

AEROSPACE ENGINEERING (AER E)

Courses primarily for undergraduates:

AER E 101H: Engineering Honors Orientation

Cr. R. F.

Prereq: Membership in the Freshman Honors Program

Introduction to the College of Engineering and the Aerospace Engineering profession. Information concerning university, college, and department policies, procedures and resources with emphasis on the Freshman Honors Program. Topics include experiential education study abroad opportunities, and department mentorships.

AER E 112: Orientation to Learning and Productive Team Membership

(Cross-listed with CON E, FS HN, HORT, NREM). (2-0) Cr. 2. F.

Introduction to developing intentional learners and worthy team members. Learning as the foundation of human enterprise; intellectual curiosity; ethics as a personal responsibility; everyday leadership; effective team and community interactions including team learning and the effects on individuals; and growth through understanding self, demonstrating ownership of own learning, and internalizing commitment to helping others. Intentional mental processing as a means of enhancing learning. Interconnectedness of the individual, the community, and the world.

AER E 160: Aerospace Engineering Problems With Computer Applications Laboratory

(2-2) Cr. 3. F.S.

Prereq: MATH 143 or satisfactory scores on mathematics placement examinations; credit or enrollment in MATH 165

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.

AER E 160H: Aerospace Engineering Problems With Computer Applications Laboratory: Honors

(2-2) Cr. 3. F.S.

Prereq: MATH 143 or satisfactory scores on mathematics placement examinations; credit or enrollment in MATH 165

Solving aerospace engineering problems and presenting solutions through technical reports. Significant figures. SI units and estimation. Graphing and curve fitting. Introduction to aerospace engineering and engineering design. Spreadsheet programs. History of aerospace. Systems thinking. Team projects.

AER E 161: Numerical, Graphical and Laboratory Techniques for Aerospace Engineering

(2-2) Cr. 3. F.S.

Prereq: AER E 160 or equivalent course

Computer solutions to aerospace engineering problems using the FORTRAN language and Matlab(R), with emphasis on numerical methods. Solid modeling with emphasis on aerospace design. Analysis of basic mathematical models and engineering problem solving. Written and oral technical reports, team projects.

AER E 161H: Numerical, Graphical and Laboratory Techniques for Aerospace Engineering: Honors

(2-2) Cr. 3. F.S.

Prereq: AER E 160 or equivalent course

Computer solutions to aerospace engineering problems using the FORTRAN language and Matlab(R), with emphasis on numerical methods. Solid modeling with emphasis on aerospace design. Analysis of basic mathematical models and engineering problem solving. Written and oral technical reports, team projects.

AER E 192: Aerospace Seminar

Cr. R. S.

Experimental lab set-up, graphical skills. Academic program planning.

AER E 192H: Aerospace Seminar: Honors.

Cr. R. S.

Experimental lab set-up, graphical skills. Academic program planning.

AER E 261: Introduction to Performance and Design

(3-0) Cr. 3. F.S.

Prereq: AER E 161, MATH 166, PHYS 221

Introduction to aerospace disciplinary topics, including: aerodynamics, structures, propulsion, and flight dynamics with emphasis on performance. Written technical reports and team projects.

AER E 265: Scientific Balloon Engineering and Operations

(Cross-listed with MTEOR). (0-2) Cr. 1. Repeatable. F.

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.

AER E 290: Aerospace Engineering Independent Study: Independent Study

Cr. 1-2. Repeatable.

Prereq: Sophomore classification, approval of the department

AER E 290A: Aerospace Engineering Independent Study: Flight ground instruction

Cr. 1-2. Repeatable.

Prereq: Sophomore classification, approval of the department

AER E 290B: Aerospace Engineering Independent Study: In-flight training

Cr. 1-2. Repeatable.

Prereq: AER E 301

AER E 290C: Aerospace Engineering Independent Study: Other

Cr. 1-2. Repeatable.

Prereq: AER E 301

AER E 291: Aerospace Advising Seminar

Cr. R. F.

Academic program planning. Offered on a satisfactory-fail basis only.

AER E 292: Aerospace Advising Seminar

Cr. R. S.

Academic program planning. Offered on a satisfactory-fail basis only.

AER E 298: Cooperative Education

Cr. R. F.S.SS.

