Engineering Mechanics

Administered by the Department of Aerospace Engineering

Undergraduate Study

The undergraduate courses in mechanics are intermediate between those in physics and mathematics and the professional and design courses of the several engineering curricula. In these courses the student is expected to acquire an understanding of the basic principles and analysis techniques pertaining to the static and dynamic behavior of rigid media, deformable solids, fluids, and gasses. Physical properties of engineering materials are studied in the classroom and are tested in the laboratory. General physical laws are given mathematical expression and are made suitable for use in the solution of specific problems in machine and structural design, and in the flow and measurement of fluids.

Graduate Study

The department offers graduate programs that lead to the degrees master of science, master of engineering, and doctor of philosophy with major in engineering mechanics, and minor work to students taking major work in other departments.

The master of science degree requires a thesis and a minimum of 8 research credits. It has strong research emphasis and is recommended for students who anticipate entering a doctoral program later. At least 30 credits of acceptable graduate work are required for the degree.

The master of engineering degree does not require either research credits or a thesis. However, at least two credits of acceptable creative component and at least 26 credits of acceptable graduate coursework are required. A minimum of 30 credits of acceptable graduate work is required for the degree. The program is intended to give students additional instruction at the graduate level to better qualify them for advanced professional engineering work. By careful selection of electives and perhaps additional courses during the senior undergraduate year, students should be able to qualify for the master of engineering degree with an additional year of full-time study after receiving their baccalaureate degree in one of the several engineering curricula.

Credits for creative component will be obtained by registering for E M 599 Creative Component. A written report and an oral presentation will be given to the student's graduate committee.

The normal prerequisite to major graduate work is the completion of a curriculum substantially equivalent to that required of undergraduate students in engineering at this university. However, because of the diversity of interests in graduate work in engineering mechanics, it is possible for a student to qualify for graduate study even though undergraduate or prior graduate training has been in a discipline other than engineering—e.g., physics or mathematics.

Courses primarily for undergraduates:

E M 274. Statics of Engineering.
(3-0) Cr. 3. F.S.SS. *Prereq: Credit or enrollment in MATH 166; credit or enrollment in PHYS 111 or PHYS 221*
Vector and scalar treatment of coplanar and noncoplanar force systems. Resultants, equilibrium, friction, centroids, second moments of areas, principal second moments of area, radius of gyration, internal forces, shear and bending moment diagrams.

E M 274H. Statics of Engineering: Honors.
(3-0) Cr. 3. F.S.SS. *Prereq: Credit or enrollment in MATH 166; credit or enrollment in PHYS 111 or PHYS 221*
Vector and scalar treatment of coplanar and noncoplanar force systems. Resultants, equilibrium, friction, centroids, second moments of areas, principal second moments of area, radius of gyration, internal forces, shear and bending moment diagrams.

E M 324. Mechanics of Materials.
(3-0) Cr. 3. F.S.SS. *Prereq: E M 274*
Plane stress, plane strain, stress-strain relationships, and elements of material behavior. Application of stress and deformation analysis to members subject to centric, torsional, flexural, and combined loadings. Elementary considerations of theories of failure, buckling. Nonmajor graduate credit.

E M 327. Mechanics of Materials Laboratory.
(0-2) Cr. 1. F.S.SS. *Prereq: Credit or enrollment in E M 324*
Experimental determination of mechanical properties of selected engineering materials. Experimental verification of assumptions made in 324. Use of strain measuring devices. Preparation of reports. Nonmajor graduate credit.

E M 345. Dynamics.
(3-0) Cr. 3. F.S.SS. *Prereq: E M 274, credit or enrollment in MATH 266 or MATH 267*
Particle and rigid body kinematics, Newton's laws of motion, kinetics of plane motion, rigid body problems using work-energy, linear, and angular impulse-momentum principles, vibrations. Nonmajor graduate credit.

E M 350. Introduction to Nondestructive Evaluation Engineering.
(3-0) Cr. 3. S. *Prereq: E M 324, MATH 266 or MATH 267, PHYS 222*
The physics of ultrasonic, eddy current, and x-ray testing. Introduction to linear system concepts, wave propagation, electromagnestics and radiation. Models of the generation, scattering and reception of waves in ultrasonics, the electrical impedance changes of eddy current testing, and image formation process for x-rays. Pattern recognition methods for the interpretation of measured responses. Nonmajor graduate credit.

