The department offers programs leading to the degrees of Master of Science in Aerospace Engineering and Mechanics and Doctor of Philosophy in Aerospace Engineering and Mechanics.

Research

A vigorous program of research is conducted by the faculty and students. The department houses excellent laboratory facilities and advanced computer facilities, including wind tunnels, a water tunnel, extensive servo-hydraulic materials and structural testing equipment, and engineering workstations.

Major research laboratories include:

- Advanced Materials Behavior Laboratory
- Aerospace Structures Laboratory
- Advanced Materials Processing Laboratory
- Computational Fluid Dynamics Laboratory
- Experimental Stress Analysis Laboratory
- High-Speed Fluid Mechanics Laboratory and Supersonic Tunnel
- Impact and Penetration Mechanics Laboratory
- Jet Propulsion Stand
- Mechanical Testing Laboratory
- Laser Doppler Velocimetry Laboratory
- Low-Speed Wind Tunnel Laboratory
- Luminescent Imaging Laboratory
- Water Tunnel Laboratory

Some current research projects include theoretical and experimental studies in a variety of areas, including aerodynamics; computational fluid mechanics and heat transfer; transition and drag reduction; laser diagnostics; fluid-structure interaction; rotorcraft aeromechanics; buckling of thin-walled shell structures; fracture mechanics; multiaxial fatigue of spot welds and automotive structures; low-cycle fatigue; high-strain rate flow studies; penetration mechanics; improved finite-element methods for thermal and structural analysis; computational structural dynamics; computer simulation of aircraft and missile performance; dynamic response of rapid transit vehicles; solid rockets; flight dynamics; aircraft design and reliability; unmanned and micro air vehicles; aerospace dynamics and control; multi-body dynamics; aeroelasticity; condition monitoring in electro-mechanical systems and composites materials.

Degree Requirements

A list of current degree requirements and additional information can be found on the Department of Aerospace Engineering and Mechanics website. The following
departmental requirements are in addition to those specified by the Graduate School (Degree Requirements) and the College of Engineering (MS Degree and PhD Degree requirements) detailed in earlier sections of this catalog.

**MS in Aerospace Engineering and Mechanics**

A total of 30 hours is required for a master's degree, consisting of at least 24 regular course hours and 6 thesis research hours for Plan I students. At least 18 hours of AEM-designated courses or approved substitutions are required. The MS degree is comprised of two tracks: aerospace and mechanics. Master’s students can choose which track they will pursue. Plan II (non-thesis) students are required to complete a culminating experience or pass a comprehensive exam. Plan I (thesis) students are required to pass a thesis defense. The following core courses are required:

**Aerospace Track**

- AEM 530 Continuum Mechanics
- AEM 500 Intermediate Fluid Mechanics
- AEM 520 Computational Fluid Dynamics or AEM 635 Finite Element Methods
- AEM 668 Advanced Dynamics of Flight
- GES 554 Partial Differential Equations

**Mechanics Track**

- AEM 530 Continuum Mechanics
- AEM 500 Intermediate Fluid Mechanics
- AEM 562 Intermediate Dynamics
- AEM 637 Theory of Elasticity
- GES 554 Partial Differential Equations

AEM 530 Continuum Mechanics is recommended as your first class (offered in the fall semester).

A “B” average in the core courses is a departmental requirement for graduation. Additionally, one of the following areas is chosen as a field of specialization (two additional courses): (a) dynamics, flight dynamics, controls, (b) fluid mechanics, aerodynamics, propulsion, or (c) solid mechanics, flight vehicle structures and materials.

There is a 6 hour mathematics course requirement. GES 554 Partial Differential Equations is required plus one other approved mathematics or engineering analysis course (often GES 551 Matrix and Vector Analysis is selected).

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**Course Descriptions (AEM)**

Master's students may, with permission of the department and prior approval by the Graduate School, receive credit for six (6) hours of 400-level credit. No 400-level courses can be approved for application to a PhD degree, other than the maximum of six (6) hours already completed as part of a master's degree. A master's student may, with approval of a petition, meet prerequisites with a combination of related coursework and experience.
AEM 500 Intermediate Fluid Mechanics. Three hours. 
Prerequisites: MATH 238, ME 215 and AEM 311 or instructor’s consent. 
Development and use of the integral and differential forms of the equations of continuity, 
momentum, and energy with ideal fluids and compressible fluids. Advanced topics in fluid 
mechanics, including potential flow, boundary layer flow, compressible flow, and open channel 
flow.

