The Guggenheim School of Aerospace Engineering prepares students at the bachelor's, master's, and doctoral levels for a career in vehicle engineering with primary emphasis on flight vehicles. A combined BS/MS honors program is also offered, preparing students for graduate studies and research (www.ae.gatech.edu (http://www.ae.gatech.edu)). In addition, the School offers a minor in aerospace engineering, and interdisciplinary minors in the fields of energy systems and scientific and engineering computing. The School is housed in five buildings with a total of approximately 122,000 square feet, most of which is devoted to instructional and research laboratories. Additional information may be found at http://www.ae.gatech.edu/academics/undergraduate

**Minor**
- Minor in Aerospace Engineering (http://www.catalog.gatech.edu/programs/minor-aerospace-engineering)

In partnership with other units on campus, the School also offers interdisciplinary minors in the areas of energy systems, and scientific and engineering computing.

**Bachelor's Degree**
- Bachelor of Science in Aerospace Engineering (http://www.catalog.gatech.edu/programs/aerospace-engineering-bs)

**Master's Degrees**
- Master of Science in Aerospace Engineering (http://www.catalog.gatech.edu/programs/aerospace-engineering-ms)
- Master of Science in Computational Science and Engineering (http://www.catalog.gatech.edu/programs/computational-science-engineering-ms)

**Doctoral Degrees**
- Doctor of Philosophy with a Major in Aerospace Engineering (http://www.catalog.gatech.edu/programs/aerospace-engineering-phd)
- Doctor of Philosophy with a Major in Computational Science and Engineering (http://www.catalog.gatech.edu/programs/computational-science-engineering-phd)
- Doctor of Philosophy with a Major in Robotics (http://www.catalog.gatech.edu/programs/robotics-phd)

**AE 1350. Introduction to Aerospace Engineering. 2 Credit Hours.**
Introduction to the field of aerospace engineering, discussion of basic aerospace systems and disciplines, working vocabulary of the field. Demonstration through examples. Wind tunnel visit. Students cannot receive credit for both AE 1350 and AE 1601.

**AE 1355. Aerospace Systems Design Competition I. 3 Credit Hours.**
Team-oriented aerospace systems design project directed by a faculty advisor. Typically a national student competition in aircraft, rotorcraft, or spacecraft design. Technical role commensurate with freshman standing.

**AE 1601. Introduction to Aerospace Engineering. 1 Credit Hour.**
Overview of aerospace engineering. Common terminology, introduction to use of engineering models, professional and ethical standards and experience with team-based design of aerospace systems. Students cannot receive credit for both AE 1601 and AE 1350.

**AE 1750. Introduction to Bioengineering. 3 Credit Hours.**
An introduction to the field of bioengineering, including the application of engineering principles and methods to problems in biology and medicine, the integration of engineering with biology, and the emerging industrial opportunities. Crosslisted with BMED, CHE, ECE, ME, and MSE 1750.

**AE 1770. Introduction to Engineering Graphics and Visualization. 3 Credit Hours.**
Introduction to engineering graphics and visualization including sketching, line drawing, and solid modeling. Development and interpretation of drawings and specifications for product realization. Crosslisted with CEE 1770 and ME 1770.

**AE 1XXX. Aerospace Engr Elective. 1-21 Credit Hours.**

**AE 2010. Thermodynamics & Fluids Fundamentals. 4 Credit Hours.**
Thermodynamic and fluid properties. Conservation laws, Isentropic flow, shocks and expansions, introduction to flows with friction and heat transfer. Applications to aerospace devices. Students cannot receive credit for both AE 2010 and AE 3450.

**AE 2020. Low-Speed Aerodynamics. 3 Credit Hours.**
Basic results, conservation laws, potential, airfoil, and wing analysis. Boundary layers on plates and airfoils. Pressure gradients. Introduction to turbulence and vortex-dominated flows.

**AE 2120. Introduction to Mechanics. 3 Credit Hours.**
Forces and movements; equilibrium in two and three dimensions; multforce members; friction; stress and strain; axial loading, torsion, and bending of beams.

**AE 2220. Dynamics. 3 Credit Hours.**
Motion of particles and mass center of bodies, kinematics and kinetics of rigid bodies in plane motion, work-energy and impulse-momentum methods, 3-D dynamics of rigid bodies.

**AE 2355. Aerospace Systems Design Competition II. 3 Credit Hours.**
Team-oriented aerospace systems design project directed by a faculty advisor. Typically a national student competition in aircraft, rotorcraft, or spacecraft design. Technical role commensurate with sophomore standing.

**AE 2610. Introduction to Experimental Methods in Aerospace. 1 Credit Hour.**
Introduction to laboratory instrumentation and measurement techniques used in aerospace. Basic application of sensor principles, uncertainty analysis, interpretation and analysis of experimental data, and documentation.

**AE 2611. Technical Communications for Aerospace Engineers. 1 Credit Hour.**
Development of technical communication skills required by aerospace engineers. Includes written, oral and visual communication methods.

**AE 2698. Undergraduate Research Assistantship. 1-12 Credit Hours.**
Independent research conducted under the guidance of a faculty member.

**AE 2699. Undergraduate Research. 1-12 Credit Hours.**
Independent research conducted under the guidance of a faculty member.

**AE 2801. Special Topics. 1 Credit Hour.**
Normally taken by sophomores. Course material devoted to special topics in aerospace engineering.

**AE 2802. Special Topics. 2 Credit Hours.**
Normally taken by sophomores. Course material is devoted to special topics in aerospace engineering.
AE 2901. Special Problems. 1-21 Credit Hours.
Research topic selected in consultation with advisor. A brief description, endorsed by the faculty advisor, must be approved by the School.

