AEROSPACE ENGINEERING (AERE)

Courses primarily for undergraduates:

AERE 1600: Aerospace Engineering Problems With Computer Applications Laboratory
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: Credit or enrollment in MATH 1650 *or satisfactory (76+) score on mathematics placement exam*
Introduction to aerospace engineering and systems thinking through engineering design team projects such as flight control of Lighter Than Air (LTA) vehicles. Introduction to programming using python. Solving aerospace engineering problems while learning about significant figures, estimation, units of measure, graphing, curve fitting, and presenting solutions through technical reports. Brief history of aerospace engineering. Satisfactory placement scores can be found at: https://math.iastate.edu/academics/undergraduate/aleks/placement/. Graduation Restriction: Only one of ENGR 1600, ABE 1600, AERE 1600, BME 1600, CE 1600, CHE 1600, CPRE 1850, EE 1850, IE 1480, ME 1600, and SE 1850 may count towards graduation. (Typically Offered: Fall, Spring)

AERE 1600H: Aerospace Engineering Problems With Computer Applications Laboratory: Honors
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: Credit or enrollment in MATH 1650 *or satisfactory (76+) score on mathematics placement exam; Membership in the University Honors Program*

Solving aerospace engineering problems and presenting solutions through technical reports. Significant figures and estimation. SI units. Graphing and curve fitting. Introduction to aerospace engineering and engineering design. Spreadsheet programs. History of aerospace. Systems thinking. Team projects. Satisfactory placement scores can be found at: https://math.iastate.edu/academics/undergraduate/aleks/placement/. Graduation Restriction: Only one of ENGR 1600, ABE 1600, AERE 1600, CE 1600, CHE 1600, CPRE 1850, EE 1850, IE 1480, ME 1600, and SE 1850 may count towards graduation. (Typically Offered: Fall, Spring)

AERE 1610: Numerical, Graphical and Laboratory Techniques for Aerospace Engineering
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
Prereq: Credit or enrollment in ABE 1600*,* AERE 1600*,* BME 1600*,* CE 1600*,* CHE 1600*,* CPRE 1850*,* EE 1850*,* ENGR 1600*,* IE 1480*,* ME 1600*, or SE 1850*
Computer-based problem solving using Matlab(R), with emphasis on numerical methods. Introduction to solid modeling and aerospace design using SolidWorks. (Typically Offered: Fall, Spring)

AERE 1610H: Numerical, Graphical and Laboratory Techniques for Aerospace Engineering: Honors
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
Prereq: ABE 1600*,* AERE 1600*,* BME 1600*,* CE 1600*,* CHE 1600*,* CPRE 1850*,* EE 1850*,* ENGR 1600*,* IE 1480*,* ME 1600*, or SE 1850*
Computer-based problem solving using Matlab(R), with emphasis on numerical methods. Introduction to solid modeling and aerospace design using SolidWorks. (Typically Offered: Fall, Spring)

AERE 1920: Aerospace Seminar
Credits: Required. Contact Hours: Lecture 1.
Vectors, differentiation, integration, matrices, and systems of linear equations. (Typically Offered: Spring)

AERE 1920H: Aerospace Seminar: Honors
Credits: Required. Contact Hours: Lecture 1.
Vectors, differentiation, integration, matrices, and systems of linear equations. (Typically Offered: Spring)

AERE 2610: Introduction to Performance and Design
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATH 1660 *or* MATH 1660H*; PHYS 2210 or* PHYS 2310 *or* PHYS 2310H*;* PHYS 2310L*; Credit or enrollment in* AERE 1610
Aerodynamics of the airplane, lift and drag, drag polar, propulsion characteristics of turbojets and piston props, level flight, range, endurance, climbing flight, turning flight, take-off and landing, design examples. (Typically Offered: Fall, Spring)

AERE 2650: Scientific Balloon Engineering and Operations
Credits: 1. Contact Hours: Laboratory 2.
Repeatable.
Engineering aspects of scientific balloon flights. Integration of science mission objectives with engineering requirements. Operations team certification. FAA and FCC regulations, communications, and command systems. Flight path prediction and control. (Typically Offered: Fall)

AERE 2900A: Aerospace Engineering Independent Study: Flight Ground Instruction
Credits: 1-2. Repeatable.
Prereq: Sophomore classification, approval of the department

AERE 2900B: Aerospace Engineering Independent Study: In-flight Training
Credits: 1-2. Repeatable.
Prereq: Instructor Permission for Course

AERE 2900C: Aerospace Engineering Independent Study: Other
Credits: 1-2. Repeatable.
Prereq: Instructor Permission for Course

AERE 2940: Make to Innovate I
Credits: 1. Repeatable.
Prereq: Freshman or Sophomore classification
Multidisciplinary projects to engage students in the fundamentals of engineering, project management, systems engineering, teamwork, and oral and visual communication. Students will define and attain their team objectives and milestones that are approved by the instructor. Graduation Restriction: Can only be used toward graduation in these cases. To make credit deficiencies in 1000 or 2000 level courses. No more than 2 credits of AERE 2940 can be used to make-up credit deficiencies in 1000 or 2000 level courses. Cannot be used in any category or technical electives in the AERE curriculum. (Typically Offered: Fall, Spring)