AEM 502 V/STOL Aerodynamics. Three hours. 
Prerequisites: AEM 313 or instructor’s consent.
Theory and design techniques applicable to hovering and slow-flying vehicles.

AEM 503 Intermediate Gas Dynamics. Three hours. Cross-listed with ME 503. 
Prerequisites: ME 215 and AEM 311 or instructor’s consent. 
Basic equations and concepts of compressible flow; shock and expansion waves; and 
development of the generalized one-dimensional equations and solution of these equations for 
various types of flow, using computer software.

AEM 508 Aerospace Propulsion Systems. Three hours. 
Prerequisites: AEM 413 or instructor’s consent. 
Basic propulsion dynamics, thermodynamics of fluid flow, combustion kinetics, air-breathing 
engines, rockets, design criteria, performance, and advanced propulsion systems.

AEM 513 High-Speed Aerodynamics. Three hours. 
Prerequisites: ME 215 and AEM 313 or instructor’s consent. 
Fundamentals of high-speed aerodynamics theory along with basic high-speed vehicle design.

AEM 514 Experimental Aerodynamics. Three hours. 
Prerequisites: AEM 313 or instructor’s consent. 
The course provides a laboratory counterpart to concepts discussed in aerodynamics and fluid 
mechanics. Course topics include statistical and uncertainty analysis techniques, design of 
experiments, computer-based data-acquisition, sensors for fluid mechanic measurements, 
and aerodynamic measurement techniques and facilities.

AEM 516 Helicopter Theory. Three hours. 
Prerequisites: MATH 238, AEM 264, and AEM 311 or instructor’s consent. 
Critical examination of the propulsive aircrew, including induced velocity relations, flow 
patterns, and similarity. Practical applications approached through existing theory and 
practice.

AEM 520 Computational Fluid Dynamics. Three hours. 
Prerequisites: MATH 238, AEM 311 and AEM 349 or instructor’s consent. 
Introduction to basic mathematical concepts and engineering problems associated with 
numerical modeling of fluid systems. Application of the state of the art numerical models to 
engineering problems. Fundamentals of Finite Difference and Finite Volume Methods and their
applications in fluid dynamics and heat transfer problems will be covered.

**AEM 523 Principles of Simulation.** Three hours.  
Prerequisites: AEM 368 or instructor's consent.  
An overview of man-in-the-loop, real-time simulation. Includes survey of modeling, digital image generation, projection systems, principles of optics, vibration and motion cueing, and control loading. Issues of computer architecture and system integration and of fidelity and latency are discussed. The simulator in the Flight Dynamics Laboratory is used for illustration.

**AEM 525 Spacecraft Attitude Dynamics and Control.** Three hours.  
Prerequisites: AEM 368 or instructor's consent.  
This course introduces the student to the theory and practice of spacecraft dynamics and control. Topics covered include kinematics and dynamics of angular motion, spacecraft stabilization, attitude control devices, and design of linear and nonlinear spacecraft control systems.

**AEM 528 Space Propulsion.** Three hours.  
Prerequisite: AEM 408 or instructor’s consent.  
Descriptions and analyses of space and launch vehicle propulsion. Topics covered include advanced schemes such as nuclear, solar, and laser propulsion; power cycles; and tether systems.

**AEM 530 Continuum Mechanics.** Three hours.  
Prerequisites: MATH 238, AEM 250 and AEM 311 or instructor’s consent.  

**AEM 546 Intermediate Solid Mechanics.** Three hours.  
Prerequisites: MATH 238 and AEM 250 or instructor’s consent.  
Two-dimensional theory of elasticity; exact and approximate solutions of bending, torsion, and buckling for bars; open sections and curved beams; stresses in axisymmetric members; and finite-element and energy methods.

**AEM 552 Composite Materials.** Three hours.  
Prerequisite: AEM 250 or instructor’s consent.  
Mechanisms and influence of heterogeneity/anisotropy on thermomechanical behavior. The behavior, manufacturing, and test methods of continuous fiber reinforced polymeric composites are emphasized.