AE 2902. Special Problems. 1-21 Credit Hours.
Research topic selected in consultation with advisor. A brief description, endorsed by the faculty advisor, must be approved by the School.

AE 2903. Special Problems. 1-21 Credit Hours.
Research topic selected in consultation with advisor. A brief description, endorsed by the faculty advisor, must be approved by the School.

AE 2XXX. Aerospace Engr Elective. 1-21 Credit Hours.

AE 3021. High-Speed Aerodynamics. 3 Credit Hours.
Compressibility effects on airfoil and wing aerodynamics: supersonic and hypersonic flight. Laminar and turbulent boundary layers and effects of viscosity on aerodynamic performance.

AE 3030. Aerodynamics. 4 Credit Hours.
Aerodynamics of airfoils and wings in subsonic, transonic, and supersonic flight. Laminar and turbulent boundary layers and effects of viscosity on aerodynamic performance.

AE 3051. Experimental Fluid Dynamics. 2 Credit Hours.
Experiments in fluid mechanics, aerodynamics, and propulsion with emphasis on data acquisition and analysis, e.g., measurement techniques, laboratory instrumentation, measurement errors/noise, and digital sampling.

AE 3090. Numerical Methods for Aerospace Engineering. 3 Credit Hours.
Basic numerical methods in Aerospace Engineering taught in Fortran or C, language instruction included. Numerical integration, interpolation, FFT, linear algebra, initial and boundary value problems.

AE 3120. Introduction to Structural Analysis. 3 Credit Hours.

AE 3125. Aerospace Structural Analysis. 4 Credit Hours.

AE 3140. Structural Analysis. 3 Credit Hours.
Application to structural analysis. Basic equations of elasticity. Bending, shearing and torsion of thin walled structures. Energy methods for structural analysis and application to finite element theory for trusses and beam structures. Students cannot receive credit for both AE 3140 and AE 3125.

AE 3145. Structures Laboratory. 1 Credit Hour.
Introduction to mechanical measurements, instrumentation principles and practice, measurement of stress and strain, shear center, column stability, properties of composite structural materials, fracture toughness test.

AE 3310. Introduction to Aerospace Vehicle Performance. 3 Credit Hours.
Introduction to aerospace vehicle performance: VTOL, STOL, CTOL and spaceflight. Drag estimation, thrust required and available, basic point and path performance, special performance items, maneuvers. Students cannot receive credit for both AE 3310 and AE 3330.

AE 3330. Introduction to Aerospace Vehicle Performance. 3 Credit Hours.

AE 3340. Design and Systems Engineering Methods. 2 Credit Hours.
Overview of aerospace design and systems engineering. Tools to organize the design process and to support design decisions. Introduction to numerical optimization and trade studies.

AE 3355. Aerospace Systems Design Competition III. 3 Credit Hours.
Team-oriented aerospace systems design project directed by a faculty advisor. Typically a national student competition in aircraft, rotorcraft, or spacecraft design. Technical or leadership role commensurate with junior standing.

AE 3450. Thermodynamics and Compressible Flow. 3 Credit Hours.

AE 3515. System Dynamics and Control. 4 Credit Hours.
Dynamic modeling and response of systems with mechanical, hydraulic, electrical, and/or thermal elements. Classical methods of feedback control system design and analysis. Students cannot receive credit for AE 3515 and AE 3530 or AE 3515 and AE 3531.

AE 3521. Aircraft and Spacecraft Flight Dynamics. 4 Credit Hours.
Three-dimensional rigid body dynamics, aircraft and spacecraft equations of motion, principles of static stability and control, dynamic stability of uncontrolled motion, gyroscopic instruments. Students cannot receive credit for both AE 3521 and AE 4531.

AE 3530. System Dynamics and Vibration. 3 Credit Hours.
Modeling and analysis of lumped- and distributed-parameter systems, free and forced vibration in mechanical systems, free vibration in structural systems. Students cannot receive credit for both AE 3530 and ME 3017 or AE 3530 and AE 3515.

AE 3531. Control System Analysis and Design. 3 Credit Hours.
Control system performance analysis and specifications, classical methods of control system analysis and design, introduction to modern control methods. Students cannot receive credit for AE 3531 and AE 3515 or AE 3531 and ME 4452.

AE 3610. Experiments in Fluid and Solid Mechanics. 2 Credit Hours.
Experimental laboratory in solid and fluid mechanics, aerodynamics, propulsion. Emphasis on measurement techniques, analysis and interpretation of data, comparison to analytical predictions, and reporting.

AE 3801. Special Topics. 1 Credit Hour.
Normally taken by juniors. Course material devoted to special topics in aerospace engineering.

AE 3802. Special Topics. 2 Credit Hours.
Normally taken by juniors. Course material devoted to special topics in aerospace engineering.

AE 3803. Special Topics. 3 Credit Hours.
Normally taken by juniors. Course material devoted to special topics in aerospace engineering.

AE 3901. Special Problems. 1-21 Credit Hours.
Research topic selected in consultation with advisor. A brief description, endorsed by the faculty advisor, must be approved by the School.
AE 3902. Special Problems. 1-21 Credit Hours.
Research topic selected in consultation with advisor. A brief description, endorsed by the faculty advisor, must be approved by the School.

AE 3903. Special Problems. 1-21 Credit Hours.
Research topic selected in consultation with advisor. A brief description, endorsed by the faculty advisor, must be approved by the School.

AE 3XXX. Aerospace Engr Elective. 1-21 Credit Hours.