AERE 3010: Flight Experience
Credits: Required.
Prereq: Credit or enrollment in AERE 3550
Two hours of in-flight training and necessary ground instruction. Course content prescribed by the Aerospace Engineering Department. Ten hours of flight training certified in a pilot log book can be considered by the course instructor as evidence of satisfactory performance in the course. Offered on a satisfactory-fail basis only. (Typically Offered: Fall, Spring)

AERE 3100: Aerodynamics I: Incompressible Flow
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATH 2650*; Grade of C- or better in* AERE 2610
Introduction to fluid mechanics and aerodynamics. Fluid properties and kinematics. Conservation equations in differential and integral form. Bernoulli's equation. Basic potential flow concepts and solutions. Boundary layer concept. Incompressible flow over airfoils and wings. Examples of numerical methods. Applications of multi-variable calculus to fluid mechanics and aerodynamics. (Typically Offered: Fall, Spring)

AERE 3110: Aerodynamics II: Compressible Flow
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3100 *and* ME 2310
Review of thermodynamics, energy equation, compressible flow, and isentropic flow. Normal and oblique shocks. Mach waves and expansion fans. Applications to ducts and nozzles. Compressible airfoil and wing theory. Introduction to advanced compressible flow topics. (Typically Offered: Fall, Spring)

AERE 3210: Flight Structures Analysis
Credits: 3. Contact Hours: Lecture 3.
Prereq: EM 3240 *and Credit or concurrent enrollment in* MATH 2660 *or* MATH 2670
Introduction to elasticity, airworthiness, and flight loads. Introduction to fatigue. Materials selection for flight applications. Thin walled cross-sections under bending, torsion, and shear loads using classical methods. Shear center. Column buckling. Matrix methods of structural analysis. (Typically Offered: Fall, Spring)

AERE 3220: Aerospace Structures Laboratory
Credits: 2. Contact Hours: Lecture 1, Laboratory 2.
Prereq: Credit or enrollment in AERE 3210
Design of experiments. Data analysis. Strain gage installation. Measurement of stiffness/strength of aluminum. Analysis/fabrication/testing of riveted joints. Shear/bending measurements inbeam sections. Analysis/measurement of strains in frames. Buckling of columns. Stress concentration. Vibration testing of beams and plates. Fabrication/testing of composites. (Typically Offered: Fall, Spring)

AERE 3310: Flight Control Systems I
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3550
Linear system analysis. Control system designs using root-locus and frequency response methods. Applications in flight control systems. (Typically Offered: Fall, Spring)

AERE 3440: Aerodynamics and Propulsion Laboratory
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: AERE 3100 *AND concurrent enrollment in* AERE 3110
Similitude and dimensional analysis. Measurement uncertainty analysis. Pressure and velocity measurement methods and instruments. Pressure distribution around a circular cylinder. Aerodynamic performance of low-speed airfoils. Airfoil wake flow; Boundary layer flow. Flow visualization techniques for supersonic flows and de Laval nozzles. (Typically Offered: Fall, Spring)

AERE 3510: Astrodynamics I
Credits: 3. Contact Hours: Lecture 3.
Prereq: ME 3450
Introduction to astrodynamics. Two-body Keplerian satellite and planetary motion. Geocentric and extraterrestrial trajectories and applications. Ballistic missiles. (Typically Offered: Fall, Spring)

AERE 3550: Aircraft Flight Dynamics and Control
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 2610*,* MATH 2670*, and* ME 3450
Aircraft rigid body equations of motion, linearization, and modal analysis. Longitudinal and lateral-directional static and dynamic stability analysis. Flight handling characteristics analysis. Longitudinal and lateral-directional open loop response to aircraft control inputs. Aircraft flight handling qualities. (Typically Offered: Fall, Spring)

AERE 3610: Computational Techniques for Aerospace Design
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: AERE 3100*;* EM 3240*; (*ENGL 3090 *or* ENGL 3140*);* ME 3450*;* MATH 2670
Advanced programming, workstation environment, and development of computational tools for aerospace analysis and design. Technical report writing. (Typically Offered: Fall, Spring)

AERE 3620: Aerospace Systems Integration
Credits: 3. Contact Hours: Lecture 3.
Prereq: ENGL 2500*, Junior classification in Aerospace Engineering or permission of instructor for* AERE 3620
Emphasis on impact of component interfaces in aerospace systems. Understand how changes in variables associated with individual components impact the performance of the aerospace system. Solving aerospace engineering problems and presenting solutions through reports. Specific integration challenges include: capturing implicit disciplinary interactions (e.g. structures/aerodynamics, propulsion/aerodynamics, etc.), propagating tolerances through the system (i.e. uncertainty modeling), balancing component attributes in the system objective. (Typically Offered: Fall, Spring)