Prereq: Permission of department and Engineering Career Services

First professional work period in the cooperative education program. Students must register for this course prior to commencing work. Offered on a satisfactory-fail basis only.

AER E 301: Flight Experience

Cr. R. F.S.

Prereq: Credit or enrollment in AER E 355

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.

AER E 310: Aerodynamics I: Incompressible Flow

(3-0) Cr. 3. F.S.

Prereq: Grade of C- or better in AER E 261 and MATH 265

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.

AER E 311: Aerodynamics II: Compressible Flow

(3-0) Cr. 3. F.S.

Prereq: AER E 310, M E 231

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.

AER E 321: Flight Structures Analysis

(3-0) Cr. 3. F.S.

Prereq: E M 324, Credit or enrollment in MATH 266 or 267

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.

AER E 322: Aerospace Structures Laboratory

(1-2) Cr. 2. F.S.

Prereq: Credit or enrollment in AER E 321

Design of experiments. Data analysis. Strain gage installation. Measurement of stiffness/strength of aluminum. Analysis/fabrication/testing of riveted joints. Shear/bending measurements in beam sections. Analysis/measurement of strains in frames. Buckling of columns. Stress concentration. Vibration testing of beams and plates. Fabrication/testing of composites.

AER E 331: Flight Control Systems I

(3-0) Cr. 3. F.S.

Prereq: AER E 355

Linear system analysis. Control system designs using root-locus and frequency response methods. Applications in flight control systems.

AER E 344: Aerodynamics and Propulsion Laboratory

(2-2) Cr. 3. F.S.

Prereq: AER E 310; Coreq: AER E 311

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.

AER E 351: Astrodynamics I

(3-0) Cr. 3. F.S.

Prereq: E M 345, AER E 261, Credit or enrollment in AER E 310

Introduction to astrodynamics. Two-body motion. Geocentric, lunar and interplanetary trajectories and applications. Launch and atmospheric re-entry trajectories.

AER E 355: Aircraft Flight Dynamics and Control

(3-0) Cr. 3. F.S.

Prereq: AER E 261, MATH 267, E M 345

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.

AER E 361: Computational Techniques for Aerospace Design

(2-2) Cr. 3. F.S.

Prereq: AER E 310, MATH 267, E M 324, E M 345

Advanced programming, workstation environment, and development of computational tools for aerospace analysis and design. Technical report writing.

AER E 362: Aerospace Systems Integration

(3-0) Cr. 3. F.S.

Prereq: Junior standing in Aerospace Engineering or permission of instructor

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. 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.

AER E 381: Introduction to Wind Energy

(3-0) Cr. 3. S.

Prereq: MATH 166, PHYS 221

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.

AER E 391: Aerospace Advising Seminar

Cr. R. F.S.

Academic program planning. Offered on a satisfactory-fail basis only.

AER E 392: Aerospace Advising Seminar

Cr. R. S.

Academic program planning. Offered on a satisfactory-fail basis only.

AER E 396: Summer Internship

Cr. R. Repeatable. SS.

Prereq: Permission of department and Engineering Career Services

Summer professional work period. Students must register for this course prior to commencing work. Offered on a satisfactory-fail basis only.

AER E 397: Engineering Internship

Cr. R. Repeatable. F.S.

Prereq: Permission of department and Engineering Career Services

Students must register for this course prior to commencing work. Offered on a satisfactory-fail basis only. Professional work period, one semester maximum per academic year.

AER E 398: Cooperative Education

Cr. R. F.S.SS.

Prereq: AER E 298, permission of department and Engineering Career Services
Second professional work period in the cooperative education program. Students must register for this course prior to commencing work. Offered on a satisfactory-fail basis only.

AER E 411: Aerospace Vehicle Propulsion I

(3-0) Cr. 3. F.S.

Prereq: AER E 311

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 turbojets and turbofans. Rocket engines and ramjet principles.

AER E 412: Aerospace Vehicle Propulsion II

(3-0) Cr. 3. S.

Prereq: AER E 311

Electricity and magnetism. Plasma physics. Ion engine performance. Introduction to advanced electromagnetic propulsion systems. Energy sources and nuclear propulsion. Space mission requirements.

AER E 417: Experimental Mechanics

(Dual-listed with AER E 517). (Cross-listed with E M). (2-2) Cr. 3. Alt. F., offered even-numbered years.