AE 4040. Computational Fluid Dynamics. 3 Credit Hours.
Discretization of PDEs, stability and accuracy considerations, iterative and time/space marching schemes, aerospace applications.

AE 4051. Flow Diagnostics. 3 Credit Hours.
Overview of experimental techniques. Flow visualization; statistical methods. Laboratory operation, data acquisition, analysis, interpretation, reporting.

AE 4060. Aeroacoustics. 3 Credit Hours.
Concepts and techniques, noise sources, data acquisition and reduction, aeroacoustic resonances, commonalities in the music of wind instruments and sources of aircraft noise, community impact.

AE 4070. Introduction to Propeller and Rotor Theory. 3 Credit Hours.
A study of the theory and equations used in the design of propellers and helicopter rotors.

AE 4080. Aerothermodynamics. 3 Credit Hours.
Convective heat transfer and viscous drag in high-temperature and high-speed flowfields. Inviscid hypersonic theory, real gas effects, and wall thermal protection strategies.

AE 4120. Introduction to Aerospace Engineering Composite Structures. 3 Credit Hours.

AE 4131. Introduction to Finite Element Methods. 3 Credit Hours.
Finite Element Method and its application to linear structural problems. The basic formulations of various structural elements are discussed.

AE 4170. Structural Integrity and Durability. 3 Credit Hours.
Multiaxial stress states, inelasticity in metals and polymers, yield criteria, metal fatigue, fracture, stress intensity factors, fracture toughness, fatigue crack growth, metal creep, and polymer viscoelasticity.

AE 4220. Structural Dynamics and Aeroelasticity. 3 Credit Hours.
Structural dynamics of one-dimensional systems. Analysis of static aeroelastic phenomena, unsteady aerodynamics, and flutter. Equations of motion for complete aeroelastic systems; solution techniques.

AE 4310. Space Flight Mechanics. 3 Credit Hours.
First course in astrodynamics that encompasses two-body orbital mechanics, orbit determination, orbital maneuvers, orbital prediction, interplanetary trajectories, launch and space vehicle performance and atmospheric entry. Students cannot receive credit for both AE 4310 and AE 4532.

AE 4341. Aircraft Design. 3 Credit Hours.
Aircraft Vehicle Design. Preliminary design or case study of a complete flight vehicle, including a propulsion system, a structural system, and a control system. Students cannot receive credit for both AE 4341 and AE 4350.

AE 4342. Space System Design. 3 Credit Hours.
Spacecraft subsystems and synthesis. Students apply mission and spacecraft design principles in developing a space flight mission concept. Topics may vary. Students cannot receive credit for AE 4342 and AE 4356.

AE 4343. Rotorcraft Design. 3 Credit Hours.
Rotorcraft Vehicle Design. Preliminary design or case study of a complete rotorcraft flight vehicle, including a propulsion system, a structural system, and a control system. Students cannot receive credit for both AE 4343 and AE 4358 or AE 4343 and AE 6333.

AE 4350. Aerospace Engineering Design Project I. 3 Credit Hours.
Conceptual design methodology developed and applied incorporating center of gravity, inertias, structural layout, materials, propulsion integration, stability and control, vehicle sizing, performance, and acquisition costs. Students cannot receive credit for both AE 4350 and AE 4341.

AE 4351. Aerospace Engineering Design Project II. 3 Credit Hours.
Design methodology further developed and applied. Teams formed to prepare competitive proposals in response to given mission requirements. Designs publicly presented and defended.

AE 4355. Aerospace Systems Design Competition IV. 3 Credit Hours.
Team-oriented aerospace systems design project directed by a faculty advisor. Typically a national student competition in aircraft, rotorcraft, or spacecraft design. Technical or leadership role commensurate with senior standing.

AE 4356. Space Systems Design Project I. 3 Credit Hours.
First-semester space-oriented capstone design course. Introduction to design processes for spacecraft and launch vehicle design. Students respond to two mock-proposal requests. Topics may vary. Students cannot receive credit for both AE 4356 and AE 4342.

AE 4357. Space Systems Design Project II. 3 Credit Hours.
Second-semester team-oriented space capstone design course. Competing teams of 5-6 students respond to an instructor-provided mock-RFP for a space system. Topics may vary.

AE 4358. Rotorcraft Design I. 3 Credit Hours.
Conceptual design methodology applied to rotorcraft sizing and performance estimation for a given mission. Students cannot receive credit for both AE 4358 and AE 4343.

AE 4359. Rotorcraft Design II. 3 Credit Hours.
Detailed multidisciplinary design of a rotorcraft. Teams formed to prepare competitive proposals in response to given mission requirements. Designs publicly presented and defended.

AE 4370. Life Cycle Cost Analysis. 3 Credit Hours.
Modeling of total cost of complex systems over their entire life cycle. Modeling risk uncertainty for complex energy, environmental, and military systems.

AE 4375. Fundamentals of Computer-Aided Engineering and Design. 3 Credit Hours.
Introduction to the principles of geometric modeling; 2-D systems; 3-D wireframe, surface and solid representations; mathematical representations of curves, surfaces, solids; application to aerospace design problems.

AE 4451. Jet and Rocket Propulsion. 3 Credit Hours.
AE 4461. Introduction to Combustion. 3 Credit Hours.
Basics of combustion and combustion devices. Chemical thermodynamics, reaction rates, premixed/nonpremixed flames, ignition, stabilization, and pollutants. Applications in turbine, rocket, and internal combustion engines.

AE 4521. Vehicle Guidance and Simulation. 3 Credit Hours.

AE 4525. Control System Design Laboratory. 2 Credit Hours.
Experiments in system dynamics and control with emphasis on vehicle flight control system design.