AERE 3640X: Cyber-Physical Systems Application
(Cross-listed with CPS 3640X).
Credits: 3. Contact Hours: Laboratory 2, Lecture 2.
Repeatable.
Prereq: ENGR 1600 *or equivalent; credit or enrollment in* MATH 2670
Fundamental principles of cyber-physical systems and their system-level applications at an introductory level; introduction to radio control systems and control of actuators; computer programming of physical systems; data processing and communication; control loops; X-by-wire control systems; simulation; testing of control loops. (Typically Offered: Spring)

AERE 3810: Introduction to Wind Energy
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATH 1660 *or* MATH 1660H*;* PHYS 2310 *or* PHYS 2310H*;* PHYS 2310L
Basic introduction to the fundamentals of Wind Energy and Wind Energy conversion systems. Topics include but not limited to various types of wind energy conversion systems and the aerodynamics, blade and tower structural loads, kinematics of the blades and meteorology. (Typically Offered: Spring)

AERE 4070: Applied Formal Methods
(Dual-listed with AERE 5070/ COMS 5070). (Cross-listed with COMS 4070).
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3610 *for AERE majors.* COMS 3110 *for COMS majors.* AERE 3610 *or* COMS 3110*, or an equivalent course, plus instructor permission for other majors.*
Introduction to the fundamentals of formal methods, a set of mathematically rigorous techniques for the formal specification, validation, and verification of safety- and security-critical systems. Tools, techniques, and applications of formal methods with an emphasis on real-world use-cases such as enabling autonomous operation. Build experience in writing mathematically analyzable specifications from English operational concepts for real cyberphysical systems, such as aircraft and spacecraft. Review capabilities and limitations of formal methods in the design, verification, and system health management of today's complex systems. (Typically Offered: Spring)

AERE 4110: Aerospace Vehicle Propulsion
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3110 *and* AERE 3440
Atmospheric propulsion system performance and cycle analysis. Momentum theorem, thrust and propulsive efficiency. Thermodynamics of compressible flow with heat and work addition. Components and principles of turbojet, ramjet, and turbofan aircraft engines. Introduction to rocket engines. (Typically Offered: Fall, Spring)

AERE 4120: Spacecraft Electric Propulsion
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3110
Electricity and magnetism. Plasma physics. Ion engine performance. Introduction to advanced electromagnetic propulsion systems. Energy sources and nuclear propulsion. Space mission requirements. (Typically Offered: Spring)

AERE 4150: Rocket Propulsion
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3110 *and* AERE 3440
Components and principles of liquid rocket engines, solid rocket motors, and hybrid rocket motors. Rocket flight performance and rocket staging. Combustion and thermochemistry. Rocket cooling and nozzle heat transfer. Introduction to nuclear thermal propulsion and electric propulsion systems. Applications to spacecraft. (Typically Offered: Fall, Spring)

AERE 4170: Experimental Mechanics
(Dual-listed with EM 5170/ AERE 5170). (Cross-listed with EM 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)

AERE 4210: Advanced Flight Structures
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: AERE 3210*,* MATH 2660 *or* MATH 2670
Analysis of indeterminate flight structures including finite element laboratory. Static analysis of complex structural components subject to thermal and aerodynamic loads. Analytical and finite element solutions for stresses and displacements of membrane, plane stress, plate structures. Buckling of beams, frames, and plate structures. Introduction to vibration of flight structures. Steady state and transient structural response using normal modal analysis. (Typically Offered: Fall, Spring)

AERE 4220: Vibrations and Aeroelasticity
Credits: 3. Contact Hours: Lecture 3.
Prereq: EM 3240 *or* AERE 3210
Vibration theory. Steady and unsteady flows. Mathematical foundations of aeroelasticity, static and dynamic aeroelasticity. Linear unsteady aerodynamics, non-steady aerodynamics of lifting surfaces. Stall flutter. Aeroelastic problems in civil engineering structures. Aeroelastic problems of rotorcraft. Experimental aeroelasticity. Selected wind tunnel laboratory experiments. Offered even-numbered years. (Typically Offered: Spring)

AERE 4230: Composite Flight Structures
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: EM 3240*, and* MATE 2730
Fabrication, testing and analysis of composite materials used in flight structures. Basic laminate theory of beams, plates and shells. Manufacturing and machining considerations of various types of composites. Testing of composites for material properties, strength and defects. Student projects required. (Typically Offered: Spring)

AERE 4260: Design of Aerospace Structures
(Dual-listed with AERE 5260).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: EM 3240
Detailed design and analysis of aerospace vehicle structures. Material selection, strength, durability and damage tolerance, and validation analysis. Design for manufacturability. (Typically Offered: Fall)

AERE 4320: Flight Control Systems II
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3310
Aircraft lateral directional stability augmentation. Launch vehicle pitch control system design. Control of flexible vehicles. Satellite attitude control. Flight control designs based on state-space methods. Introduction to sample-data systems. (Typically Offered: Fall)

AERE 4330: Spacecraft Dynamics and Control
Credits: 3. Contact Hours: Lecture 3.
Prereq: ME 3450
Three-dimensional rotational kinematics and attitude dynamics of a rigid body in space. Classical stability analysis of spinning spacecraft with or without energy dissipation. Attitude dynamics, stability, and control of spacecraft in a circular orbit in the presence of gravity-gradient torques. Introduction to spacecraft attitude determination and control systems (ADCS) with emphasis on modern attitude determination algorithms. Simulation of spacecraft attitude dynamics and control problems of practical interest using programming and analysis software. (Typically Offered: Fall)