Prereq: E M 324; MAT E 273

Introduction to fundamental concepts for force, displacement, stress and strain measurements for structures and materials applications. Strain gage theory and application. Full field deformation measurements with laser interferometry and digital image processing. Advanced experimental concepts at the micro- and nano-scale regimes. Selected laboratory experiments.

AER E 421: Advanced Flight Structures

(2-2) Cr. 3. F.S.

Prereq: AER E 321, MATH 266 or MATH 267

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.

AER E 422: Vibrations and Aeroelasticity

(3-0) Cr. 3. Alt. S., offered even-numbered years.

Prereq: E M 324 or AER E 321

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.

AER E 423: Composite Flight Structures

(2-2) Cr. 3. S.

Prereq: E M 324; MAT E 273

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.

AER E 426: Design of Aerospace Structures

(1-6) Cr. 3. F.

Prereq: E M 324

Detailed design and analysis of aerospace vehicle structures. Material selection, strength, durability and damage tolerance, and validation analysis. Design for manufacturability.

AER E 432: Flight Control Systems II

(3-0) Cr. 3. F.

Prereq: AER E 331

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.

AER E 433: Spacecraft Dynamics and Control

(3-0) Cr. 3. F.

Prereq: EM 345

Three-dimensional rotational kinematics and attitude dynamics of a rigid body in space. Stability analysis of a spinning spacecraft with or without energy dissipation. Attitude dynamics and stability of a satellite in circular orbit. Introduction to spacecraft attitude determination and control systems (ADCS). Simulation of spacecraft attitude-dynamics and control problems of practical interest using MATLAB.

AER E 442: V/STOL Aerodynamics and Performance

(3-0) Cr. 3. F.

Prereq: AER E 261

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.

AER E 446: Computational Fluid Dynamics

(3-0) Cr. 3. F.

Prereq: AER E 311, AER E 361

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.

AER E 448: Fluid Dynamics of Turbomachinery

(Cross-listed with M E). (3-0) Cr. 3. S.

Prereq: AER E 311 or M E 335

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.

AER E 451: Astrodynamics II

(3-0) Cr. 3. F.S.

Prereq: AER E 351

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.

AER E 461: Modern Design Methodology with Aerospace Applications
(2-2) Cr. 3. F.S.*Prereq: AER E 361, AER E 311, AER E 321, AER E 351, AER E 355*

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.

AER E 462: Design of Aerospace Systems

(1-4) Cr. 3. F.S.

Prereq: AER E 461

Fundamental principles used in engineering design of aircraft, missile, and space systems. Preliminary design of aerospace vehicles. Engineering Ethics.

AER E 463: Introduction to Multidisciplinary Design Optimization

(Dual-listed with AER E 563). (3-0) Cr. 3. F.

Prereq: senior standing in College of Engineering 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.

AER E 464: Spacecraft Systems

(3-0) Cr. 3. S.

Prereq: AER E 351

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.

AER E 466: Multidisciplinary Engineering Design

(Cross-listed with A B E, B M E, CPR E, E E, ENGR, I E, M E, MAT E). (1-4) Cr. 3. Repeatable. F.S.

Prereq: Student must be within two semesters of graduation and permission of instructor.

Application of team design concepts to projects of a multidisciplinary nature. Concurrent treatment of design, manufacturing and life cycle considerations. Application of design tools such as CAD, CAM and FEM. Design methodologies, project scheduling, cost estimating, quality control, manufacturing processes. Development of a prototype and appropriate documentation in the form of written reports, oral presentations, computer models and engineering drawings.

AER E 467: Multidisciplinary Engineering Design II

(Cross-listed with CPR E, E E, ENGR, I E, M E, MAT E). (1-4) Cr. 3. Repeatable, maximum of 2 times. Alt. F., offered irregularly. Alt. S., offered irregularly.

Prereq: Student must be within two semesters of graduation or receive permission of instructor.

Build and test of a conceptual design. Detail design, manufacturability, test criteria and procedures. Application of design tools such as CAD and CAM and manufacturing techniques such as rapid prototyping. Development and testing of a full-scale prototype with appropriate documentation in the form of design journals, written reports, oral presentations and computer models and engineering drawings.