AE 4531. Aircraft Flight Dynamics. 3 Credit Hours.
Three-dimensional rigid body dynamics, aircraft equations of motion, static and dynamic stability, flight control design, introduction to aeroelastic phenomena. Students cannot receive credit for both AE 4531 and AE 3521.

AE 4532. Spacecraft Flight Dynamics. 3 Credit Hours.
Cover fundamental material in orbit and attitude dynamics. Investigate orbits, rendezvous/intercept maneuvers, interplanetary transfers, attitude coordinates, attitude stability, attitude control, and attitude estimation. Students cannot receive credit for both AE 4532 and AE 4310.

AE 4552. Introduction to Humans & Autonomy. 3 Credit Hours.
Learn the fundamental principles underlying the functions performed by humans and by autonomous systems in dynamic, complex domains. Credit will not be awarded for both AE 4552 and AE 6552.

AE 4580. Introduction to Avionics Integration. 3 Credit Hours.
Avionics in modern aerospace vehicle systems, including impact on design and performance. Specific case-studies; covers: navigation, GPS, stability augmentation, radar, health monitoring, databases, human factors, and software.

AE 4610. Dynamics and Control Laboratory. 2 Credit Hours.
Experiments in dynamics and control related to aerospace engineering topics.

AE 4698. Undergraduate Research Assistantship. 1-12 Credit Hours.
Independent research conducted under the guidance of a faculty member.

AE 4699. Undergraduate Research. 1-12 Credit Hours.
Independent research conducted under the guidance of a faculty member.

AE 4701. Wind Engineering. 3 Credit Hours.
An introductory course on wind energy and its potential; modeling and design of wind turbines; analysis of the economic benefits of wind turbine systems. Credit not allowed for both AE 4701 and ME 4701.

AE 4757. Biofluid Mechanics. 3 Credit Hours.
Introduction to the study of blood flow in the cardiovascular system. Emphasis on modeling and the potential of flow studies for clinical research application. Crosslisted with CHE and ME 4757.

AE 4758. Biosolid Mechanics. 3 Credit Hours.
The mechanics of living tissue, e.g., arteries, skin, heart muscle, ligament, tendon, cartilage, and bone. Constitutive equations and some simple mechanical models. Mechanics of cells. Applications. Crosslisted with CHE and ME 4758.

AE 4760. Engineering Acoustics and Noise Control. 3 Credit Hours.
Study of acoustics related to noise and its control; acoustics terminology wave propagation, wave equation solutions, instrumentation, data processing, room acoustics, noise control, noise legislation. Crosslisted with ME 4760.

AE 4791. Mechanical Behavior of Composites. 3 Credit Hours.
Stress-strain behavior of composites, property of matrix and reinforcing materials, mechanics of fiber-reinforced composites, lamina and laminate analysis, and mechanical performance. Crosslisted with CEE, CHE, ME, MSE, and PTFE 4791.

AE 4793. Composite Materials and Processes. 3 Credit Hours.
Basic principles of selection and design of composite materials and their manufacturing and testing. Cost factors. Laboratory exercises on manufacturing and tests. Crosslisted with CEE, CHE, ME, MSE, and PTFE 4793.

AE 4794. Composite Materials and Manufacturing Testing. 3 Credit Hours.
Basic principles of selection and sign of composite materials and their manufacturing and testing. Cost factors. Laboratory exercises on manufacturing and tests. Crosslisted with CEE, CHE, ME, MSE, and PTFE 4794.

AE 4801. Special Topics. 1 Credit Hour.
Normally taken by seniors. Course material devoted to special topics in aerospace engineering.

AE 4802. Special Topics. 2 Credit Hours.
Normally taken by seniors. Course material devoted to special topics in aerospace engineering.

AE 4803. Special Topics. 3 Credit Hours.
Normally taken by seniors. Course material devoted to special topics in aerospace engineering.

AE 4804. Special Topics. 4 Credit Hours.
Normally taken by seniors. Course material devoted to special topics in aerospace engineering.

AE 4883. Special Topics. 3 Credit Hours.

AE 4901. Special Problems in Aerospace Engineering. 1-21 Credit Hours.
Research topic selected in consultation with advisor. A brief description, endorsed by the faculty advisor, must be approved by the School.

AE 4902. Special Problems in Aerospace Engineering. 1-21 Credit Hours.
Research topic selected in consultation with advisor. A brief description, endorsed by the faculty advisor, must be approved by the School.

AE 4903. Special Problems. 1-21 Credit Hours.
Research topic selected in consultation with advisor. A brief description, endorsed by the faculty advisor, must be approved by the School.

AE 4XXX. Aerospace Engr Elective. 1-21 Credit Hours.

AE 6009. Viscous Fluid Flow. 3 Credit Hours.
Fundamental conservation laws. Laminar flows, wall-bound and free shear flows. Separation, heat transfer, and compressibility effects. Introduction to flow instability and transition to turbulence.

AE 6012. Turbulent Flows. 3 Credit Hours.

AE 6015. Advanced Aerodynamics. 3 Credit Hours.
Introduce concepts, derivation and application of aerodynamic fundamentals. Emphasis on advanced knowledge in analysis and design of fixed-wing, launch/athmospheric return vehicles, and rotating systems.
AE 6020. Elements of Compressible Flow. 3 Credit Hours.

AE 6030. Advanced Potential Flow I. 3 Credit Hours.
Unsteady potential theory for various speed ranges. Calculation of steady and unsteady aerodynamic loads on airfoils and wings. Vortex flows.
Topics of current research interest.

AE 6042. Computational Fluid Dynamics. 4 Credit Hours.

