

ENGINEERING SCIENCE AND MECHAN (ESM)

ESM 2014 - Professnl Dvlpmnt Seminar ESM (1 credit)

Topics designed to foster the professional development of the ESM student. ESM program objectives and outcomes. Professional careers, employment opportunities, expectations to the profession. Technical concentration within the ESM major. Ethical decision-making, safe and life-long learning.

ESM 2074 - Computational Methods (2 credits)

Solving engineering problems using numerical methods and software, truncation and round-off error, root finding, linear and polynomial regression, interpolation, splines, numerical integration, numerical differentiation, solution of linear simultaneous equations. A grade of C- or better required in the prerequisite.

Prerequisite(s): ENGE 1216 or ENGE 1434 or ENGE 1414

Cross-listed: AOE 2074

ESM 2104 - Statics (3 credits)

Vector mechanics of forces and moments, free-body diagrams, couples, resultants, equilibrium of particles and rigid bodies in two and three dimensions, forces in trusses, frames, and machines, centroids, centers of mass, distributed forces, internal shear forces and bending moments in beams, shear and moment diagrams, friction, belt friction, area of moments of inertia, parallel axis theorem. Course requirements may be satisfied by taking MATH prerequisite prior to or concurrent with course.

Prerequisite(s): MATH 1226

Corequisite(s): MATH 2204 or MATH 2204H or MATH 2224 or MATH 2406H

ESM 2114 - Statics & Structures (3 credits)

Vector algebra of forces, movements, couples and resultants. Free-body diagrams. Equilibrium of particles and rigid bodies in two and three dimensions. Friction. Forces in trusses and frames. Centroids, centers of mass, area moments of inertia. Internal axial forces, shear forces, and bending moments in bars in beams. Shear and moment diagrams. Stress and strain in bars in beams.

Corequisite(s): MATH 2204 or MATH 2204H or MATH 2406H.

ESM 2204 - Mechanics of Deformable Bodies (3 credits)

Concepts of stress, strain, and deformation. Factor of safety. Stress-strain relationships and material properties. Stress concentrations. Area moments of inertia. Axially loaded members, torsionally loaded members, bending of beams. Shear and moment diagrams. Stresses due to combined loading. Thin-walled pressure vessels. Transformation of stress including Mohr's circle. Beam deflections and buckling stability.

Prerequisite(s): (ESM 2104 or ESM 2114) and (MATH 2224 or MATH 2224H or MATH 2204 or MATH 2204H)

ESM 2214 - Statics and Mechanics of Materials (3 credits)

Forces, moment, resultants, and equilibrium. Stress, strain, and stress-strain relations. Centroids and distributed loads. Analysis of axially loaded bars and beams. Principal stresses and Mohr's circle, combined loading. Pressure vessels and buckling of columns. Partially duplicates 2104 and 2204. Must be CHE major.

Corequisite(s): MATH 2224

ESM 2304 - Dynamics (3 credits)

Vector treatment of the kinematics and kinetics of particles and rigid bodies, Newton's laws, work and energy, impulse and momentum, impact, mass moments of inertia, rotating axes.

Prerequisite(s): (ESM 2104 or ESM 2114) and (MATH 2224 or MATH 2224H or MATH 2204 or MATH 2204H)

Corequisite(s): MATH 2214

ESM 2974 - Independent Study (1-19 credits)

ESM 2984 - Special Study (1-19 credits)

ESM 2994 - Undergraduate Research (1-19 credits)

ESM 2994H - Undergraduate Research (1-19 credits)

ESM 3024 - Introduction to Fluid Mechanics (3 credits)

Fluid properties. Hydrostatics. Derivation and application of the mass, momentum, and energy conservation equations. Dimensional analysis and similitude. Introduction to analyses of pipe flows and piping systems, open channel flows, and fluid forces on solid bodies.

Prerequisite(s): ESM 2304

ESM 3034 - Fluid Mechanics Laboratory (1 credit)

Introduction to experimental fluid mechanics. Dimensional analysis. Experiments on fluid properties, flow measurements, and flow visualization, including manometry, determining hydrostatic forces on submerged surfaces, applications of the impulse-momentum principle, velocity measurements, measuring drag forces, quantifying flow in channels. Modern data acquisition techniques.

Prerequisite(s): ESM 2304 and ECE 3054

Corequisite(s): ESM 3234

ESM 3054 - Mechanical Behavior of Materials (3 credits)

Mechanical properties and behavior of solid materials subjected to static, cyclic, and sustained loads resulting from stress states, environments, and stress histories typical of service conditions; multiaxial failure criteria; behavior of cracked bodies; fatigue of materials; creep of materials; microstructure-property relationships; design methodologies.