AERE 4420: V/STOL Aerodynamics and Performance
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 2610
Introduction to the aerodynamics, performance, stability, control and critical maneuvering characteristics of V/STOL vehicles. Topics include hovercrafts, jet flaps, ducted fans and thrust vectored engines. (Typically Offered: Fall)

AERE 4450: Experimental Flow Mechanics and Heat Transfer
(Dual-listed with AERE 5450).
Credits: 3. Contact Hours: Lecture 3.
Prereq: ABE 3780 *or* AERE 3100 *or ME 3350*
Similitude and dimensional analysis. Measurement uncertainty analysis; Fluid mechanical apparatus: wind tunnel and water tunnels. Various experimental techniques widely used for fluid mechanics, aerodynamics, heat transfer, and combustion studies: Pressure gauge and transducers; Pitot tube; hot wire anemometry; Shadowgraph and Schlieren Photography; laser Doppler velocimetry; particle image velocimetry (PIV); advanced PIV techniques (stereo PIV, 3-D PIV, Tomographic PIV, Holograph PIV and microscopic PIV); laser induced fluorescence; pressure sensitive painting, temperature sensitive painting; molecular tagging velocimetry; molecular tagging thermometry. Extensive applications and laboratory experiments will be included. (Typically Offered: Fall)

AERE 4460: Computational Fluid Dynamics
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3110 *and* AERE 3610
Introduction to computational fluid dynamics. Discretization, consistency, and stability. Explicit and implicit methods for ordinary and partial differential equations. Linearization techniques. Iterative and direct solution algorithms. Numerical methods for parabolic, elliptic and hyperbolic equations. Curvilinear coordinates and numerical grid generation. Applications to Euler, boundary-layer and Navier-Stokes equations. Proficiency in at least one programming language recommended. (Typically Offered: Fall)

AERE 4480: Fluid Dynamics of Turbomachinery
(Cross-listed with ME 4480).
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3110 *or ME 3350*
Applications of principles of fluid mechanics and thermodynamics in performance analysis and design of turbomachines. Conceptual and preliminary design of axial and radial flow compressors and turbines using velocity triangles and through-flow approaches. (Typically Offered: Spring)

AERE 4510: Astrodynamics II
(Dual-listed with AERE 5510).
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3510
Orbit determination and prediction using Gibb's and Gauss' methods. Advanced orbit maneuvers, triple-, and fixed-impulse; universal variables; Kepler's problem. Earth gravity field models and gravity harmonics, orbit perturbations, advanced dynamics, variational methods, relative orbital mechanics, and Clohessy-Wiltshire equations. (Typically Offered: Fall, Spring)

AERE 4520: Introduction To Systems Engineering And Analysis
(Cross-listed with IE 4520).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Junior Classification in an Engineering Major
Principles of systems engineering to include problem statement formulation, stakeholder analysis, requirements definition, system architecture and concept generation, system integration and interface management, verification and validation, and system commissioning and decommissioning operations. Introduction to discrete event simulation processes. Students will work in groups to propose, research, and present findings for a systems engineering topic of current relevance. (Typically Offered: Summer)

AERE 4610: Modern Design Methodology with Aerospace Applications
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: AERE 3610, AERE 3110, AERE 3210, AERE 3220, AERE 3440, AERE 3510, *and* AERE 3550
Introduction to modern engineering design methodology. Computational constrained optimal design approach including selection of objective function, characterization of constraint system, materials and strength considerations, and sensitivity analyses. The class contains two focus sections. One section assigns design projects in Aeronautics, and the other assigns design projects in Astronautics. (Typically Offered: Fall, Spring)

AERE 4620: Design of Aerospace Systems
Credits: 3. Contact Hours: Lecture 1, Laboratory 4.
Prereq: AERE 4610
Fundamental principles used in engineering design of aircraft, rockets, and space systems. Preliminary design of aerospace vehicles. Engineering Ethics. The class contains two focus sections. One section assigns design projects in Aeronautics, and the other section assigns design projects in Astronautics. (Typically Offered: Fall, Spring)

AERE 4630: Introduction to Multidisciplinary Design Optimization (MDO)
(Dual-listed with AERE 5630).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Senior classification in an Engineering major or Permission of Instructor
Introduction to the theory and methods of Multidisciplinary Design Optimization (MDO), including system coupling, system sensitivity methods, decomposition methods, MDO formulations (such as multiple-discipline feasible (MDF), individual discipline feasible (IDF) and all-at-once (AAO) approaches, and MDO search methods. (Typically Offered: Fall)

AERE 4640: Spacecraft Systems
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3510
An examination of spacecraft systems including attitude determination and control, power, thermal control, communications, propulsion, guidance, navigation, command and data handling, and mechanisms. Explanation of space and operational environments as they impact spacecraft design. Includes discussion of safety, reliability, quality, maintainability, testing, cost, legal, and logistics issues. (Typically Offered: Spring)