AER E 468: Large-Scale Complex Engineered Systems (LSCES)

(Dual-listed with AER E 568). (Cross-listed with I E). (3-0) Cr. 3. S.

Prereq: senior standing in College of Engineering or permission of AerE 468 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.

AER E 480: Ultrasonic Nondestructive Evaluation

(Cross-listed with E M). (3-0) Cr. 3. S.

Prereq: E M 324, MATH 266 or MATH 267, PHYS 222

Introduction to stress/strain, Hooke's law, and elastic wave propagation in two dimensions in isotropic media. Ultrasonic plane-wave reflection and transmission; and simple straight-crested guided waves. Transducer construction, behavior, and performance. Simple signal analysis and discrete signal processing. The last few weeks of the course are devoted to case studies.

AER E 481: Advanced Wind Energy: Technology and Design

(3-0) Cr. 3. S.

Prereq: AER E 381 or senior classification in engineering or junior in engineering with a course in fluid mechanics

Advanced topics in wind energy, emphasis on current practices. Theoretical foundations for horizontal and vertical axis wind turbine. Design codes for energy conversion systems design, aerodynamic and structural load estimation, wind resource characterization wind farm design, optimization.

AER E 490: Aerospace Engineering Independent Study

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490A: Aerospace Engineering Independent Study: Aero and/or Gas Dynamics**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490B: Aerospace Engineering Independent Study: Propulsion**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490C: Aerospace Engineering Independent Study: Aerospace Structures**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490D: Aerospace Engineering Independent Study: Flight Dynamics**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490E: Aerospace Engineering Independent Study: Spacecraft Systems**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490F: Aerospace Engineering Independent Study: Flight Control Systems**

Cr. 1-6. Repeatable.

Prereq: Junior or senior classification, approval of the department

AER E 490G: Aerospace Engineering Independent Study: Aeroelasticity

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490H: Aerospace Engineering Independent Study: Independent Study, Honors**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490I: Aerospace Engineering Independent Study: Design**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490J: Aerospace Engineering Independent Study: Non-destructive Evaluation**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490K: Aerospace Engineering Independent Study: Wind Engineering**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490L: Aerospace Engineering Independent Study: Multi-functional Ultra-light Structures**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 490O: Aerospace Engineering Independent Study: Other**

Cr. 1-6. Repeatable.

*Prereq: Junior or senior classification, approval of the department***AER E 491: Aerospace Advising Seminar**

Cr. R. F.S.

Academic program planning.

AER E 498: Cooperative Education

Cr. R. Repeatable. F.S.SS.

Prereq: AER E 398, permission of department and Engineering Career Services

Third and subsequent professional work periods in the cooperative education program. Students must register for this course before commencing work. Offered on a satisfactory-fail basis only.

AER E 499: Senior Project

Cr. 1-2. Repeatable. F.S.

Prereq: Senior classification, credit or enrollment in AER E 491

Development of aerospace principles and concepts through individual research and projects. Written report.

Courses primarily for graduate students, open to qualified undergraduates:**AER E 514: Advanced Mechanics of Materials**

(Cross-listed with E M). (3-0) Cr. 3. F.

Prereq: E M 324

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.

AER E 517: Experimental Mechanics

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

Prereq: E M 510 or E M 514 or E M 516

Fundamental concepts for force, displacement, stress, and strain measurements. Strain gages. Full field deformation measurements with laser interferometry and digital image processing. Advanced experimental concepts at the micro and nano scale regimes.

AER E 521: Airframe Analysis

(3-0) Cr. 3. F.

Prereq: AER E 421 or E M 424

Analysis of static stresses and deformation in continuous aircraft structures. Various analytical and approximate methods of analysis of isotropic and anisotropic plates and shells.

AER E 522: Design and Analysis of Composite Materials

(3-0) Cr. 3. F.

Prereq: E M 324

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.

AER E 524: Numerical Mesh Generation

(3-0) Cr. 3. F.

Prereq: MATH 385, proficiency in programming

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.

AER E 525: Finite Element Analysis

(Cross-listed with E M). (3-0) Cr. 3. S.

Prereq: E M 425, MATH 385

Variational and weighted residual approach to finite element equations. Emphasis on two- and three-dimensional problems in solid mechanics. Isoparametric element formulation, higher order elements, numerical integration, imposition of constraints and penalty, convergence, and other more advanced topics. Use of two- and three-dimensional computer programs. Dynamic and vibrational problems, eigenvalues, and time integration. Introduction to geometric and material nonlinearities.