Prerequisite(s): ESM 2204 and (MSE 2034 or MSE 2044 or MSE 3094 or AOE 3094 or CEE 3684)

Cross-listed: MSE 3054

ESM 3064 - Mechanical Behavior of Materials Laboratory (1 credit)

Laboratory experiments on behavior and mechanical properties of solid materials. Tension, compression, bending, hardness, nano-indentation, and impact tests; behavior of cracked bodies; fatigue and crack growth tests; creep deformation; microstructure-property relationships; laboratory equipment, instrumentation, and computers.

Prerequisite(s): ESM 2204

Corequisite(s): ESM 3054

Cross-listed: MSE 3064

ESM 3114 - Problem Definition and Scoping in Engineering Design (1 credit)

Define open-ended engineering design projects, identify relevant broad social, global, economic, cultural and technical needs and constraints, determine ways in which technical skills contribute to addressing complex engineering design challenges. Identify a capstone project for ESM 4015-4016. Pre-requisite: Junior standing in ESM.

Prerequisite(s): ESM 2014

ESM 3124 - Dynamics II- Analytical and 3-D Motion (3 credits)

Review of Newtons Laws, introduction to Lagranges equations, rotating coordinate systems, particle dynamics, systems of particles, rigid-body dynamics, small amplitude oscillations, holonomic and nonholonomic constraints, phase space and energy methods.

Prerequisite(s): ESM 2304 and MATH 2214 and (MATH 2224 or MATH 2204 or MATH 2204H)

ESM 3134 - Dynamics III - Vibration and Control (3 credits)

Single-degree-of-freedom vibration, n-degree-of-freedom systems, continuous systems, nonlinear systems, system stability, introduction to the feedback control of dynamic systems.

Prerequisite(s): ESM 3124 and MATH 4564

ESM 3154 - Solid Mechanics (3 credits)

Introduction to tensors, mathematical description of deformations and internal forces in solids, equations of equilibrium, principle of virtual work, linear elastic material behavior, solution for linear elastic problems including axially and spherically symmetric solutions, stress function solutions to plane stress and strain problems, solutions to 3-D problems, energy methods.

Prerequisite(s): ESM 2204 and (MATH 2214 or MATH 2214H)

Corequisite(s): MATH 4574

ESM 3234 - Fluid Mechanics I-Control Volume Analysis (3 credits)

Fluid statics. Control volume approach to flow analysis: conservation laws, pipe flows, compressible flow, open channel flow.

Prerequisite(s): ESM 2304 and PHYS 2306

ESM 3334 - Fluid Mechanics II-Differential Analysis (3 credits)

Introduction to continuum mechanics for fluid systems. Fluid kinematics. Differential approach to flow analysis: conservation equations, exact solutions, potential flows, viscous flows.

Prerequisite(s): ESM 3234 or ME 3404

Corequisite(s): MATH 4574

ESM 3444 - Mechanics Laboratory (2 credits)

Concepts in instrumentation, data acquisition, and signal analysis. Measurements of mechanics quantities and phenomena associated with solid, fluid, and dynamical systems. Open-ended problem definition and approach formulation. Application and synthesis of engineering mechanics fundamentals to the modeling and solution of open-ended problems. Group-working skills and effective written and oral communication.

Prerequisite(s): ESM 3234 and ESM 3034 and ESM 3054 and ESM 3064 and ESM 3124 and ECE 3054

Corequisite(s): ESM 3134, ESM 3154, ESM 3334

ESM 3704 - Basic Principles of Structures (3 credits)

Static equilibrium of forces and moments, concurrent and nonconcurrent force systems, center of gravity, concentrated and distributed loads.

Solution of trusses. Stress and strain, elastic behavior of materials, cables and arches, shear, bending, and deformation in beams, indeterminate structures. Not available to students in engineering.

ESM 4014 - Applied Fluid Mechanics (3 credits)

Analysis of flow over practical configurations, panel methods, Reynolds-averaged Navier-Stokes equations, turbulent boundary layers, flow separation and three-dimensional effects. Unsteady flows, fluid-structure interactions.

Prerequisite(s): ESM 2074 and ESM 3016

ESM 4015 - Creative Design and Project (3 credits)

Capstone senior design project. Synthesis and application of fundamental principles of engineering science and mechanics to an open-ended problem. 4015: Project proposal, including objectives, goals and plans for project. Identification of needs, constraints, and engineering standards with consideration of public health, safety, and welfare, including ethical, global, cultural, societal, environmental, and economic contexts. Proof-of-concept prototyping. Teamwork and communication of design and project progress. 4016: Design specifications with consideration of public health, safety, and welfare, as well as ethical, global, cultural, social, environmental, and economic factors where applicable. Design, test, and analysis of functional prototype. Teamwork and communication of design and project progress. Pre: Senior standing.