E M 362. Principles of Nondestructive Testing.
(Cross-listed with MAT E). (3-0) Cr. 3. S. *Prereq: PHYS 112 or PHYS 222*
Radiography, ultrasonic testing, magnetic particle inspection, eddy current testing, dye penetrant inspection, and other techniques. Physical bases of tests; materials to which applicable; types of defects detectable; calibration standards, and reliability safety precautions. Nonmajor graduate credit.

E M 362L. Nondestructive Testing Laboratory.
(Cross-listed with MAT E). (0-3) Cr. 1. S. *Prereq: Credit or enrollment in MAT E 362*
Application of nondestructive testing techniques to the detection and sizing of flaws in materials and to the characterization of material's microstructure. Included are experiments in hardness, dye penetrant, magnetic particle, x-ray, ultrasonic and eddy current testing. Field trips to industrial laboratories. Nonmajor graduate credit.

E M 378. Mechanics of Fluids.
(2-2) Cr. 3. F.S.SS. *Prereq: E M 274*
Properties of fluids. Fluid statics. Kinematics and kinetics of fluid flow. Mass, momentum, and energy conservation laws; dimensional analysis; flow in pipes and channels. Selected laboratory experiments. Nonmajor graduate credit.

E M 417. Experimental Mechanics.
(Cross-listed with AER E). (2-2) Cr. 3. Alt. F., offered 2012. *Prereq: E M 324*
Introduction of different aspects of measuring deformation, strains, and stress for practical engineering problems. Strain gage theory and application. Selected laboratory experiments. Nonmajor graduate credit.

E M 424. Intermediate Mechanics of Materials.
(3-0) Cr. 3. F.S. *Prereq: E M 324*
Analysis of stresses, strains, and deflections. Torsion and bending of unsymmetrical members. Analysis of thick wall pressure vessels and shrink fit problems. Dynamic load effects, fatigue and fracture mechanics introduction. Work-strain energy methods. Nonmajor graduate credit.

E M 425. Introduction to the Finite Element Method.
(3-0) Cr. 3. S. *Prereq: E M 324, MATH 266 or MATH 267*
Introduction of finite element analysis through applications to one-dimensional, steady-state problems such as elastic deformation, heat and fluid flow, consolidation, beam bending, and mass transport. Transient heat conduction and wave propagation. Two-dimensional triangular and quadrilateral elements. Plane problems of torsion, thermal and potential flow, stress analysis. Simple computer programs for one- and two-dimensional problems. Nonmajor graduate credit.

E M 451. Engineering Acoustics.
(Cross-listed with M E). (2-2) Cr. 3. Alt. S., offered 2012. *Prereq: PHYS 221 and MATH 266 or MATH 267*
Properties of sounds waves and noise metrics (pressure, power levels, etc). Sound sources and propagation. Principles of wave propagation in one-, two-, and three-dimensions. Wave reflection and transmission. Wave propagation in rectangular, cylindrical, and annular ducts. Acoustics fields for model noise sources. Introduction to aerodynamic noise sources in aircraft, aircraft engines, and wind turbines. Selected laboratory experiments. Nonmajor graduate credit.

E M 490. Independent Study.
Cr. arr. Repeatable. *Prereq: Permission of instructor*

E M 490H. Independent Study: Honors.
Cr. arr. Repeatable. *Prereq: Permission of instructor*

Courses primarily for graduate students, open to qualified undergraduates:

E M 510. Continuum Mechanics.
(3-0) Cr. 3. F. *Prereq: MATH 385*
Introduction to Cartesian tensors as linear vector transformations. Kinematics of continuous deformations, Lagrangian and Eulerian descriptions of motion. Fundamental equations or balance laws of continuous media, linear and angular momentum balance. Conservation laws of momentum and energy. Introduction to constitutive equations of classical elastic solids and simple fluids. Formulations and solutions of some canonical problems.

E M 514. Advanced Mechanics of Materials.
(Cross-listed with AER E). (3-0) Cr. 3. F. *Prereq: E M 324*
Theory of stress and strain, stress-strain relationships. Unsymmetrical bending, curved beams, shear center. Torsion of thin-walled noncircular sections. Equilibrium, compatibility equations. Airy stress functions. Membrane stresses in shells, thick-walled cylinders.