AERE 4680: Large-Scale Complex Engineered Systems (LSCES)
(Dual-listed with AERE 5680/ IE 5680). (Cross-listed with IE 4680).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Senior classification in an Engineering major or Permission of Instructor
Introduction to the theorectical foundation and methods associated with the design for large-scale complex engineered systems, including objective function formation, design reliability, value-driven design, product robustness, utility theory, economic factors for the formation of a value function and complexity science as a means of detecting unintended consequences in the product behavior. (Typically Offered: Spring)

AERE 4800: Ultrasonic Nondestructive Evaluation
(Cross-listed with EM 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)

AERE 4830: Aeroacoustics
(Dual-listed with AERE 5830).
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3110 *or ME 3350 and* MATH 2660 *or* MATH 2670
Noise metrics, Linear wave equation and its solution in 1-, 2-, and 3-D using Green's functions. Propagation of sound in free and confined spaces. Aerodynamic noise sources in engineering machines: aircraft engine noise, airfram noise, wind turbine noise, etc.

AERE 4900A: Aerospace Engineering Independent Study: Aero and/or Gas Dynamics
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900B: Aerospace Engineering Independent Study: Propulsion
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900C: Aerospace Engineering Independent Study: Aerospace Structures
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900D: Aerospace Engineering Independent Study: Flight Dynamics
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900E: Aerospace Engineering Independent Study: Spacecraft Systems
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900F: Aerospace Engineering Independent Study: Flight Control Systems
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900G: Aerospace Engineering Independent Study: Aeroelasticity
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900H: Aerospace Engineering Independent Study: Independent Study, Honors
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission; Membership in the University Honors Program

AERE 4900I: Aerospace Engineering Independent Study: Design
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900J: Aerospace Engineering Independent Study: Non-destructive Evaluation
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900K: Aerospace Engineering Independent Study: Wind Engineering
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900L: Aerospace Engineering Independent Study: Multi-functional Ultra-light Structures
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4900M: Aerospace Engineering Independent Study: Intelligent Systems and Autonomy
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission
(Typically Offered: Fall, Spring, Summer)

AERE 4900O: Aerospace Engineering Independent Study: Other
Credits: 1-6. Repeatable.
Prereq: Junior or Senior classification; Instructor Permission

AERE 4940: Make to Innovate II
Credits: 2-3. Repeatable.
Prereq: Junior or Senior Classification
Multidisciplinary projects to engage students in the fundamentals of engineering, project management, systems engineering, teamwork, and oral and visual communication. Students will define and attain their team objectives and milestones that are approved by their instructors. Graduation Restriction: Maximum of 6 credits may count toward graduation as Technical Elective. (Typically Offered: Fall, Spring)

AERE 4990: Senior Project
Credits: 1-2. Repeatable.
Prereq: Senior classification, credit or enrollment in AERE 4910
Development of aerospace principles and concepts through individual research and projects. Written report. (Typically Offered: Fall, Spring)

Courses primarily for graduate students, open to qualified undergraduates:

AERE 5010: Advanced Engineering Analysis
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Linear ordinary differential equations with variable coefficients; hyperbolic, parabolic, and elliptic equations; tensors. (Typically Offered: Fall)

AERE 5070: Applied Formal Methods
(Dual-listed with AERE 4070/ COMS 4070). (Cross-listed with COMS 5070).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Introduction to the fundamentals of formal methods, a set of mathematically rigorous techniques for the formal specification, validation, and verification of safety- and security-critical systems. Tools, techniques, and applications of formal methods with an emphasis on real-world use-cases such as enabling autonomous operation. Build experience in writing mathematically analyzable specifications from English operational concepts for real cyberphysical systems, such as aircraft and spacecraft. Review capabilities and limitations of formal methods in the design, verification, and system health management of today's complex systems. (Typically Offered: Spring)

AERE 5110: Wind Energy System Design
(Cross-listed with WESEP 5110).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Advanced design, control, and operation of wind plants. Topics include electromechanical energy conversion systems, aerodynamic and aeroelastic loads, optimal control of wind farms, life cycle management strategies, tall tower design, and prediction of component residual life.

AERE 5140: Advanced Mechanics of Materials
(Cross-listed with EM 5140).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
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)

AERE 5150: Atomistic and Multiscale Mechanics of Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Introduction to atomistic and multiscale computational methodology for the graduate-level study of mechanics of materials. At the end of this course, students will have an awareness and understanding of the application of atomistic and multiscale materials modeling techniques to fracture, plasticity, phase transformation, corrosion, thermal and mass transport in a variety of engineering materials. Offered odd-numbered years. (Typically Offered: Fall)

AERE 5170: Experimental Mechanics
(Dual-listed with EM 4170/ AERE 4170). (Cross-listed with EM 5170).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: Graduate Standing or Permission of Instructor
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)

AERE 5210: Airframe Analysis
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Analysis of static stresses and deformation in continuous aircraft structures. Various analytical and approximate methods of analysis of isotropic and anisotropic plates and shells. (Typically Offered: Fall)