AE 6050. High-temperature Gas Dynamics I. 3 Credit Hours.
Defining equations for compressible flows, real gas properties and their effect on the behavior of equilibrium and non-equilibrium flows.

AE 6052. Flow Diagnostics and Control. 3 Credit Hours.
Introduction to experimental techniques; flow visualization; statistical methods; pressure, velocity, temperature, density, particle size, reaction rate measurements. Experiment design, data acquisition, and interpretation. Flow control.

AE 6060. Aeroacoustics. 3 Credit Hours.
Lighthill’s theory of aerodynamic noise and extensions, flow/acoustic interactions, feedback phenomenon, supersonic jet noise, aeroacoustics of ducts, propeller noise, helicopter noise, sonic boom.

AE 6070. Rotary Wing Aerodynamics. 3 Credit Hours.
Vortex wake modeling; analytical inflow theories; modern computational methods for rotary wing aerodynamic analysis; aerodynamic noise.

AE 6080. Dynamics of Turbulence. 3 Credit Hours.

AE 6100. Advanced Structural Analysis I. 3 Credit Hours.

AE 6101. Advanced Structural Analysis II. 3 Credit Hours.
Buckling of beams on elastic foundations, rings and arches; elasticity theory; torsional buckling of shafts, buckling of plates, circular cylindrical shells, rotating beams, nonconservative problems.

AE 6104. Computational Mechanics. 3 Credit Hours.
Development of finite element methods for linear, static structural analysis. The basic tools of the finite element method. The formulation of various structural elements.

AE 6106. Analysis of Aerospace Structural Elements. 3 Credit Hours.
This course focuses on the analysis of advanced aerospace structures. Beam theory is reviewed, plate theory is introduced. Classical and energy solutions are presented.

AE 6107. Analysis of Aerospace Structural Elements. 3 Credit Hours.
This course focuses on the analysis of advanced aerospace structures. Beam theory is reviewed. Examples of nonlinear behavior of materials are discussed. Plate theory is introduced; classical and energy solution methods are studied.

AE 6111. Elasticity II. 3 Credit Hours.
Stresses and deformations in continuum media. Stress and strain measures used in nonlinear elasticity. Equilibrium equations and energy principles. Nonlinear beam, plate, and shell applications.

AE 6112. Inelastic Response. 3 Credit Hours.

AE 6114. Fundamentals of Solid Mechanics. 3 Credit Hours.
Unified overview of fundamental aspects of solid mechanics, from nonlinear continuum mechanics to linear elasticity, including an introduction to energy methods and other special topics.

AE 6115. Fundamentals of Aerospace Structural Analysis. 3 Credit Hours.
Overview and fundamentals of aerospace structural analysis, including virtual work and energy methods, buckling and advanced structural theories.

AE 6123. Design of Fiber-Reinforced Composite Structures. 3 Credit Hours.
Composite material systems, composite structures including anisotropic plate and shell theory, shear deformation, hygrothermal and interlaminar stresses. Finite element modeling. Design case studies and cost-effective applications for thin-walled sections.

AE 6161. Theory of Plates. 3 Credit Hours.
Development of isotropic and anisotropic plate theories. Classical and energy solutions for various geometrics and loadings. Aerospace applications including elastically coupled composite and sandwich plates.

AE 6162. Shell Structures. 3 Credit Hours.
Analysis of stresses and deformation of shells with and without bending, shells forming surfaces of revolution, asymptote methods, buckling of shells, nonlinear theories.

AE 6165. Principles of Fracture and Fatigue. 3 Credit Hours.

AE 6170. Structural Optimization. 3 Credit Hours.
Mathematical methods of constrained optimization, sensitivity analysis, approximation concepts, decomposition techniques, shape optimization in the context of structural design.

AE 6200. Advanced Aeroelasticity I. 3 Credit Hours.
Understanding and analysis of aeroelastic phenomena in fixed-wing aircraft, static aeroelasticity, dynamic aeroelasticity, and dynamic response and transient stresses in aircraft structures.

AE 6210. Advanced Dynamics I. 3 Credit Hours.
Kinematics of particles and rigid bodies, angular velocity, inertia properties, holonomic and nonholonomic constraints, generalized forces.

AE 6211. Advanced Dynamics II. 3 Credit Hours.
A continuation of AE 6210. Equations of motion, Newtonian frames, consistent linearization, energy and momentum integrals, collisions, mathematical representation of finite rotation.

AE 6220. Rotorcraft Structural Dynamics and Aeroelasticity. 3 Credit Hours.
Elementary blade dynamics, flap-lag dynamics, ground resonance, structural dynamics of rotating beams, nonlinear elastic blade analysis, harmonic balance and trim, Floquet theory.

AE 6230. Structural Dynamics. 3 Credit Hours.
Dynamic response of single-degree-of-freedom systems, Lagrange's equations; modal decoupling; vibration of Euler-Bernoulli and Timoshenko beams, membranes and plates.
AE 6231. System Identification in Structural Dynamics. 3 Credit Hours.
System identification by complex exponential methods, poly ref
techniques, eigen-realization methods and frequency domain methods.
Effects of noise, generalized least squares, and recursive online
identification.

AE 6240. Numerical Methods in Structural Dynamics. 3 Credit Hours.
Rayleigh quotient, Rayleigh-Ritz and Galerkin methods; extraction of
eigenvalues and eigenvectors; analysis of forced harmonic response;
direct time integration of large-scale systems.

AE 6251. Experimental Methods in Structural Dynamics. 3 Credit Hours.
Experimental methods for measurement of structural vibration, random
vibration, analytical methods for analysis of vibration data, applications
to single and multi-degree- of-freedom problems.