AER E 531: Automatic Control of Flight Vehicles

(3-0) Cr. 3. S.

Prereq: AER E 331

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.

AER E 532: Compressible Fluid Flow

(Cross-listed with M E). (3-0) Cr. 3. S.

Prereq: AER E 310, 311 or equivalent

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.

AER E 541: Incompressible Flow Aerodynamics

(3-0) Cr. 3. F.

Prereq: AER E 310 or M E 335 or equivalent

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.

AER E 545: Experimental Flow Mechanics and Heat Transfer

(3-0) Cr. 3. F.

Prereq: AER E 310 or M E 335 or E M 378

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.

AER E 546: Computational Fluid Mechanics and Heat Transfer I

(Cross-listed with M E). (3-0) Cr. 3. F.

Prereq: AER E 310 or M E 335, and programming experience

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.

AER E 547: Computational Fluid Mechanics and Heat Transfer II

(Cross-listed with M E). (3-0) Cr. 3. S.

Prereq: AER E 546 or equivalent

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.

AER E 551: Orbital Mechanics

(3-0) Cr. 3. F.

Prereq: AER E 351

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.

AER E 556: Guidance and Navigation of Aerospace Vehicles

(3-0) Cr. 3. F.

Prereq: AER E 331

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.

AER E 563: Introduction to Multidisciplinary Design Optimization

(Dual-listed with AER E 463). (3-0) Cr. 3. F.

Prereq: senior standing in College of Engineering 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.

AER E 564: Fracture and Fatigue

(Cross-listed with E M, M E, M S E). (3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: E M 324 and either MATE 216 or MATE 273 or MATE 392.**Undergraduates: Permission of instructor*

Materials and mechanics approach to fracture and fatigue. Fracture mechanics, brittle and ductile fracture, fracture and fatigue characteristics, fracture of thin films and layered structures. Fracture and fatigue tests, mechanics and materials designed to avoid fracture or fatigue.

AER E 565: Systems Engineering and Analysis

(Cross-listed with E E, I E). (3-0) Cr. 3.

Prereq: Coursework in basic statistics

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. Not available for degrees in industrial engineering.

AER E 566: Avionics Systems Engineering

(Cross-listed with E E). (3-0) Cr. 3. S.

Prereq: E E 565

Avionics functions. Applications of systems engineering principles to avionics. Top down design of avionics systems. Automated design tools.

AER E 568: Large-Scale Complex Engineered Systems (LSCES)

(Dual-listed with AER E 468). (Cross-listed with I E). (3-0) Cr. 3. S.

Prereq: senior standing in College of Engineering or permission of AerE 468 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.

AER E 569: Mechanics of Composite and Combined Materials

(Cross-listed with E M, M S E). (3-0) Cr. 3. Alt. S., offered even-numbered years.

Prereq: E M 324

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.

AER E 570: Wind Engineering

(Cross-listed with E M). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

Prereq: E M 378, E M 345

Atmospheric circulations, atmospheric boundary layer wind, bluff-body aerodynamics, aeroelastic phenomena, wind-tunnel and full-scale testing, wind-load code and standards, effect of tornado and thunderstorm winds, design applications.

AER E 572: Turbulence

(Cross-listed with CH E). (3-0) Cr. 3.

Prereq: AER E 541 or M E 538

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.

AER E 573: Random Signal Analysis and Kalman Filtering

(Cross-listed with E E, M E). (3-0) Cr. 3. F.

Prereq: E E 324 or AER E 331 or M E 370 or M E 411 or MATH 341

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.

AER E 574: Optimal Control

(Cross-listed with E E, M E). (3-0) Cr. 3. S.

Prereq: E E 577

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.

AER E 575: Introduction to Robust Control

(Cross-listed with E E, M E). (3-0) Cr. 3.

Prereq: E E 577

Introduction to modern robust control. Model and signal uncertainty in control systems. Uncertainty description. Stability and performance robustness to uncertainty. Solutions to the H₂, H_∞, and l₁ control problems. Tools for robustness analysis and synthesis.