AERE 5220: Design and Analysis of Composite Materials
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Composite constituent materials, micro-mechanics, laminate analysis, hygro-thermal analysis, composite failure, joining of composites, design of composite beams and plates, honeycomb core, manufacturing of composites, short fiber composites, and demonstration laboratory. (Typically Offered: Fall)

AERE 5240: Numerical Mesh Generation
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Introduction to modern mesh generation techniques. Structured and unstructured mesh methods, algebraic and PDE methods, elliptic and hyperbolic methods, variational methods, error analysis, Delaunay triangulation, data structures, geometric modeling with B-spline and NURBS surfaces, surface meshing. (Typically Offered: Fall)

AERE 5250: Finite Element Analysis
(Cross-listed with EM 5250).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
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)

AERE 5260: Design of Aerospace Structures
(Dual-listed with AERE 4260).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Prereq: Graduate Standing or Permission of Instructor
Detailed design and analysis of aerospace vehicle structures. Material selection, strength, durability and damage tolerance, and validation analysis. Design for manufacturability. (Typically Offered: Fall)

AERE 5310: Automatic Control of Flight Vehicles
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Applications of classical and modern linear control theory to automatic control of flight vehicles. Spacecraft attitude control. Control of flexible vehicles. Linear-quadratic regulator design applications. (Typically Offered: Spring)

AERE 5320: Compressible Fluid Flow
(Cross-listed with ME 5320).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Thermodynamics of compressible flow. Viscous and inviscid compressible flow equations. One dimensional steady flow; isentropic flow, shocks, expansions. Multidimensional compressible flow aspects. Linear and nonlinear wave analysis and method of characteristics. Subsonic, transonic, supersonic and hypersonic flows. (Typically Offered: Spring)

AERE 5380: Foundations of Engineering Education
(Cross-listed with ENGR 5380/ HGED 5380).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Introduction to the field of engineering education, with an emphasis on engineering education history, existing challenges, teaching and learning pedagogies and theories, research opportunities, and research methodologies. The course goal is to develop students as scholars and to have students think critically about engineering and education. Students will apply the knowledge gained from this course to propose a research project related to their own discipline. The proposal is intended to help students learn and apply the key elements of engineering education research. This course is intended for students with a variety of interests and career goals, including those interested in learning to conduct engineering education research, exploring research discoveries about teaching and learning, and engaging with the engineering education community. (Typically Offered: Fall)

AERE 5410: Incompressible Flow Aerodynamics
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Kinematics and dynamics of fluid flow. Derivation of the Navier-Stokes, Euler and potential flow equations. Introduction to generalized curvilinear coordinates. Ideal fluids. Two-dimensional and three-dimensional potential flow. Complex variable methods. (Typically Offered: Fall)

AERE 5440: Viscous Flow
Credits: 3. Contact Hours: Lecture 3.
Prereq: AERE 3110 *or ME 3350*
Kinematics and dynamics of compressible viscous fluid flow in aerodynamics. Derivation of the Navier-Stokes and compressible Prandtl boundary layer equations. Asymptotic analysis and solution methods for low/high Reynolds number compressible boundary layer flows. (Typically Offered: Spring)

AERE 5450: Experimental Flow Mechanics and Heat Transfer
(Dual-listed with AERE 4450).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Similitude and dimensional analysis. Measurement uncertainty analysis; Fluid mechanical apparatus: wind tunnel and water tunnels. Various experimental techniques widely used for fluid mechanics, aerodynamics, heat transfer, and combustion studies: Pressure gauge and transducers; Pitot tube; hot wire anemometry; Shadowgraph and Schlieren Photography; laser Doppler velocimetry; particle image velocimetry (PIV); advanced PIV techniques (stereo PIV, 3-D PIV, Tomographic PIV, Holograph PIV and microscopic PIV); laser induced fluorescence; pressure sensitive painting, temperature sensitive painting; molecular tagging velocimetry; molecular tagging thermometry. Extensive applications and laboratory experiments will be included. (Typically Offered: Fall)

AERE 5460: Computational Fluid Mechanics and Heat Transfer I
(Cross-listed with ME 5460).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Basic concepts of discretization, consistency, and stability. Explicit and implicit methods for ordinary differential equations. Methods for each type of partial differential equation. Iterative solution methods; curvilinear grids. Students will program basic algorithms. (Typically Offered: Fall)

AERE 5470: Computational Fluid Mechanics and Heat Transfer II
(Cross-listed with ME 5470).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Application of computational methods to current problems in fluid mechanics and heat transfer. Methods for solving the Navier-Stokes and reduced equation sets such as the Euler, boundary layer, and parabolized forms of the conservation equations. Introduction to relevant aspects of grid generation and turbulence modeling. (Typically Offered: Spring)

AERE 5510: Orbital Mechanics
(Dual-listed with AERE 4510).
Credits: 3. Contact Hours: Lecture 3.
Review of 2-body problem. Orbital maneuvers. Relative motion in orbit. Orbit perturbation analysis. Gravity field expansions and effects on orbiters. 3-body problem with applications. (Typically Offered: Fall)