AE 6252. Smart Structures and Structural Control. 3 Credit Hours.
Modeling smart sensors and actuators, development of closed loop
models, design of controllers, validation of controllers, application to
vibration control, noise control, and shape control.

AE 6263. Flexible Multi-body Dynamics. 3 Credit Hours.
Nonlinear, flexible multi-body dynamic systems, parameterization of finite
rotations, strategies for enforcement of holonomic and non holonomic
constraints, formulation of geometrically nonlinear structural elements,
time-integration techniques.

AE 6270. Applied Nonlinear Dynamics. 3 Credit Hours.
Nonlinear vibration methods through averaging and multiple scales,
bifurcation, periodic and quasi-periodic systems, transition to chaos,
characterization of chaotic vibrations, thermodynamics of chaos, chaos
control.

AE 6280. Wave Propagation. 3 Credit Hours.
Dilational, equivalence mixed waves; Rayleigh and Lamb waves, reflection,
refraction, impact problems, plastic waves, N.D.E, vibration control,
numerical methods, finite deformation wave propagation, constitutive
equations.

AE 6310. Optimization for the Design of Engineered Systems. 3 Credit
Hours.
Introduction to optimization problem formulations for engineering design,
algorithms for constrained nonlinear programming, multiobjective and
multidisciplinary optimization, and robust design optimization.

AE 6322. Spacecraft and Launch Vehicle Design I. 4 Credit Hours.
Early design of spacecraft and launch vehicles. Emphasis on preliminary
vehicle sizing and performance, effect of new technologies, and
disciplinary interactions. Individual design projects.

AE 6323. Spacecraft and Launch Vehicle Design II. 3 Credit Hours.
Space Vehicle Design methodology further developed and applied. Teams
formed to prepare competitive proposals in response to given mission
requirements. Designs publicly presented and defended.

AE 6333. Rotorcraft Design I. 3 Credit Hours.
System approach to conceptual design of aerospace systems with
emphasis on rotorcraft. Comprehensive methodologies for aerospace
vehicle synthesis and sizing. Integration of technologies. Students
cannot receive credit for both AE 6333 and AE 4343.

AE 6334. Rotorcraft Design II. 4 Credit Hours.
Students work together on this application to complete the preliminary
design stage of a specific rotorcraft. Participants are exposed to
disciplinary and interdisciplinary issues.

AE 6343. Aircraft Design I. 3 Credit Hours.
Stochastic approach to conceptual design of aerospace systems with
emphasis on aircraft and missiles. Comprehensive methodologies for
aerospace vehicle synthesis and sizing. Integration of technologies.

AE 6344. Aircraft Design II. 4 Credit Hours.
Students work together on this application to complete the preliminary
design stage of a specific aircraft or missile. Participants are exposed to
disciplinary and interdisciplinary issues.

AE 6353. Orbital Mechanics. 3 Credit Hours.
First graduate-level astrodynamics class that includes two-body orbital
mechanics, orbit determination, orbit prediction, orbital maneuvers, lunar
and interplanetary trajectories, orbital rendezvous and space navigation.

AE 6354. Advanced Orbital Mechanics. 3 Credit Hours.
Advanced concepts in orbital mechanics including orbit determination,
orbital perturbations, time of flight, rendezvous, low thrust trajectories,
and multi-body problems. Taught in alternate years.

AE 6355. Planetary Entry, Descent and Landing. 3 Credit Hours.
Enter flight mechanics and dynamics, aerothermodynamics, thermal
protection systems, aerodynamic decelerators, descent and landing.
Robotic and human exploration mission studies for aerobraking,
planetary entry, aerocapture.

AE 6361. Air Breathing Propulsion System Design I. 3 Credit Hours.
Air breathing propulsion design with emphasis on multidisciplinary
design issues related to system integration, cycle selection, performance,
cost, reliability, maintainability, etc.

AE 6362. Safety by Design. 4 Credit Hours.
Autonomous situational flight model allows students to examine complex
behaviors in the "pilot-vehicle-operational conditions" system. Flight
certification and airworthiness requirements are mapped into formal
scenarios.

AE 6372. Aerospace Systems Engineering. 3 Credit Hours.
Introduction to aerospace systems engineering. Systems engineering
and quality engineering methods and tools. Top-down design decision
support processes, computer integrated environments, Integrated
Product/Process Development (IPPD).

AE 6373. Advanced Design Methods I. 4 Credit Hours.
Introduction to modern probabilistic design methods and techniques.
Design of experiments, Taguchi methods, response surface equations,
robust design, risk and uncertainty, technology assessment and
selection.

AE 6374. Advanced Design Methods II. 3 Credit Hours.
Introduction to modern multidisciplinary design optimization methods
and techniques. Numerical optimization with applications, stochastic
methods, Genetic Algorithms, multidisciplinary decomposition methods,
multi-level optimization strategies.

AE 6380. Fundamentals of Computer-aided Design and Engineering. 3
Credit Hours.
Introduction to the principles of geometric modeling; 2-D systems;
3-D wireframe, surface and solid representations; mathematical
representations of curves, surfaces, solids; application to aerospace
design problems. Credit not allowed for both AE 4375 and AE 6380.

AE 6381. Software Development for Engineering Applications. 3 Credit
Hours.
Introduction to the development of engineering analysis and visualization
software for UNIX workstations with emphasis on rapid prototyping,
information modeling, distributed processing, and client/server
architectures.
AE 6382. Computing Systems for Engineering Research Laboratory. 1 Credit Hour.
Introduction to computational systems used for engineering research. Basics of Unix and Windows operating systems, survey of the major programming languages, and computing frameworks.