**AEM 556 Strengthening Mechanisms in Metallic Materials.** Three hours. Cross-listed with MTE 556.  
Prerequisite: AEM 455 or instructor’s consent.  
Topics include elementary elasticity, plasticity, and dislocation theory; strengthening by
dislocation substructure, and solid solution strengthening; precipitation and dispersion strengthening; fiber reinforcement; martensitic strengthening; grain-size strengthening; order hardening; dual phase microstructures, etc.

**AEM 562 Intermediate Dynamics.** Three hours.  
Prerequisites: MATH 238 and AEM 264 or instructor’s consent.  
Dynamics of systems in moving coordinate frames; Lagrangian formulation and Hamilton’s principle; stability and perturbation concepts for rigid body motion; motion of systems of rigid bodies in three dimensions.

**AEM 567 Fundamentals of Orbital Mechanics.** Three hours.  
Prerequisites: MATH 238 and AEM 264 or instructor’s consent.

Fundamentals of astrodynamics and orbital mechanics.

**AEM 570 Theory of Vibrations.** Three hours. Cross-listed with ME 570.  
Prerequisites: MATH 238 and AEM 264 instructor’s consent.  
Vibrations of multiple degree of freedom and elastic continuous systems; application of Hamilton’s principle; Lagrange’s equations; finite element method.

**AEM 571 Fundamentals of Acoustics.** Three hours. Cross-listed with ME 571.  
Prerequisites: MATH 238 and ECE 320 or instructor’s consent.  
Fundamental physical principles underlying wave propagation and resonance in mechanical systems; introduces applications and provides experience in acoustic and audio measurements and the associated instrumentation.

**AEM 574 Structural Dynamics.** Three hours.  
Prerequisites: AEM 349 and AEM 451 or instructor’s consent.  
Fundamental methods for predicting the dynamic response of structures.

**AEM 577 Advanced Linear Control.** Three hours. Cross-listed with ME 577.  
Prerequisite: ME 475 or instructor’s consent.  
For description, see ME 577.

**AEM 578 Nonlinear Control Systems.** Three hours. Cross-listed with ECE 674.  
Prerequisite: ECE 475 or instructor’s consent.  
For description, see ECE 674.

**AEM 591 Special Problems.** Variable credit.  
Prerequisite: Instructor’s consent.  
Independent investigations of special problems. Credit is based on the amount of work undertaken.

**AEM 594 Special Project.** Two to six hours.  
Prerequisite: Instructor’s consent.
Planning, executing, and presenting results of individual project involving a research design, analysis, or similar undertaking.

**AEM 598 Research Not Related to Thesis.** One to three hours.  
Prerequisite: Instructor’s consent.

**AEM 599 Master's Thesis Research.** One to six hours.  
Prerequisite: Instructor’s consent.

**AEM 602 Advanced Fluid Mechanics.** Three hours.  
Prerequisite: AEM 500 or instructor’s consent.  
Potential motion in two and three dimensions, conformal mapping, application of Schwartz-Christoffel transformation, virtual mass, and approximate methods.

**AEM 604 Compressible Flow Theory.** Three hours.  
Prerequisites: AEM 513 or Consent of Instructor  
Theory on Three-Dimensional flows, Transonic, Hypersonic flows and Properties of High-Temperature Gases. Transonic and Hypersonic similarity, Frozen, Equilibrium, non-equilibrium flows.

**AEM 610 Aerodynamic Heating.** Three hours.  
Prerequisite: AEM 503 or AEM 513 or instructor’s consent  
Radiative and convective aerodynamic heating at hypersonic speeds in real, low, and high-density atmospheres; includes resistive, ablative, transpiration, and heat capacity thermal protection techniques.

**AEM 612 Advanced Experimental Aerodynamics.** Three hours.  
Prerequisite: AEM 514 or instructor’s consent  
Compressible flow, measurement of pressure, Mach number, temperature, density, turbulence, and heat transfer. Some experimental work and illustration of the uses of modern wind tunnel instruments.

**AEM 614 Airfoil and Wing Theory.** Three hours.  
Prerequisite: AEM 313 or instructor’s consent  
Compressible and incompressible airfoil and wing theory.

**AEM 621 Boundary Layer Theory I.** Three hours. Cross-listed with ME 621.  
Prerequisite: AEM 500 or instructor’s consent.  
Development of basic boundary layer equations and concepts. Classical incompressible solutions for laminar boundary layer, approximate solutions, and concepts of turbulence.