AERE 5560: Guidance and Navigation of Aerospace Vehicles
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Principles of guidance systems for spacecraft, launch vehicles, homing and ballistic missiles. Optimal guidance. Interplanetary transfer guidance with low thrust. Principles of inertial navigation. Theory and applications of the Global Positioning System. Celestial navigation procedures. Application of Kalman filtering to recursive navigation theory. (Typically Offered: Fall)

AERE 5630: Introduction to Multidisciplinary Design Optimization
(Dual-listed with AERE 4630).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Introduction to the theory and methods of Multidisciplinary Design Optimization (MDO), including system coupling, system sensitivity methods, decomposition methods, MDO formulations (such as multi-discipline feasible (MDF), individual discipline feasible (IDF) and all-at-once (AAO) approaches, and MDO search methods. (Typically Offered: Fall)

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

AERE 5650: Systems Engineering and Analysis
(Cross-listed with IE 5650/ EE 5650).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Classification or Permission of Department
Introduction to organized multidisciplinary approach to designing and developing systems. Concepts, principles, and practice of systems engineering as applied to large integrated systems. Life cycle costing, scheduling, risk management, functional analysis, conceptual and detail design, test and evaluation, and systems engineering planning and organization. Graduation Restrictions: Not available for degrees in industrial engineering.

AERE 5660: Avionics Systems Engineering
(Cross-listed with EE 5660).
Credits: 3. Contact Hours: Lecture 3.
Avionics functions. Applications of systems engineering principles to avionics. Top down design of avionics systems. Automated design tools. (Typically Offered: Spring)

AERE 5680: Large-Scale Complex Engineered Systems (LSCES)
(Dual-listed with AERE 4680/ IE 4680). (Cross-listed with IE 5680).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Introduction to the theoretical foundation and methods associated with the design for large-scale complex engineered systems, including objective function formation, design reliability, value-driven design, product robustness, utility theory, economic factors for the formation of a value function and complexity science as a means of detecting unintended consequences in the product behavior. (Typically Offered: Spring)

AERE 5690: Mechanics of Composite and Combined Materials
(Cross-listed with EM 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)

AERE 5700: Wind Engineering
(Cross-listed with EM 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)

AERE 5720: Turbulence
(Cross-listed with CHE 5720).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Qualitative features of turbulence. Statistical representation of turbulent velocity fields: averages, moments, correlations, length and time scales and the energy cascade. Averaged equations of motion, closure requirements, Reynolds averaged models. Homogeneous shear flows, free shear flows, boundary layers. Numerical simulation of turbulence: DNS, LES, DES.

AERE 5730: Random Signal Analysis and Kalman Filtering
(Cross-listed with EE 5730/ ME 5730).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Elementary notions of probability. Random processes. Autocorrelation and spectral functions. Estimation of spectrum from finite data. Response of linear systems to random inputs. Discrete and continuous Kalman filter theory and applications. Smoothing and prediction. Linearization of nonlinear dynamics. (Typically Offered: Fall)

AERE 5740: Optimal Control
(Cross-listed with EE 5740/ ME 5740).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
The optimal control problem. Variational approach. Pontryagin's principle, Hamilton-Jacobi equation. Dynamic programming. Time-optimal, minimum fuel, minimum energy control systems. The regulator problem. Structures and properties of optimal controls. (Typically Offered: Spring)

AERE 5750: Introduction to Robust Control
(Cross-listed with EE 5750/ ME 5750).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Introduction to modern robust control. Model and signal uncertainty in control systems. Uncertainty description. Stability and performance robustness to uncertainty. Solutions to the H2, Hoo, and l1 control problems. Tools for robustness analysis and synthesis.

AERE 5760: Digital Feedback Control Systems
(Cross-listed with EE 5760/ ME 5760).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Sampled data, discrete data, and the z-transform. Design of digital control systems using transform methods: root locus, frequency response and direct design methods. Design using state-space methods. Controllability, observability, pole placement, state estimators. Digital filters in control systems. Microcomputer implementation of digital filters. Finite wordlength effects. Linear quadratic optimal control in digital control systems. Simulation of digital control systems. (Typically Offered: Fall)

AERE 5770: Linear Systems
(Cross-listed with EE 5770/ ME 5770/ MATH 5770).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Linear algebra review. Least square method and singular value decomposition. State space modeling of linear continuous-time systems. Solution of linear systems. Controllability and observability. Canonical description of linear equations. Stability of linear systems. State feedback and pole placements. Observer design for linear systems. (Typically Offered: Fall)

AERE 5780: Nonlinear Systems
(Cross-listed with EE 5780/ ME 5780/ MATH 5780).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Linear vs nonlinear systems. Phase plane analysis. Bifurcation and center manifold theory. Lyapunov stability. Absolute stability of feedback systems. Input-output stability. Passivity theory and feedback linearization. Nonlinear control design techniques. (Typically Offered: Spring)

AERE 5810: Perturbation Methods
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Mathematical perturbation methods with applications to ordinary and partial differential equations. Perturbation expansions. Order of magnitude and gauge functions. Matched asymptotic expansions. Boundary layer problems. Multiple scales. Resonance and mode coupling. Solvability conditions for differential equations. Physical and engineering applications. (Typically Offered: Fall)

AERE 5830: Aeroacoustics
(Dual-listed with AERE 4830).
Credits: 3. Contact Hours: Lecture 3.
Prereq: Graduate Standing or Permission of Instructor
Noise metrics, Linear wave equation and its solution in 1-, 2-, and 3-D using Green's functions. Propagation of sound in free and confined spaces. Aerodynamic noise sources in engineering machines: aircraft engine noise, airfram noise, wind turbine noise, etc.