AE 6383. Applied Design Laboratory. 1 Credit Hour.
Introduction to computing tools and processes used in subsequent applied design courses in graduate fixed wing, rotary wing, and space systems design tracks.

AE 6410. Combustion Dynamics. 3 Credit Hours.
Acoustic wave propagation in inhomogeneous flows, flame-acoustic wave interactions, and control of combustion-driven oscillations.

AE 6412. Turbulent Combustion. 3 Credit Hours.

AE 6414. Multi-Phase Combustion. 3 Credit Hours.

AE 6440. Turbine Engine Aerothermodynamics. 3 Credit Hours.
Analysis and design of gas turbine engine components including axial flow compressors, turbines, inlets, and nozzles. Heat transfer and turbine blade cooling.

AE 6445. Combustor Fundamentals. 3 Credit Hours.
Examination of the chemical and aerothermodynamic processes that govern gas turbine combustor performance and design. Also fuel injection, noise, emissions, and testing methodologies.

AE 6450. Rocket Propulsion. 3 Credit Hours.
Analysis and design of rocket engines including liquid, solid, hybrid, and advanced propulsion systems.

AE 6451. Electric Propulsion. 3 Credit Hours.
The course provides a solid background of the operating principles, performance characteristics, and design features of the state-of-the-art electric propulsion systems.

AE 6503. Helicopter Stability and Control. 3 Credit Hours.
Helicopter general equations of motion, rotor forces and moments, helicopter stability and control characteristics, handling qualities, flight control system design.

AE 6504. Modern Methods in Aircraft Flight Control. 3 Credit Hours.
Linear quadratic regulator design. Model following control. Stochastic control. Fixed structure controller design. Applications to aircraft flight control.

AE 6505. Random Processes and Kalman Filtering. 3 Credit Hours.
Probability and random variables and processes; correlation; shaping filters; simulation of sensor errors; Wiener filter; random vectors; covariance propagation; recursive least-squares; Kalman filter; extensions.

AE 6506. Aerospace Guidance and Navigation. 3 Credit Hours.

AE 6511. Optimal Guidance and Control. 3 Credit Hours.
Euler-Lagrange formulation; Hamilton-Jacobi approach; Pontryagin’s minimum principle; Systems with quadratic performance index; Second variation and neighboring extremals; Singular solutions; numerical solution techniques.

AE 6520. Advanced Flight Dynamics. 3 Credit Hours.
Reference frames and transformations, general equations of unsteady motion, application to fixed-wing, rotary-wing and space vehicles, stability characteristics, flight in turbulent atmosphere.

AE 6530. Multivariable Linear Systems and Control. 3 Credit Hours.
Techniques for analysis and description of multivariable linear systems. Tools for advanced feedback control design for these systems, including computational packages. Credit will not be awarded for both AE 6530 and ECE 6650 or AE 6530 and ME 6401.

AE 6531. Aerospace Robust Control I. 3 Credit Hours.

AE 6532. Aerospace Robust Control II. 3 Credit Hours.
Advanced treatment of robustness issues. Controller analysis and design for linear and nonlinear systems with structured and non-structured uncertainty. Reduced-order control, stability, multipliers, and mixed-mu.

AE 6534. Control of Aerospace Structures. 3 Credit Hours.
Advanced treatment of control of flexible structures. Topics include stability of multi-degree-of-freedom systems, passive and active absorbers and isolation, positive real models, and robust control for flexible structures.

AE 6551. Cognitive Engineering. 3 Credit Hours.
Cognitive engineering addresses a range of technologies and work environments that will support human cognitive performance, including information systems, decision support, automation, and intelligent systems.

AE 6552. Advanced Topics in Humans and Autonomy. 3 Credit Hours.
Establish a deep understanding of the theoretical basis for functions performed by humans and by autonomous systems in dynamic, complex domains.

AE 6561. Reliable Control Software for Aerospace and Embedded Applications. 3 Credit Hours.
Basic principles of reliable control and embedded software design, with aerospace applications. Programming languages and their specific features covered in student projects.

AE 6571. Air Traffic Control and Management. 3 Credit Hours.
Fundamentals and technologies of air traffic control and management in the areas of communication, navigation, surveillance; decision aiding, automation; conflict detection resolution; collaborative decision-making.

AE 6580. Aerospace Nonlinear Control. 3 Credit Hours.

AE 6694. Graduate Internship. 1-21 Credit Hours.
Graduate Internship for which the student is paid.

AE 6701. Wind Engineering. 3 Credit Hours.
An introductory course on wind energy and its potential; modeling and design of wind turbines; analysis of the economic benefits of wind turbine systems. Credit will not be awarded for both AE 6701 and ME 6701.

AE 6721. Evaluation of Human Integrated Systems. 3 Credit Hours.
Evaluation of human integrated systems including translating research questions into measurable objectives, overview of evaluation methods and data analysis techniques applicable to such systems. Credit not allowed for both AE 6721 and ISYE 6231.
AE 6760. Acoustics I. 3 Credit Hours.
Fundamental principles governing the generation, propagation, reflection, and transmission of sound waves in fluids. Crosslisted with ME 6760.

AE 6761. Engineering Acoustics II. 3 Credit Hours.
Radiation and scattering of sound waves in fluids, duct acoustics, dissipation phenomena. Crosslisted with ME 6761.

AE 6762. Applied Acoustics. 3 Credit Hours.
Mufflers, resonators, acoustic materials, barriers, industrial noise, room acoustics, active noise control. Crosslisted with ME 6762.

