography. Topics include similarities of plant communities in different parts of the world, common distribution patterns among individual taxa, and methods for inferring biogeographic history and predicting future changes in plant distribution.

BOT 4650 Plant Symbiosis

Credits: 3; Prereq: BSC 2010/2010L and BSC 2011/2011L with minimum grades of C.

Examines the crucial role of symbioses in shaping the diversity of life. Topics include generalities among symbioses, origins and establishment of symbioses, and coevolution and cospeciation, as well as specifics of well-studied exemplars of bacterial, fungal, animal, and plant symbioses with plants.

BSC 3096 Human Physiology

Credits: 3; Prereq: CHM 2046 or CHM 1031 and either BSC 2011 or APK 2105C.

The functioning of human tissues, organs and organ systems, emphasizing the physical, chemical and mechanistic bases of normal physiology and the integrated function of the human body. Also introduces pathophysiological changes associated with human diseases.

BSC 3307C Climate Change Biology

Credits: 4; Prereq: BSC 2011 and BSC 2011L with minimum grades of C.

Climate change and its impacts on biological communities, feedbacks from the biosphere to the climate system and human impacts on the carbon cycle. Emphasis on the response of vegetation to climate change and rising atmospheric CO₂ concentrations and the role of terrestrial ecosystems in regulating climate via the carbon cycle.

BSC 3402 Theory and Practice in the Biological Sciences

Credits: 2.

Presents the scientific method, in its many formulations, from historical, philosophical and sociological perspectives. Explores generation and presentation of data, formulation of hypotheses and theories and dissemination of results. Also examines the ethical implication of biological research.

BSC 3422C Principles of the Biotechnology Industry

Credits: 2; Prereq: BSC 2011, BSC 2011L, CHM 2046 and CHM2046L.

Introduces practices, skills, and careers in the biotechnology industry; provides an applied understanding of regulatory compliance, product development, process development, manufacture, testing, and release-for-sale of biomedical products. Learn the profiles of major departments and participate in simulated departmental roles through lecture and hands-on laboratory applications.

BSC 3911 Entering Research in Biology

Credits: 1; Coreq: BSC 4910 or BOT 4905 or ZOO 4905 or IDH 4912

A seminar course to complement a student's mentored research experience. Must be taken concurrently with research credits. Students meet weekly to share their research experiences and to get feedback on the progress of their research projects.

BSC 4821C Evolutionary Biogeography

Credits: 3; Prereq: BSC 2011 and BSC 2011L with minimum grades of C.

How to interpret biological data sets in a biogeographical context. Topics and methods in historical and ecological biogeography are discussed.

ISC 3523 Integrative Biomedical Science

Credits: 3; Prereq: BSC 2011, and CHM 2211 or CHM 2213 or CHM 3217, and PHY 2048 or PHY 2053 or PHY 2060, and MAC 2311 or STA 2023, and PSY 2012 or SYG 2000.

Introduces biomedical science as the application of the natural sciences to medicine. Focuses on integration of biological and biochemical sciences, chemical and physical sciences, and social and behavioral sciences in the context of health. Activities promote skills in problem-solving, critical analysis, and quantitative reasoning.

PCB 3023 Essential Cell Biology

Credits: 3; Prereq: BSC 2011 and BSC 2011L, or equivalent.

Introduces the basic concepts of molecular cell biology in prokaryotic and eukaryotic systems including experimental strategies and methodology. This course is intended for those interested in plants.

PCB 3034C Introduction to Ecology

Credits: 4; Prereq: introductory college biology.

Basic principles of ecology as they apply to environmental problems including major terrestrial and aquatic ecosystems of Florida.

PCB 3063 Genetics

Credits: 4; Prereq: BSC 2011 and BSC 2011L, or equivalent, with minimum grades of C and general chemistry.

The fundamental properties of inheritance in eukaryotic organisms emphasizing examples in man. Basic concepts are developed for the nature, organization, transmission, expression, recombination and function of genetic materials and principles are derived for genetically characterizing populations.

PCB 3601C Plant Ecology

Credits: 3; Prereq: introductory college biology or botany.

Principles of ecology at scales ranging from individual plants to landscapes. Emphasis is on species, ecosystems and environmental programs in Florida.

PCB 3713C Cellular and Systems Physiology

Credits: 4; Prereq: BSC 2010 and CHM 2046, CHM 2047, CHM 2051, or CHM 2096 and PHY 2048 or PHY 2060, all with minimum grades of C; Coreq: PHY 2049 or PHY 2061.