**AEM 622 Boundary Layer Theory II.** Three hours.  
Prerequisite: AEM 621 or instructor’s consent.  
Turbulent boundary layer theory; compressible boundary layer theory including shock
interaction and heating effects; selected topics.

**AEM 624 Hypersonic Flow Theory.** Three hours. 
Prerequisite: AEM 503 or AEM 513 or instructor’s consent.  
Nonlinear treatment of compressible flow, linearized theory, methods for blunt bodies, blast wave theory, numerical methods, and hypersonic wind tunnels.

**AEM 628 Molecular Aerothermodynamics.** Three hours. 
Prerequisite: AEM 503 or AEM 513 or instructor’s consent.  
Understanding gas flows and reactions by developing gas properties from an analysis of molecular interactions.

**AEM 635 Finite-Element Method in Engineering Mechanics.** Three hours. 
Prerequisites: MATH 238 and AEM 250 or instructor’s consent.  
Finite-element formulations in the areas of solid mechanics, fluid mechanics, and heat conduction; isoparametric elements; assembly process; solution of stiffness equations; and convergence of results.

**AEM 637 Theory of Elasticity.** Three hours. 
Corequisite: GES 551 or instructor’s consent.  
Equations of linear elasticity, principal stresses and strains, stress and displacement potentials, energy principles, and numerical methods. Boundary value problems of elasticity.

**AEM 638 Introduction to Experimental Mechanics.** Three hours. 
Prerequisite: AEM 250 or instructor’s consent.  
Theory and application of electrical resistance strain gauges for stress analysis and for use as transducers. Study of circuits and instruments used for strain measurement. Theory and application of photoelasticity for measurement of stress. Fundamentals of servohydraulic testing.

**AEM 639 Aircraft Shell Structures.** Three hours. 
Prerequisite: Instructor’s consent.  
Theoretical analysis of plane and curved web shell structures. Diagonal tension, shear lag, multi-stringer cells, and cutouts. Theoretical analyses are correlated with available experimental evidence to obtain the most effective use of the combined knowledge for practical applications.

**AEM 640 Advanced Topics in Continuum Mechanics.** Three hours. 
Prerequisite: AEM 530 or instructor’s consent.  
Kinematics of finite deformation; principles of mechanics; principles of frame indifference and objectivity; theory of viscoelasticity; creep and viscoplastic model; and applications in large deformation.

**AEM 641 Applied Elasticity.** Three hours. 
Prerequisite: AEM 637 or instructor’s consent.
Structural analysis as a unified theory based on the principle of virtual displacements. Minimal principles of structural theory and applications to beam columns, sandwich-type beams, and cables; the Rayleigh-Ritz method, Galerkin's method, and trigonometric series solutions.

**AEM 642 Structural Behavior of Flight Vehicle Configurations.** Three hours.
Prerequisite: Instructor’s consent.
Application of classical and modern numerical methods for predicting the strength, stability, and stiffness of typical aerospace structures. Includes treatment of stiffened plate and shell structures, composite materials, and determination of postbuckled configurations for selected geometries.

**AEM 644 Engineering Fracture Mechanics.** Three hours.
Prerequisites: GES 554 and AEM 637 or instructor’s consent.
Linear elastic and elastic-plastic fracture mechanics. Fracture analysis using Griffith’s criterion, stress intensity factors, CTOD methods, and the J-Integral.

Prerequisite: AEM 635 or instructor’s consent.
Basic concepts, reduced integration with hourglass control, Navier-Stokes equations, eigenvalue problems, beam and plate elements, time integration, adaptive methods, nonlinear solid mechanics. Familiarization with general purpose codes.

**AEM 646 Theory of Plates and Shells.** Three hours.
Prerequisites: AEM 635 and AEM 637 or instructor’s consent.
Linear and nonlinear theories of plates and shells, analytic solutions of rectangular, circular plates and cylindrical shells and shells of revolution. Application of finite-element method to plates and shells.

**AEM 648 Theory of Plasticity.** Three hours.
Prerequisite: AEM 637 or instructor’s consent.
Fundamentals of inelastic behavior of solids. Basic stress-strain relations for plastic action, yield criteria of metals, plastic instability, and slip-line field theory. Applications to axial, flexural, torsional, and cylindrically symmetric loads.