AE 6765. Kinetics and Thermodynamics of Gases. 4 Credit Hours.
Thermodynamics of nonreacting and reacting gas mixtures. Introductory quantum theory, statistical thermodynamics, and gas kinetic theory. Crosslisted with ME 6765.

AE 6766. null. 3 Credit Hours.
Introductory chemical kinetics, detonations and deflagrations, laminar flame propagation in premixed gases, ignition and quenching, laminar diffusion flames and droplet burning, turbulent reacting flows. Crosslisted with ME 6766.

AE 6767. Combustion II. 3 Credit Hours.
Turbulent combustion, combustion instability and control, solid propellants and explosives, chemical kinetics, pollutant formation and destruction, computational and experimental methods for reacting flows. Crosslisted with ME 6767.

AE 6769. Linear Elasticity. 3 Credit Hours.
Governing equations of linear elasticity, plane elasticity, boundary value problems, airy stress function and complex variable methods, simple three-dimensional solutions. Crosslisted with ME 6769.

AE 6770. Energy and Variational Methods in Elasticity and Plasticity. 3 Credit Hours.
Applications of energy and variational methods in engineering mechanics to elastic, plastic, and dynamical behavior of deformable bodies. Crosslisted with ME 6770.

AE 6779. Dynamic System Simulation and Modeling. 3 Credit Hours.
Models of dynamic systems, such as aircraft, ground vehicles and machinery, and manual control. Numerical simulation techniques and applications. Interactive simulators. Student programming project. Crosslisted with ISYE 6779.

AE 6XXX. Aerospace Engr Elective. 1-21 Credit Hours.

AE 7000. Master's Thesis. 1-21 Credit Hours.

AE 7764. Acoustic Propagation. 3 Credit Hours.
Propagation of sound in inhomogeneous fluids; ray acoustics, ocean and atmospheric acoustics, nonlinear acoustics. Crosslisted with ME 7764.

AE 7772. Fundamentals of Fracture Mechanics. 3 Credit Hours.
Advanced study of failure of structural materials under load, mechanics of fracture, and microscopic and macroscopic aspects of the fracture of engineering materials. Crosslisted with CHE, CEE, ME, and MSE 7772.

AE 7773. Advanced Fracture Mechanics. 3 Credit Hours.
Nonlinear fracture mechanics including elastic-plastic and time-dependent fracture, advanced test methods, J-integral theory, and extensions. Crosslisted with CEE, CHE, ME, and MSE 7773.

AE 7774. Fatigue of Materials and Structures. 3 Credit Hours.
Mechanical and microstructural aspects of nucleation and growth of cracks under cyclic loading conditions, notch effects, cumulative damage, multiaxial loading, and fatigue crack propagation. Crosslisted with CEE, CHE, ME, and MSE 7774.

AE 7775. Topics in Fracture and Fatigue of Metallic and Composite Structures. 3 Credit Hours.

AE 7785. Introduction to Robotics Research. 3 Credit Hours.
Familiarizes students with the core areas of robotics; mechanics, control, perception, AI, and autonomy. Provides an introduction to the mathematical tools required in robotics research.

AE 7791. Damage, Failure and Durability of Composite Materials. 3 Credit Hours.

AE 7792. Advanced Mechanics of Composites. 3 Credit Hours.
Anisotropic elasticity, hygrothermal behavior, stress analysis of laminated composites including 3D effects, stress concentrations, free-edge effects, thick laminates, adhesive and mechanical connections, fracture of composites. Crosslisted with CHE, CEE, ME, MSE, and PTFE 7792.

AE 7793. Manufacturing of Composites. 3 Credit Hours.
Major manufacturing techniques of metal-ceramic and polymer-matrix composites. Modeling of processes with emphasis on fundamental mechanisms and effects. Crosslisted with CHE, CEE, ME, MSE, and PTFE 7793.

AE 8001. Design Seminar. 1 Credit Hour.
Case studies of existing aerospace systems; assessment of design payoffs and risks; industry experts provide case examples and knowledge transfer to course participants; field trips.

AE 8002. AE Graduate Seminar. 1 Credit Hour.
Introduce AE graduate students to world-class aerospace researchers and topics, discuss and demonstrate basic graduate student resources and skills.

AE 8750. Robotics Research Foundation I. 3 Credit Hours.
Multidisciplinary research course supervised by two robotics faculty from different schools participating in the robotics Ph.D. program.

AE 8751. Robotics Research Foundation II. 3 Credit Hours.
Continuation of AE 8751 (Robotics Research Foundation I).

AE 8801. Special Topics. 1 Credit Hour.
Special topics of current interest.

AE 8802. Special Topics. 2 Credit Hours.
Special topics of current interest.

AE 8803. Special Topics. 3 Credit Hours.
Special topics of current interest.

AE 8804. Special Topics. 4 Credit Hours.
Special topics of current interest.

AE 8805. Special Topics. 5 Credit Hours.
Special topics of current interest.
AE 8883. Special Topics. 3 Credit Hours.
AE 8900. Special Problems. 1-21 Credit Hours.
AE 8901. Special Problems. 1-21 Credit Hours.
AE 8902. Special Problems. 1-21 Credit Hours.
AE 8903. Special Problems. 1-21 Credit Hours.
AE 8997. Teaching Assistantship. 1-9 Credit Hours.
For graduate students holding graduate teaching assistantships.
AE 8998. Research Assistantship. 1-9 Credit Hours.
For graduate students holding graduate research assistantships.
AE 8999. Preparation for Doctoral Dissertation. 1-21 Credit Hours.
AE 9000. Doctoral Thesis. 1-21 Credit Hours.