How cells, organs and higher level systems are integrated and coordinated in the functions of humans and other animals. Emphasizes the use of model organisms, mathematical models and the physical sciences to understand the mechanistic basis of normal physiology and dysfunction.

PCB 4043C General Ecology

Credits: 4; Prereq: BSC 2011 and 2011L, or equivalent, with minimum grades of C.

Ecological processes and organization in terrestrial and aquatic habitats. Laboratory and field exercises emphasize techniques of ecological analysis.

PCB 4085 Genetical Ethics

Credits: 1; Prereq: PCB 3063 or AGR 3303.

Presentation and critical discussion of new genetic discoveries and discoveries in the context of society. Includes policy, historical, and legal perspectives. Covers responsible conduct of research.

PCB 4460 Biodiversity and Ecology Field Immersion

Credits: 4; Can be repeated with change in content up to 12 credits; Prereq: BSC 2010, BSC 2010L, BSC 2011 and 2011L.

Five-week intensive study of the earth's rich biodiversity. Emphasizes comparative study of form and function, and of complexity and diversity in phylogenetic and environmental contexts. Focuses on the study of living organisms in the laboratory and field in diverse habitats. Focal organisms and settings rotate according to instructor and semester.

PCB 4553 Population Genetics

Credits: 4; Prereq: BSC 2011 and 2011L with minimum grades of C.

Population and quantitative genetics, including the theory of gene frequency dynamics within and between populations, and deterministic and stochastic processes in evolution.

PCB 4674 Evolution

Credits: 4; Prereq: BSC 2011 and 2011L, or equivalent, with minimum grades of C; Coreq: one semester of calculus; PCB 3063 recommended.

Processes and mechanisms of evolution, including population genetics, speciation, patterns of evolution and molecular evolution.

PCB 4712 Comparative Biomechanics

Credits: 3; Prereq: BSC 2011 and 2011L, or equivalent, with minimum grades of C; PHY 2048, PHY 2053L, PCB 4674 and ZOO 3713C.

Reviews physical principles governing the form and function of organisms.

PCB 4723C Physiology and Molecular Biology of Animals

Credits: 5; Prereq: BSC2011, and CHM2046 or CHM2047. Recommended: PHY2053 and PHY2054, or PHY2060 and PHY2061, PCB3063, and PCB4674; all with a minimum grade of C or above.

Discusses the processes and mechanisms of maintenance, activity and integration in animals with emphasis on vertebrates. Laboratory experience in quantitative methods and techniques of physiological investigation.

PCB 4917 Molecular Biology Lab Immersion

Credits: 4; Can be repeated with change in content up to 12 credits; Prereq: BSC 2010, BSC 2010L, BSC 2011 and 2011L with minimum grades of B.

Perform authentic research employing techniques of molecular biology in an intensive 5 week format. Each semester the instructor chooses a general area of research and set of techniques for projects. Design hypotheses, plan and carry out experiments, and analyze data.

ZOO 3513C Animal Behavior

Credits: 4; Prereq: BSC 2011 and 2011L, or equivalent, with minimum grades of C, and PCB 4674.

The causes, origins and evolution of animal behavior emphasizing field observations and experiments on the behavior of a variety of animal groups.

ZOO 3603C Evolutionary Developmental Biology

Credits: 4; Prereq: BSC 2011 and 2011L, or equivalent, with minimum grades of C.

Analysis of embryonic development, underlying genetic mechanisms and how these processes have driven the evolutionary diversification of animal body plans.

ZOO 3713C Functional Vertebrate Anatomy

Credits: 4; Prereq: BSC 2011 and 2011L, or equivalent, with minimum grades of C.

The form and function of chordates accompanied by laboratory work dealing with a selected series of chordates.

ZOO 4205C Invertebrate Biodiversity

Credits: 4; Prereq: BSC 2011 and BSC 2011L with minimum grades of C.

Comparative biology of invertebrates, emphasizing morphology, evolution, ecology and life history.

ZOO 4307C Vertebrate Biodiversity

Credits: 4; Prereq: BSC 2011 and BSC 2011L with minimum grades of C.

Comparative biology of vertebrates, emphasizing morphology, evolution, ecology and behavior.

ZOO 4403C Marine Biology

Credits: 4; Prereq: BSC 2011 and 2011L, or equivalent, with minimum grades of C.

Survey of major marine taxa, systematics of local marine fauna and flora, with familiarization of the marine environment. Laboratory emphasizes field work and independent projects.