Prerequisite(s): ESM 3114

Pathway Concept Area(s): 1A Discourse Advanced, 10 Ethical Reasoning

ESM 4016 - Creative Design and Project (3 credits)

Capstone senior design project. Synthesis and application of fundamental principles of engineering science and mechanics to an open-ended problem. 4015: Project proposal, including objectives, goals and plans for project. Identification of needs, constraints, and engineering standards with consideration of public health, safety, and welfare, including ethical, global, cultural, societal, environmental, and economic contexts. Proof-of-concept prototyping. Teamwork and communication of design and project progress. 4016: Design specifications with consideration of public health, safety, and welfare, as well as ethical, global, cultural, social, environmental, and economic factors where applicable. Design, test, and analysis of functional prototype. Teamwork and communication of design and project progress. Pre: Senior standing.

Prerequisite(s): ESM 4015

Pathway Concept Area(s): 1A Discourse Advanced, 10 Ethical Reasoning

ESM 4024 - Advanced Mechanical Behavior of Materials (3 credits)

Mechanical behavior of materials, emphasizing solid mechanics aspects and methods for predicting strength and life of engineering components. Plasticity, failure criteria, fracture mechanics, crack growth, strain-based fatigue, and creep. Microstructure-property relationships, and laboratory demonstrations.

Prerequisite(s): ESM 3054 or MSE 3054

ESM 4044 - Mechanics of Composite Materials (3 credits)

Introduction to the deformation, stress, and strength analysis of continuous-fiber-polymer-matrix laminated composites. Fabrication, micromechanics of stiffness and expansional coefficients, classical lamination theory (CLT). Environmentally induced stresses. Computerized implementation and design.

Prerequisite(s): ESM 2204 or AOE 2024

Cross-listed: CEE 4610

ESM 4084 - Engineering Design Optimization (3 credits)

Use of mathematical programming methods for engineering design optimization including linear programming, penalty function methods, and gradient projection methods. Applications to minimum weight design, open-loop optimum control, machine design, and appropriate design problems from other engineering disciplines.

Prerequisite(s): MATH 2224 or MATH 2204 or MATH 2204H

Cross-listed: AOE 4084

ESM 4105 - Engineering Analysis of Physiologic Systems (3 credits)

Engineering analysis of human physiology. Physiologic systems are treated as engineering systems with emphasis input-output considerations, system interrelationships and engineering analogs. 4105 - Mass and electrolyte transfer, nerves, muscles, renal system. 4106 - cardiovascular mechanics, respiratory system, digestive systems, senses.

Prerequisite(s): ESM 2304 and MATH 2214

ESM 4106 - Engineering Analysis of Physiologic Systems (3 credits)

Engineering analysis of human physiology. Physiologic systems are treated as engineering systems with emphasis input-output considerations, system interrelationships and engineering analogs. 4105 - Mass and electrolyte transfer, nerves, muscles, renal system. 4106 - cardiovascular mechanics, respiratory system, digestive systems, senses.

Corequisite(s): ME 3105

ESM 4114 - Nonlinear Dynamics and Chaos (3 credits)

Motion of systems governed by differential equations: stability, geometry, phase planes, bifurcations, Poincare sections, point attractors, limit cycles, chaos and strange attractors, Lyapunov exponents. Forced, nonlinear oscillations: jump phenomena, harmonic resonances, Hopf bifurcations, averaging and multiple-scales analysis. Systems governed by discrete maps: return maps, cobweb plots, period-multiplying bifurcations, intermittency, delay coordinates, fractal dimensions.

Prerequisite(s): (ESM 2304 or PHYS 2504) and (MATH 2214 or MATH 2214H)

Cross-listed: AOE 4514

ESM 4154 - Nondestructive Evaluation of Materials (3 credits)

Concepts and methods of nondestructive evaluation of materials. Discussion of techniques and mathematical bases for methods involving mechanical, optical, thermal, and electromagnetic phenomena; design for inspectability; technique selection criteria; information processing and handling; materials response measurement and modeling; signal analysis.

Prerequisite(s): ESM 3054 and (PHYS 2206 or PHYS 2306)

ESM 4194 - Sustainable Energy Solutions for a Global Society (3 credits)

Addresses energy metrics, global and US energy supply and demand, transitional energy sources (natural gas, petroleum, coal, nuclear), sustainable/renewable source (solar, geothermal, hydro, tidal, wind, biofuels), and methods for increasing efficiencies (energy storage, batteries, green building, conservation). Options for transportation, electricity, lighting and heating needs of industry, agriculture, community, and citizens. Production, transmission, storage, and disposal issues considered in the context of global political, economic, and environmental impacts. Senior Standing in major may be substituted for pre-requisite ENGL 3764.