AER E 576: Digital Feedback Control Systems

(Cross-listed with E E, M E). (3-0) Cr. 3. F.

Prereq: E E 475 or AER E 432 or M E 411 or MATH 415; and MATH 267

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.

AER E 577: Linear Systems

(Cross-listed with E E, M E, MATH). (3-0) Cr. 3. F.

Prereq: E E 324 or AER E 331 or MATH 415; and MATH 207

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.

AER E 578: Nonlinear Systems

(Cross-listed with E E, M E, MATH). (3-0) Cr. 3. S.

Prereq: E E 577

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.

AER E 581: Perturbation Methods

(3-0) Cr. 3. F.

Prereq: MATH 267

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.

AER E 590: Aerospace Engineering Independent Study: Special Topics

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590A: Aerospace Engineering Independent Study: Aero and/or Gas Dynamics

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590B: Aerospace Engineering Independent Study: Propulsion

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590C: Aerospace Engineering Independent Study: Aerospace Structures

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590D: Aerospace Engineering Independent Study: Flight Dynamics

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590E: Aerospace Engineering Independent Study: Spacecraft Systems

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590F: Aerospace Engineering Independent Study: Flight Control Systems

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590G: Aerospace Engineering Independent Study: Aeroelasticity

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590H: Aerospace Engineering Independent Study: Viscous Aerodynamics

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590I: Aerospace Engineering Independent Study: Design

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590J: Aerospace Engineering Independent Study: Hypersonics

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590K: Aerospace Engineering Independent Study: Computational Aerodynamics

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590L: Aerospace Engineering Independent Study: Optimization

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590M: Aerospace Engineering Independent Study: Non Destructive Evaluation

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 590N: Aerospace Engineering Independent Study: Wind Engineering

Cr. 1-5. Repeatable, maximum of 3 times.

AER E 591: Graduate Student Seminar Series

Cr. R. Repeatable.

Presentation of professional topics by department graduate students. Development of presentation skills used in a professional conference setting involving question and answer format.

AER E 599: Creative Component

Cr. 1-5. Repeatable.

Courses for graduate students:

AER E 640: Stability of Fluid Flow

(3-0) Cr. 3.

Prereq: AerE 541

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.

AER E 647: Advanced Computational Fluid Dynamics

(Cross-listed with M E). (3-0) Cr. 3. S.

Prereq: AER E 547

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.

AER E 690: Aerospace Engineering Independent Study: Advanced Topics

Cr. 1-5. Repeatable.

AER E 690A: Aerospace Engineering Independent Study: Aero and/or Gas Dynamics

Cr. 1-5. Repeatable.

AER E 690B: Aerospace Engineering Independent Study: Propulsion

Cr. 1-5. Repeatable.

AER E 690C: Aerospace Engineering Independent Study: Aerospace Structures

Cr. 1-5. Repeatable.

AER E 690D: Aerospace Engineering Independent Study: Flight Dynamics

Cr. 1-5. Repeatable.

AER E 690E: Aerospace Engineering Independent Study: Spacecraft Systems

Cr. 1-5. Repeatable.

AER E 690F: Aerospace Engineering Independent Study: Flight Control Systems

Cr. 1-5. Repeatable.

AER E 690G: Aerospace Engineering Independent Study: Aeroelasticity

Cr. 1-5. Repeatable.

AER E 690H: Aerospace Engineering Independent Study: Viscous Aerodynamics

Cr. 1-5. Repeatable.

AER E 690I: Aerospace Engineering Independent Study: Design

Cr. 1-5. Repeatable.

AER E 690J: Aerospace Engineering Independent Study: Hypersonics

Cr. 1-5. Repeatable.

AER E 690K: Aerospace Engineering Independent Study: Computational Aerodynamics

Cr. 1-5. Repeatable.

AER E 690L: Aerospace Engineering Independent Study: Non Destructive Evaluation

Cr. 1-5. Repeatable.

AER E 690M: Aerospace Engineering Independent Study: Wind Engineering

Cr. 1-5. Repeatable.

AER E 697: Engineering Internship

Cr. R. Repeatable.

Prereq: Permission of DOGE (Director of Graduate Education), graduate classification

One semester and one summer maximum per academic year professional work period. Offered on a satisfactory-fail basis only.

AER E 699: Research

Cr. arr. Repeatable.