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 has strong research emphasis. The master of science degree is recommended for students who anticipate entering a doctoral program later. The master of engineering degree does not require either research credits or a thesis. 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.

The master of engineering degree does require a creative component which will be obtained by registering for EM 5990 Creative Component. A written report and an oral presentation will be given to the student's graduate committee.

At least 30 credits of acceptable graduate work are required for both the master of science and the master of engineering degrees. For specific course, research, and creative component requirements, see the departmental Graduate Student Handbook (http://www.aere.iastate.edu/wp-content/blogs.dir/13/files/2011/09/Graduate-Handbook-Fall-2011.pdf).

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:

EM 3240: Mechanics of Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: CE 2740
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. (Typically Offered: Fall, Spring, Summer)

EM 3270: Mechanics of Materials Laboratory
Credits: 1. Contact Hours: Laboratory 2.
Prereq: EM 3240
Experimental determination of mechanical properties of selected engineering materials. Experimental verification of assumptions made in 3240. Use of strain measuring devices. Preparation of reports. (Typically Offered: Fall, Spring)

EM 3620: Principles of Nondestructive Testing
(Cross-listed with MATE 3620).
Credits: 3. Contact Hours: Lecture 3.
Prereq: PHYS 1320 *OR* PHYS 2320 *or* PHYS 2320H
Radiography, ultrasonic testing, magnetic particle inspection, eddy current testing, dye penetrant inspection, and other techniques. Physical bases of nondestructive tests, materials to which applicable, effects of material condition, types of defects detectable, calibration standards, and reliability safety precautions. (Typically Offered: Spring)

EM 3620L: Nondestructive Testing Laboratory
(Cross-listed with MATE 3620L).
Credits: 1. Contact Hours: Laboratory 3.
Prereq: Credit or enrollment in MATE 3620 *or EM 3620*
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. (Typically Offered: Fall, Spring)

EM 4170: Experimental Mechanics
(Cross-listed with AERE 4170).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: EM 3240*, and* MATE 2730
Introduction to fundamental concepts for force, displacement, stress and strain measurements for structures and materials applications. Strain gage theory and application. Full field deformation measurements with laser interferometry and digital image processing. Advanced experimental concepts at the micro- and nano-scale regimes. Selected laboratory experiments. Offered even-numbered years. (Typically Offered: Fall)

EM 4240: Intermediate Mechanics of Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: EM 3240
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. (Typically Offered: Fall, Spring)

EM 4250: Introduction to the Finite Element Method
Credits: 3. Contact Hours: Lecture 3.
Prereq: EM 3240 *and* MATH 2660 *or* MATH 2670
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. (Typically Offered: Spring)

EM 4510: Engineering Acoustics
(Cross-listed with EE 4510/ ME 4510).
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATH 2660 or MATH 2670; PHYS 2310 and 2310L
The basics of acoustic wave propagation in fluids with an emphasis on sound propagation in air. Topics include transmission and reflection of sound at a boundary; role of acoustic sources in directing sound fields; diffraction of sound around solid objects; reverberation of sound in a room; and the measurement of sound fields. (Typically Offered: Fall)

EM 4800: Ultrasonic Nondestructive Evaluation
(Cross-listed with AERE 4800).
Credits: 3. Contact Hours: Lecture 3.
Prereq: EM 3240*,* MATH 2660 *or* MATH 2670*,* PHYS 2320
Introduction to stress/strain, Hooke's law, and elastic wave propagation in two dimensions in isotropic media. Ultrasonic plane-wave reflection and transmission; and simple straight-crested guided waves. Transducer construction, behavior, and performance. Simple signal analysis and discrete signal processing. The last few weeks of the course are devoted to case studies. (Typically Offered: Spring)

EM 4900: Independent Study
Credits: 1-30. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

EM 4900H: Independent Study: Honors
Credits: 1-30. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

Courses primarily for graduate students, open to qualified undergraduates:

EM 5100: Continuum Mechanics
Credits: 3. Contact Hours: Lecture 3.
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. (Typically Offered: Fall)

EM 5140: Advanced Mechanics of Materials
(Cross-listed with AERE 5140).
Credits: 3. Contact Hours: Lecture 3.
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. (Typically Offered: Fall)

EM 5160: Applied Elasticity and Mechanics of Deformable Solids
Credits: 3. Contact Hours: Lecture 3.
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, Lame, and Mitchell. Stress functions and potential methods and introduction to finite elements. (Typically Offered: Spring)

EM 5170: Experimental Mechanics
(Cross-listed with AERE 5170).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Introduction to fundamental concepts for force, displacement, stress and strain measurements for structures and materials applications. Strain gage theory and application. Full field deformation measurements with laser interferometry and digital image processing. Advanced experimental concepts at the micro- and nano-scale regimes. Selected laboratory experiments. Offered even-numbered years. (Typically Offered: Fall)

EM 5180: Waves in Elastic Solids with Applications to Ultrasonic Nondestructive Evaluation
Credits: 3. Contact Hours: Lecture 3.
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. (Typically Offered: Fall)

EM 5250: Finite Element Analysis
(Cross-listed with AERE 5250).
Credits: 3. Contact Hours: Lecture 3.
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. (Typically Offered: Spring)