ZOO 4472C Avian Biology

Credits: 4; Prereq: BSC 2011 and 2011L, or equivalent, with minimum grades of C, and PCB 4674 (recommended).

The basic biological characteristics of birds, which, as exceptionally unique flying vertebrates, are confronted with a spectrum of problems in terms of anatomy, physiology, behavior, migration and population ecology.

Biochemistry

CHM 2210 Organic Chemistry 1

Credits: 3; Prereq: CHM 2046 and CHM 2046L, or the equivalent.

The first half of the CHM 2210/2211 sequence intended for majors and preprofessional students. A study of the structures, syntheses and reactions of organic compounds.

CHM 2211 Organic Chemistry 2

Credits: 3; Prereq: CHM 2210 with a minimum grade of C; Coreq: CHM 2211L.

The second half of the CHM 2210/2211 sequence intended for majors and preprofessional students. A study of the structures, syntheses and reactions of organic compounds.

CHM 2211L Organic Chemistry Laboratory

Credits: 2; Coreq: CHM 2211 or CHM 3218.

Organic laboratory experiments designed to accompany CHM 2210/2211 or CHM 3217/3218.

CHM 3120 Introduction to Analytical Chemistry

Credits: 3; Prereq: CHM 2046 or CHM 2047 or CHM 2051, and CHM 2046L or 2047L.

Principles involved in quantitative analysis. Topics include acid-base equilibria and titrations, precipitation and complex formation, oxidation reduction and statistical treatment of data. Introduces spectrochemical and electrochemical methods of analysis and chemical separations.

CHM 3120L Analytical Chemistry Laboratory

Credits: 1; Prereq or Coreq: CHM 3120 or equivalent.

Laboratory experiments designed to accompany CHM 3120.

CHM 3217 Organic Chemistry/Biochemistry 1

Credits: 4; Prereq: CHM 2046 or CHM 2047 or CHM 2051; CHM 2046L or CHM 2047L, or instructor permission.

A rigorous, one-semester overview of the structure, properties and reactions of organic compounds. This is the first half of a two-semester sequence in biochemistry. Students are expected to take CHM 3218 after completing CHM 3217.

CHM 3218 Organic Chemistry/Biochemistry 2

Credits: 4; Prereq: CHM 3217 or CHM 2211, or instructor permission.

Introduces the basic concepts of biochemistry and molecular biology from the structural and mechanistic perspective of organic chemistry.

CHM 3400 Physical Chemistry for the Biosciences

Credits: 3; Prereq: MAC 2312 and CHM 2200 or CHM 2210, and two semesters of college physics; background in analytical chemistry recommended.

Thermodynamics, electrochemistry, transport, chemical kinetics and molecular structure with emphasis on biological systems.

CHM 3610 Inorganic Chemistry

Credits: 3; Prereq: CHM 2211 and 2211L, or the equivalent.

Basic theoretical concepts involved in inorganic chemistry. Periodic trends, chemical bonding, structure and reactivity.

CHM 3610L Inorganic Chemistry Laboratory

Credits: 2; Prereq: CHM 2211L and CHM 3120L, or instructor permission.

Synthesis and characterization of inorganic and organometallic compounds.

CHM 4034 Advanced Biochemistry and Chemical Biology

Credits: 4; Prereq: CHM 3218 or BCH 4024.

Secondary metabolism and biosynthetic pathways, bioinorganic chemistry, protein folding and trafficking, cellular signaling, replication and translation from a chemist's perspective. Applications in bioanalytical chemistry and in molecular and cell biology.

CHM 4130 Instrumental Analysis

Credits: 3; Prereq: CHM 2211, CHM 3120, MAC 2312 and PHY 2053 with minimum grades of C; Coreq: PHY 2054 or equivalent.

Concepts of instrumentation for chemical analysis. In-depth examination of spectrochemical and electrochemical methods and chemical separations.

CHM 4130L Instrumental Analysis Laboratory

Credits: 2; Prereq: CHM 2211, CHM 3120, CHM 3120L, MAC 2053 and PHY 2053 with minimum grades of C; Coreq: CHM 4130.

Laboratory experiments designed to accompany CHM 4130.

CHM 4143C Electronics and Instrumentation

Credits: 3; Prereq: CHM 4130, or CHM 3400 and CHM 4413L or permission of instructor.

Principles of operation of instrumentation, optimization of instrumental conditions, and interpretation of instrumental data for qualitative and quantitative analysis. Application of electronic principles necessary to code for automated electronic measurements in chemical research.