E M 516. Applied Elasticity and Mechanics of Deformable Solids.
(3-0) Cr. 3. S. *Prereq: E M 510*
Fundamental mechanics of linear elasticity, formulation and solution of simple elastostatic boundary value problems. Kinematics of small deformations, constitutive equations for isotropic and anisotropic media. Field equations for elastic solids, plane strain/plane stress and some classic analytical solutions such as Boussinesq, Hertz, Kirsch, Lam&eacute, and Mitchell. Stress functions and potential methods and introduction to finite elements.

E M 517. Experimental Mechanics.
(Cross-listed with AER E). (3-2) Cr. 4. Alt. S., offered 2012. *Prereq: E M 510 or E M 514 or E M 516*
Fundamental concepts for force, displacement, stress, and strain measurements. Strain gages. Full field deformation measurements with laser interferometry and digital image processing. Advanced experimental concepts at the micro and nano scale regimes.

E M 518. Waves in Elastic Solids with Applications to Ultrasonic Nondestructive Evaluation.
(3-0) Cr. 3. F. *Prereq: MATH 385*
Propagation of bulk waves, surface waves, and guided waves in isotropic and anisotropic elastic media. Transmission and reflection of waves at plane and curved interfaces. Radiation of sources with application to ultrasonic transducer beam modeling. Elastic wave scattering from cracks and inclusions. Reciprocity principles and their use in the development of an ultrasonic measurement model. Characterization and measurement of material attenuation.

E M 525. Finite Element Analysis.
(Cross-listed with AER E). (3-0) Cr. 3. S. *Prereq: E M 425, MATH 385*
Variational and weighted residual approach to finite element equations. Emphasis on two- and three-dimensional problems in solid mechanics. Isoparametric element formulation, higher order elements, numerical integration, imposition of constraints and penalty, convergence, and other more advanced topics. Use of two- and three-dimensional computer programs. Dynamic and vibrational problems, eigenvalues, and time integration. Introduction to geometric and material nonlinearities.

E M 526. Boundary Element Methods in Engineering.
(3-0) Cr. 3. Alt. F., offered 2012. *Prereq: E M 514 or E M 516*
Introductory boundary element methods through plane problems. Singular integrals, Cauchy principal values, integral representations and boundary integrals in one dimension. Direct and indirect formulations. Plane potential and elastostatic problems. Higher order elements, numerical integration. Regularizations. Body forces and infinite regions. Specialized fundamental solutions, half-plane and axisymmetric problems. Diffusion and wave problems. Coupling with finite elements.

E M 543. Introduction to Random Vibrations and Nonlinear Dynamics.
(Cross-listed with M E). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: 444*
Vibrations of continuous systems. Nonlinear vibration phenomena, perturbation expansions; methods of multiple time scales and slowly-varying amplitude and phase. Characteristics of random vibrations; random processes, probability distributions, spectral density and its significance, the normal or Gaussian random process. Transmission of random vibration, response of simple single and two-degree-of-freedom systems to stationary random excitation. Fatigue failure due to random excitation.

E M 548. Advanced Engineering Dynamics.
(3-0) Cr. 3. Alt. S., offered 2012. *Prereq: E M 345, MATH 266 or MATH 267*
3-D kinematics and dynamics of particles and rigid bodies. Coordinate systems, calculus of variations. Lagrange's equations with constraints, modified Euler's equations, torque-free motion of rigid bodies in 3-D, moment equations with constraints.

E M 550. Fundamentals of Nondestructive Evaluation.
(Cross-listed with M S E). (3-2) Cr. 4. S. *Prereq: E M 324, MATH 385*
Principles of five basic NDE methods and their application in engineering inspections. Materials behavior and simple failure analysis. NDE reliability, and damage-tolerant design. Advanced methods such as acoustic microscopy, laser ultrasonics, thermal waves, computed tomography, and thermoelectrics are analyzed. Laboratory experiments on all basic methods: ultrasonics, eddy currents, x-ray, liquid penetrants, magnetic testing, and visual inspection are performed.