Prerequisite(s): (CHEM 1035 or CHEM 1055) and PHYS 2306

Cross-listed: ME 4194

ESM 4204 - Musculoskeletal Biomechanics (3 credits)

Skeletal anatomy and mechanics. Muscle anatomy and mechanics. Theory and application of electromyography. Motion and force measuring equipment and techniques. Inverse dynamics modeling of the human body. Current topics in musculoskeletal biomechanics research.

Prerequisite(s): ESM 2304 and (CS 1044 or CS 1064 or CS 1114 or AOE 2074 or ESM 2074 or ME 2004)

ESM 4224 - Biodynamics and Control (3 credits)

Study of human movement dynamics and neuromuscular control of multi-degree-of-freedom systems. Computational simulation of forward-dynamics and state-space linear control of human movement to investigate functional performance and neuromuscular pathology.

Prerequisite(s): ESM 2304

ESM 4234 - Mechanics of Biological Systems (3 credits)

Anatomy and physiology of biological systems such as cells, tissues, and organs. Experimental techniques for determining the mechanical behavior of biological systems. Simplified mechanics-based mathematical models of biological systems. Specific biological systems include cells, tissues, and organs of the musculoskeletal, cardiovascular, integumentary system, and reproductive systems.

Prerequisite(s): ESM 2204 and MATH 2214 and MATH 2114

Cross-listed: BMES 4234

ESM 4245 - Mechanics of Animal Locomotion (3 credits)

4245: Mechanical and biological principles of terrestrial animal locomotion, including walking, running, jumping, climbing, burrowing, and crawling. Terrestrial locomotion-based bio-inspired design. 4246: Mechanical and biological principles of animal locomotion in fluids, including active and gliding flight, swimming, jetting, and running on water. Engineering design inspired by fluid based biological locomotion.

Prerequisite(s): ESM 3054

ESM 4246 - Mechanics of Animal Locomotion (3 credits)

Mechanical and biological principles of of animal locomotion in fluids, including active and gliding flight, swimming, jetting, and running on water. Engineering design inspired by fluid-based biological locomotion.

Prerequisite(s): ESM 3234 or ME 3414

ESM 4304 - Hemodynamics (3 credits)

Study of the human cardiovascular system and blood flow. Anatomy and physiology of the human heart, vascular system, and its organization. Blood physiology and rheology. Non-Newtonian blood flow models. Steady and pulsatile blood flow in rigid and elastic arteries. Pressure waves in elastic arteries. Three-dimensional blood flow in the aortic arch and flow around heart valves.

Prerequisite(s): ESM 3334 or ME 3404 or ME 3414

ESM 4404 - Fundamentals of Professional Engineering (2 credits)

A refresher of basic principles and problem solving techniques involving twelve subject areas most common to all engineering curricula. The topics include those tested by the National Council of Engineering Examiners on the EIT (Engineer in Training) examination, the first requirement, in all fifty states, toward P.E. (Professional Engineer) licensing. Duplicates material of other engineering courses and impracticable for non-engineers, hence not usable for credit toward any degree. Pre: Junior and senior standing in Engineering or in Building Construction or Graduate students in Engineering.

ESM 4444 - Stability of Structures (3 credits)

Introduction to the methods of static structural stability analysis and their applications. Buckling of columns and frames. Energy method and approximate solutions. Elastic and inelastic behavior. Torsional and lateral buckling. Use of stability as a structural design criterion.

Prerequisite(s): AOE 3024 or CEE 3404

Cross-listed: AOE 4054

ESM 4614 - Probability-Based Modeling, Analysis, and Assessment (3 credits)

Uncertainty analysis of engineering data, parameters estimation, probability concepts, random variables, functions of random variables, probability-based performance functions and failure modes, risk and reliability functions, probability of failure and safety index, random sequences and stochastic processes, correlation functions and spectral densities, return period and extreme values, failure rates, performance monitoring and service life prediction.

Prerequisite(s): ESM 2204

Cross-listed: BMES 4614

ESM 4734 - An Introduction to the Finite Element Method (3 credits)

The finite element method is introduced as a numerical method of solving the ordinary and partial differential equations arising in fluid flow, heat transfer, and solid and structural mechanics. The classes of problems considered include those described by the second-order and fourth-order ordinary differential equations and second-order partial differential equations. Both theory and applications of the method to problems in various fields of engineering and applied sciences will be studied.

Prerequisite(s): (CS 3414 or MATH 3414 or AOE 2074 or ESM 2074) and (MATH 2224 or MATH 2224H or MATH 2204 or MATH 2204H)

Cross-listed: AOE 4024

ESM 4904 - Project and Report (1-19 credits)

ESM 4974 - Independent Study (1-19 credits)

ESM 4974H - Independent Study (1-19 credits)

ESM 4984 - Special Study (1-19 credits)

ESM 4994 - Undergraduate Research (1-19 credits)

ESM 4994H - Undergraduate Research (1-19 credits)

Honors