CHM 4230 Organic Spectroscopy

Credits: 2; Prereq: CHM 2211.

Characterization and identification of organic compounds by spectral methods including IR, UV, NMR and mass spectrometry.

CHM 4272 The Organic Chemistry of Polymers

Credits: 2; Prereq: CHM 2200, CHM 2211, CHM 2213 and CHM 3217, or the equivalent.

Classification of polymerization types and mechanisms from a mechanistic/organic point of view. The structure of synthetic and natural polymers and polyelectrolytes. Reactions of polymers and practical synthetic methods of polymer preparation.

CHM 4300L Laboratory in Biochemistry and Molecular Biology

Credits: 2; Prereq: CHM 2211L and either CHM 3218, or CHM 2211 and BCH 4024.

Introduces experimental techniques in biochemistry, especially those used in DNA isolation and manipulation, protein purification and enzyme kinetic studies.

CHM 4304 Chemical Aspects of Cellular Control

Credits: 3; Prereq: either CHM 3218, or CHM 2211 and BCH 4024.

Control of information, materials and energy within cellular systems. Examples taken from the biochemistry of plants, bacteria and higher organisms.

CHM 4308 Introduction to Enzyme Mechanism

Credits: 3; Prereq: BCH 4024 or CHM 3218; Coreq: CHM 3400 or CHM 4411.

Principles of enzyme structure, isolation and purification and principles of the physical chemistry of enzyme/substrate interactions. Overview of concepts of biological catalysis, including transition state theory, descriptions and examples of mechanisms of biochemical catalysis, survey of co-factors, and catalytic antibodies, ribozyme structure and catalysis.

CHM 4411 Physical Chemistry - Thermodynamics and Kinetics

Credits: 4; Prereq: one year of general chemistry and one year of physics; Coreq: MAC 2313; background in analytical and organic chemistry recommended.

Gas laws, kinetic theory, classical and statistical thermodynamics and applications to solutions, phase equilibria, chemical equilibria and electrochemistry.

CHM 4411L Physical Chemistry Laboratory

Credits: 2; Prereq: CHM 3120L; Coreq: CHM 4411.

A series of laboratory experiments designed to accompany CHM 4411.

CHM 4412 Physical Chemistry - Chemical Bonding and Spectroscopy

Credits: 4; Prereq: One year of general chemistry or the equivalent (CHM 2045 and CHM 2046 OR CHM 2046C OR CHM 2047 OR CHM 2051 OR CHM 2096) and one year of general physics or the equivalent (PHY 2048 and PHY 2049 OR PHY 2049C OR PHY 2053 and PHY 2054 OR PHY 2061) with minimum grades of C; Coreq: MAC 2313.

Introduces quantum theory, atomic and molecular structure, chemical bonding and spectra, chemical reaction rate laws and mechanisms, and statistical and collision theories of reaction rates.

CHM 4413L Biophysical Chemistry Laboratory

Credits: 2; Prereq: CHM 2211L and CHM 3120L; Coreq: CHM 3400 or CHM 4413.

Laboratory experiments to demonstrate basic concepts of the physical chemistry of biological systems.

CHM 4611 Advanced Inorganic Chemistry

Credits: 3; Prereq: CHM 3120 and CHM 3610; Coreq: CHM 4412.

Introduces advanced concepts of modern inorganic chemistry. Major themes include application of group theory to structure and bonding, molecular orbital treatment of reactivity, fundamental organometallic chemistry and introduces vibrational and electronic spectroscopy.

CHM 4671 Bioinorganic Chemistry

Credits: 3; Prereq: CHM 3610 or CHM 3218 or BCH 4024 or MCB 3020 or MCB 3023 or BSC 2011 and CHM 2211 or CHM 2213 or CHM 3217, or instructor permission.

From an inorganic perspective, introduces the structure and function of a variety of metalloproteins and metalloenzymes, concentrating on systems containing transition metals. Emphasizes the role that metal ion(s) play in the function of the biomolecules.

Biochemistry & Molecular Biology

BCH 4024 Introduction to Biochemistry and Molecular Biology

Credits: 4; Prereq: CHM 2211 or CHM 3217, or instructor permission.

Introduces physical biochemistry, intermediary metabolism and molecular biology. Topics include a survey of structure, chemistry and function of proteins and nucleic acids, enzyme kinetics and mechanisms of catalysis; a survey of the pathways of carbohydrate, lipid and nitrogen metabolism and their metabolic control; regulation of gene expression at the level of DNA, RNA and protein synthesis.