EM 5260: Boundary Element Methods in Engineering
Credits: 3. Contact Hours: Lecture 3.
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. Offered even-numbered years. (Typically Offered: Fall)

EM 5430: Introduction to Random Vibrations and Nonlinear Dynamics
(Cross-listed with ME 5430).
Credits: 3. Contact Hours: Lecture 3.
Vibrations of continuous systems. Nonlinear vibration phenome, 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. Offered odd-numbered years. (Typically Offered: Spring)

EM 5480: Advanced Engineering Dynamics
Credits: 3. Contact Hours: Lecture 3.
Prereq: EM 3450, MATH 2660 *or* MATH 2670
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. Offered even-numbered years. (Typically Offered: Spring). (Typically Offered: Spring)

EM 5500: Nondestructive Evaluation
(Cross-listed with MSE 5500).
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
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, and computed tomography are analyzed. Computer-based experiments on a selection of methods: ultrasonics, eddy currents, x-rays are assigned for student completion. (Typically Offered: Spring)

EM 5640: Fracture and Fatigue
(Cross-listed with AERE 5640/ ME 5640/ MSE 5640).
Credits: 3. Contact Hours: Lecture 3.
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. Offered even-numbered years. (Typically Offered: Fall)

EM 5660: Phase Transformation in Elastic Materials
(Cross-listed with ME 5660).
Credits: 3. Contact Hours: Lecture 3.
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. (Typically Offered: Spring)

EM 5670: Nanomechanics of Materials
Credits: 3. Contact Hours: Lecture 3.
Continuum theoretical and computational approaches to material deformation and nanostructure evolution. Thermodynamics and kinetics. Nucleation and growth. Surface and interface tension and phenomena. Chemical reactions, phase transformations, and dislocation evolution. (Typically Offered: Spring)

EM 5690: Mechanics of Composite and Combined Materials
(Cross-listed with AERE 5690/ MSE 5690).
Credits: 3. Contact Hours: Lecture 3.
Prereq: EM 3240
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. Offered even-numbered years. (Typically Offered: Spring)

EM 5700: Wind Engineering
(Cross-listed with AERE 5700).
Credits: 3. Contact Hours: Lecture 3.
Prereq: ABE 3780 *and* ME 3450
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. Offered odd-numbered years. (Typically Offered: Spring)

EM 5800: Phase Transformations and Plasticity
Credits: 3. Contact Hours: Lecture 3.
Continuum approaches to phase transformations and plasticity at nano-, micro-, and macroscales. Interaction between phase transformations and plasticity and different scales. Temperature-, stress-, and strain-induced phase transformations. Transformation-induced plasticity. Thermodynamics and kinetics. Nucleation and growth. Large strain formulation. High pressure phenomena and theories. (Typically Offered: Fall)

EM 5840: High Pressure Mechanics and Phase Transformations
Credits: 3. Contact Hours: Lecture 3.
Techniques for producing static high pressure and measurements. Traditional and rotational diamond anvil cell. Phase diagrams. Pressure, stress, and plastic strain induced phase transformations: continuum thermodynamics and kinetics. Elasticity and plastic flow under high pressure. Transformation pressure hysteresis. Material synthesis and search for new phases. Interaction between phase transformations and plasticity under high pressure. High pressure mechanochemistry. Multiscale modeling.

EM 5860: Micromechanics of Structural Changes in Materials
Credits: 3. Contact Hours: Lecture 2, Discussion 1.
Continuum and micromechanical approaches to material deformation, phase transformations, and microstructure evolution. Thermodynamics and kinetics. Eshelby inclusion. Interface propagation and reorientation. Microscale phase field approach. Large strain formulation. Phase transformations, chemical reactions, twinning, and fracture. (Typically Offered: Fall)

EM 5900F: Engineering Mechanics Special Topics: Introduction to Dislocation and Plasticity
Credits: 1-4. Repeatable.
(Typically Offered: Fall, Spring, Summer)

EM 5900H: Engineering Mechanics Special Topics: Mechanics of Thin Films and Adhesives
Credits: 1-4. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

EM 5900I: Engineering Mechanics Special Topics: Mechanics of Cellular and Porous Media
Credits: 1-4. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

EM 5900J: Engineering Mechanics Special Topics: Other
Credits: 1-4. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

EM 5990: Creative Component
Credits: 1-30. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

Courses for graduate students:

EM 6900N: Engineering Mechanics Special Topics: Advanced Experimental Methods
Credits: 1-6. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

EM 6900O: Engineering Mechanics Special Topics: Advanced Wave Propagation
Credits: 1-6. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

EM 6900P. Engineering Mechanics Special Topics: Advanced Materials
Credits: 1-6. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

EM 6900Q: Engineering Mechanics Special Topics: Advanced Computational Methods
Credits: 1-6. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

EM 6900R: Engineering Mechanics Special Topics: Reliability and Failure
Credits: 1-6. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall)

EM 6900S: Engineering Mechanics Special Topics: Other
Credits: 1-6. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)

EM 6970: Engineering Internship
Credits: Required. Repeatable.
One semester and one summer maximum per academic year professional work period. Offered on a satisfactory-fail basis only. (Typically Offered: Fall, Spring, Summer)

EM 6990: Research
Credits: 1-30. Repeatable.
Prereq: Instructor Permission for Course
(Typically Offered: Fall, Spring, Summer)