AERE 5900A: Aerospace Engineering Independent Study: Aero and/or Gas Dynamics
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900B: Aerospace Engineering Independent Study: Propulsion
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900C: Aerospace Engineering Independent Study: Aerospace Structures
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900D: Aerospace Engineering Independent Study: Flight Dynamics
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900E: Aerospace Engineering Independent Study: Spacecraft Systems
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900F: Aerospace Engineering Independent Study: Flight Control Systems
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900G: Aerospace Engineering Independent Study: Aeroelasticity
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Graduate Standing or Permission of Instructor

AERE 5900H: Aerospace Engineering Independent Study: Viscous Aerodynamics
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900I: Aerospace Engineering Independent Study: Design
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900J: Aerospace Engineering Independent Study: Hypersonics
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900K: Aerospace Engineering Independent Study: Computational Aerodynamics
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900L: Aerospace Engineering Independent Study: Optimization
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900M: Aerospace Engineering Independent Study: Non Destructive Evaluation
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900N: Aerospace Engineering Independent Study: Wind Engineering
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course

AERE 5900Q: Aerospace Engineering Independent Study: Astrodynamics
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course
Independent Study for Astrodynamics. (Typically Offered: Fall, Spring, Summer)

AERE 5900R: Aerospace Engineering Independent Study: Ocean Wave Energy Conversion
Credits: 1-5. Repeatable, maximum of 3 times.
Prereq: Instructor Permission for Course
Independent Study for Ocean Wave Energy Conversion. (Typically Offered: Fall, Spring, Summer)

AERE 5910: Graduate Student Seminar Series
Credits: Required. Contact Hours: Lecture 1.
Repeatable.
Prereq: Graduate Standing or Permission of Instructor
Presentation of professional topics by department graduate students. Development of presentation skills used in a professional conference setting involving question and answer format.

AERE 5990: Creative Component
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

Courses for graduate students:

AERE 6400: Stability of Fluid Flow
Credits: 3. Contact Hours: Lecture 3.
Theoretical methods of stability analysis; linear analysis of exchange of stability and over stability; bifurcation of equilibria; most dangerous modes and pattern formation; shear flow stability theorems. Physical mechanisms. Tollmein-Schlichting waves, disintegration of capillary jets, Benard convection, Taylor-Couette flow, centrifugal instability, double diffusion.

AERE 6470: Advanced Computational Fluid Dynamics
(Cross-listed with ME 6470).
Credits: 3. Contact Hours: Lecture 3.
An examination of current methods in computational fluid dynamics. Differencing strategies. Advanced solution algorithms for unstructured meshes. Grid generation. Construction of higher-order CFD algorithms. Parallel computing. Current applications. Use of state of the art CFD codes. (Typically Offered: Spring)

AERE 6510: Space Trajectory Optimization
Credits: 3. Contact Hours: Lecture 3.
Classical methods and recent advances in space trajectory optimization. Primer vector theory, introduction to direct and indirect methods for trajectory optimization, the problem of multi gravity assist with deep space maneuvers (MGADSM), optimization of the MGADSM using evolutionary algorithms, hidden genes genetic algorithms for trajectory optimization, and shape-based methods for trajectory design. Offered odd-numbered years. (Typically Offered: Spring)

AERE 6900A: Aerospace Engineering Independent Study: Aero and/or Gas Dynamics
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

AERE 6900B: Aerospace Engineering Independent Study: Propulsion
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

AERE 6900C: Aerospace Engineering Independent Study: Aerospace Structures
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

AERE 6900D: Aerospace Engineering Independent Study: Flight Dynamics
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

AERE 6900E: Aerospace Engineering Independent Study: Spacecraft Systems
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

AERE 6900F: Aerospace Engineering Independent Study: Flight Control Systems
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

AERE 6900G: Aerospace Engineering Independent Study: Aeroelasticity
Credits: 1-5. Repeatable.

AERE 6900H: Aerospace Engineering Independent Study: Viscous Aerodynamics
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

AERE 6900I: Aerospace Engineering Independent Study: Design
Credits: 1-5. Repeatable.

AERE 6900J: Aerospace Engineering Independent Study: Hypersonics
Credits: 1-5. Repeatable.

AERE 6900K: Aerospace Engineering Independent Study: Computational Aerodynamics
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

AERE 6900L: Aerospace Engineering Independent Study: Non Destructive Evaluation
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

AERE 6900M: Aerospace Engineering Independent Study: Wind Engineering
Credits: 1-5. Repeatable.
Prereq: Instructor Permission for Course

AERE 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.

AERE 6990: Research
Credits: 1-30. Repeatable.
Prereq: Instructor Permission for Course