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 E M 599 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 274: Engineering Statics
(3-0) Cr. 3. F.S.SS.
Prereq: Credit or enrollment in MATH 166; PHYS 221
Vector analysis; analysis of force systems; resultant in two and three dimensions; free-body diagrams; equilibrium; analysis of trusses, frames, and machines; friction, belts and pulleys; shear and bending moment in beams, centroid and center of mass; second moments of areas.

EM 324: Mechanics of Materials
(3-0) Cr. 3. F.S.SS.
Prereq: EM 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.

EM 327: Mechanics of Materials Laboratory
(0-2) Cr. 1. F.S.SS.
Prereq: EM 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.

EM 345: Engineering Dynamics
(3-0) Cr. 3. F.S.SS.
Prereq: EM 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.

EM 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.

EM 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.

EM 378: Mechanics of Fluids
(2-2) Cr. 3. F.S.SS.
Prereq: EM 274
E M 417: Experimental Mechanics
(Dual-listed with E M 517). (Cross-listed with AER E). (2-2) Cr. 3. Alt. F., offered even-numbered years.
Prereq: E M 324; MAT E 273
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.

E M 424: Intermediate Mechanics of Materials
(3-0) Cr. 3. F.S.
Prereq: E M 324

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.

E M 451: Engineering Acoustics
(Cross-listed with E E, M E). (2-2) Cr. 3. Alt. S., offered even-numbered years.
Prereq: PHYS 221 and MATH 266 or MATH 267

E M 480: Ultrasonic Nondestructive Evaluation
(Cross-listed with AER E). (3-0) Cr. 3. S.
Prereq: E M 324, MATH 266 or MATH 267, PHYS 222
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.

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

E M 514: Advanced Mechanics of Materials
(Cross-listed with AER E). (3-0) Cr. 3. F.
Prereq: E M 324

(3-0) Cr. 3. S.
Prereq: E M 510 or E M 514 or E M 516
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/plan stress and some classic analytical solutions such as Boussinesq, Hertz, Kirsch, Lamé, and Mitchell. Stress functions and potential methods and introduction to finite elements.

E M 517: Experimental Mechanics
(Dual-listed with E M 417). (Cross-listed with AER E). (3-2) Cr. 4. Alt. S., offered even-numbered years.
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

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 even-numbered years.
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 odd-numbered years.
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 even-numbered years.
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: 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, and computed
tomography are analyzed. Computer-based experiments on a selection
of methods: ultrasonics, eddy currents, x-rays are assigned for student
completion.

E M 552: Advanced Acoustics
(Cross-listed with M E). (3-0) Cr. 3. Alt. F., offered irregularly.
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 AER E, M E, M S E). (3-0) Cr. 3. Alt. F., offered even-
numbered years.
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 AER E, M S E). (3-0) Cr. 3. Alt. S., offered even-numbered
years.
Prereq: E M 324
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 odd-numbered years.
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 Special Topics
Cr. 1-4. Repeatable.
Prereq: Permission of instructor

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

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

and Porous Media
Cr. 1-4. Repeatable.
Prereq: Permission of instructor

E M 590J: Engineering Mechanics Special Topics: 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 Special Topics
Cr. 1-6. Repeatable.
Prereq: Permission of instructor

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

E M 690P: Engineering Mechanics Special Topics: Advanced Materials
Cr. 1-6. Repeatable.
Prereq: Permission of instructor

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

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

E M 690S: Engineering Mechanics Special Topics: 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.