E M 552. Advanced Acoustics.
(Cross-listed with M E). (3-0) Cr. 3. Alt. F., offered 2011. *Prereq: E M 451*
Theoretical acoustics: wave propagation in fluids; acoustic radiation, diffraction and scattering; nonlinear acoustics; radiation force; cavitation; and ray acoustics.

E M 564. Fracture and Fatigue.
(Cross-listed with M S E, M E, AER E). (3-0) Cr. 3. Alt. F., offered 2012. *Prereq: E M 324 and either MAT E 216 or MAT E 273 or MAT E 392. Undergraduates: Permission of instructor*
Materials and mechanics approach to fracture and fatigue. Fracture mechanics, brittle and ductile fracture, fracture and fatigue characteristics, fracture of thin films and layered structures. Fracture and fatigue tests, mechanics and materials designed to avoid fracture or fatigue.

E M 566. Phase Transformation in Elastic Materials.
(Cross-listed with M E). (3-0) Cr. 3. S. *Prereq: EM 510 or EM 516 or EM 514*
Continuum thermodynamics and kinetics approaches to phase transformations. Phase field approach to stress- and temperature-induced martensitic transformations and twinning at the nanoscale. Nucleation and growth. Nanostructural evaluation. Analytical and numerical solutions. Surface stresses and energy. Surface-induced phase transformations. Large Strain formulation.

E M 569. Mechanics of Composite and Combined Materials.
(Cross-listed with M S E, AER E). (3-0) Cr. 3. Alt. S., offered 2012. *Prereq: E M 324*
Mechanics of fiber-reinforced materials. Micromechanics of lamina. Macromechanical behavior of lamina and laminates. Strength and interlaminar stresses of laminates. Failure criteria. Stress analysis of laminates. Thermal moisture and residual stresses. Joints in composites.

E M 570. Wind Engineering.
(Cross-listed with AER E). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: E M 378, E M 345*
Atmospheric circulations, atmospheric boundary layer wind, bluff-body aerodynamics, aeroelastic phenomena, wind-tunnel and full-scale testing, wind-load code and standards, effect of tornado and thunderstorm winds, design applications.

E M 590. Engineering Mechanics Independent Study.
Cr. 1-4. Repeatable. *Prereq: Permission of instructor*

E M 590F. Engineering Mechanics Independent Study: Introduction to Dislocation and Plasticity.
Cr. 1-4. Repeatable. *Prereq: Permission of instructor*

E M 590H. Engineering Mechanics Independent Study: Mechanics of Thin Films and Adhesives.
Cr. 1-4. Repeatable. *Prereq: Permission of instructor*

E M 590I. Engineering Mechanics Independent Study: Mechanics of Cellular and Porous Media.
Cr. 1-4. Repeatable. *Prereq: Permission of instructor*

E M 590J. Engineering Mechanics Independent Study: Other.
Cr. 1-4. Repeatable. *Prereq: Permission of instructor*

E M 599. Creative Component.
Cr. arr. Repeatable.

Courses for graduate students:

E M 690. Engineering Mechanics Independent Study.
Cr. 1-6. Repeatable. *Prereq: Permission of instructor*

E M 690N. Engineering Mechanics Independent Study: Advanced Experimental Methods.
Cr. 1-6. Repeatable. *Prereq: Permission of instructor*

E M 690O. Engineering Mechanics Independent Study: Advanced Wave Propagation.
Cr. 1-6. Repeatable. *Prereq: Permission of instructor*

E M 690P. Engineering Mechanics Independent Study: Advanced Materials.
Cr. 1-6. Repeatable. *Prereq: Permission of instructor*

E M 690Q. Engineering Mechanics Independent Study: Advanced Computational Methods.
Cr. 1-6. Repeatable. *Prereq: Permission of instructor*

E M 690R. Engineering Mechanics Independent Study: Reliability and Failure.
Cr. 1-6. Repeatable. *Prereq: Permission of instructor*

E M 690S. Engineering Mechanics Independent Study: Other.
Cr. 1-6. Repeatable. *Prereq: Permission of instructor*

E M 697. Engineering Internship.
Cr. R. Repeatable. *Prereq: Permission of DOGE (Director of Graduate Education), graduate classification*
One semester and one summer maximum per academic year professional work period. Offered on a satisfactory-fail basis only.

E M 699. Research.
Cr. arr. Repeatable.