**AEM 649 Fatigue Analysis.** Three hours.
Prerequisite: AEM 637 or instructor’s consent.
Presentation of the strain life and fracture mechanics approaches to fatigue analysis. Review of damage parameters, mean stress effects, and cycle counting methods for uniaxial and multiaxial loading.

**AEM 655 Advanced Composite Materials.** Three hours.
Prerequisite: AEM 552 or instructor’s consent
Advanced topics in composite materials, including theories of linear orthotropic elasticity, micro-mechanics of composites, nano-composites, and sandwich structures.
AEM 663 Chaotic Dynamics. Three hours.  
Prerequisite: GES 551 or instructor’s consent.  
Phase space concepts of nonlinear systems; equilibrium points, limit cycles, and strange attractors; chaotic behavior, Lyapunov exponents, and fractal dimension.

AEM 665 Advanced Structural Dynamics. Three hours.  
Prerequisite: AEM 574 or instructor’s consent.  
Theoretical and experimental methods for the dynamic analysis of structures.

AEM 667 Astrodynamics II. Three hours.  
Prerequisite: AEM 567 or instructor’s consent.  
Transfer orbits, orbital perturbations, multiple body problems, numerical treatments of n-body problems, propulsion, and powered system dynamics.

AEM 668 Advanced Dynamics of Flight. Three hours.  
Prerequisite: AEM 368 or Instructor’s consent.  
Analysis of the rigid body dynamic motions of an aircraft; response of an airplane to actuation of controls; introduction to automatic control and stability; introduction to vehicle simulation by digital computer.

AEM 669 Principles of Guidance and Navigation. Three hours.  
Prerequisite: AEM 368 or instructor’s consent.  
Gyroscopes as aircraft attitude indicating devices and as components of inertial navigation systems; Newton’s laws applied in various rotating and fixed reference frames used in guidance and navigation; space integrator and Schuler tuning; local geographic coordinate navigation for aircraft; semi-analytic navigation for missile guidance; and analytic (strap down) guidance systems.

AEM 674 Introduction to Aeroelasticity. Three hours.  
Prerequisite: AEM 574 or instructor’s consent.  
Interactions between static/dynamic structural deformation and steady/unsteady aerodynamic loading; control reversal, divergence and flutter; aeroelastic tailoring and aeroservoelasticity.

AEM 677 Optimal Control. Three hours. Cross-listed with ME 677.  
Prerequisite: AEM 577 or instructor’s consent.  
For description, see ME 677.

AEM 678 Advanced Topics in Control. Three hours. Cross-listed with ME 678.  
Prerequisite: AEM 577 or instructor’s consent.  
For description, see ME 678.

AEM 679 Wave Motion of Continuous Solids. Three hours.  
Prerequisites: AEM 470 and AEM 637 or instructor’s consent.  
The dynamics of continuous elastic bodies; the properties of wave motion and the motion of an elastic string; propagation of elastic waves in infinite and semi-infinite bodies, cylinders,
rods, and beams.

**AEM 681 Experimental Aeroelasticity.** Three hours.  
Prerequisite: AEM 574 or instructor’s consent.  
Aeroelastic model theory applied to the design and construction of flutter models and dynamic stability models. Testing techniques and model scale aeroelastic experiments.

**AEM 685 Engineering Optimization.** Three hours.  
Prerequisites: MATH 238 and **GES 551** or instructor’s consent.  
Basic principles of optimization theory, parameter optimization problems, linear and nonlinear programming. Unconstrained and constrained problems treated by simplex, penalty function, and generalized reduced gradient methods. Includes several computer projects concerning engineering applications.

**AEM 691:692 Special Problems (Area).** Variable credit.  
Prerequisite: Instructor’s consent.  
Independent investigations of special problems. Credit is based on the amount of work undertaken.

**AEM 693 Selected Topics.** One to three hours.  
Prerequisite: Instructor’s consent.  
Topics of current research in dynamics and controls, solid mechanics and structures, or thermal/fluid sciences.

**AEM 694 Special Project.** One to six hours.  
Prerequisite: Instructor’s consent.  
Planning, executing, and presenting results of an individual project involving a research design, analysis, or similar undertaking.

**AEM 695 Graduate Seminar.** One hour.  
Prerequisite: Graduate standing.  
Preparation and presentation of papers and reports on current topics.

**AEM 698 Research Not Related to Dissertation.** One to six hours.

**AEM 699 Doctoral Dissertation Research.** Three to twelve hours.