

# AERO - AEROSPACE ENGINEERING (AERO)

## AERO 201 Introduction to Flight

**Credits 3. 3 Lecture Hours. 1 Lab Hour.** Standard atmosphere, basic aerodynamic theory, airfoil and wing descriptions, introduction to orbital mechanics, elementary aerospace vehicle performance, and experiential introduction to aerospace engineering. **Prerequisite:** Grade of C or better in ENGR 102 and PHYS 206; grade of C or better in ENGR 216/PHYS 216 or PHYS 216/ENGR 216; grade of C or better in MATH 251 or MATH 253 or concurrent enrollment; Aerospace Engineering majors only.

## AERO 211 Aerospace Engineering Mechanics

**Credits 3. 3 Lecture Hours.** Fundamentals of Newtonian mechanics; static equilibrium of particles, system of particles and rigid bodies; free body diagrams; rectilinear and curvilinear motion of particles; linear momentum; angular momentum; friction; plane motion of rigid bodies; beams and trusses. **Prerequisites:** Grade of C or better in ENGR 102 and PHYS 206; grade of C or better in ENGR 216/PHYS 216 or PHYS 216/ENGR 216; grade of C or better in MATH 251 or MATH 253, or concurrent enrollment; Aerospace Engineering majors only.

## AERO 212 Introduction to Aerothermodynamics

**Credits 3. 3 Lecture Hours. 1 Lab Hour.** Study of thermodynamic properties and processes, heat and work, first and second laws of thermodynamics, ideal cycles for power and refrigeration applications; emphasis on the Brayton jet-engine cycle. **Prerequisite:** Grade of C or better in CHEM 107 and CHEM 117, or CHEM 120; grade of C or better in MATH 251 or MATH 253, or concurrent enrollment; AERO majors.

## AERO 214 Introduction to Aerospace Mechanics of Materials

**Credits 3. 2 Lecture Hours. 2 Lab Hours.** Fundamental concepts for deformable bodies (conservation of linear and angular momentum, kinematics and thermoelasticity); notions of stress and strain and illustrative examples for engineering applications; introduction to experimental methods and reporting, instrumentation and uncertainty analysis; measurement of elastic and thermal material properties. **Prerequisites:** Grade of C or better in AERO 211; grade of C or better in MATH 308, or concurrent enrollment.

## AERO 221 Analytical Methods for Aerospace Engineering

**Credits 3. 3 Lecture Hours. 1 Lab Hour.** Matrix operations, Gaussian elimination, linear transformations, coordinate transformations, eigenvalues, eigenvectors, diagonalization, including programming and computer implementation, applied to solid mechanics, fluid mechanics, dynamics and control of air and space vehicles. **Prerequisites:** Grade of C or better in ENGR 102, MATH 152, PHYS 206, and ENGR 216/PHYS 216 or PHYS 216/ENGR 216.

## AERO 222 Introduction to Aerospace Computation

**Credits 3. 2 Lecture Hours. 2 Lab Hours.** Review of basic skills required for developing computer programs and introduction to more advanced concepts in scientific computing to solve aerospace engineering problems; numerical and analytical methods of solving engineering problems involving interpolation and extrapolation; function approximation; numerical differentiation; integration; solutions to linear and non-linear equations and systems of equations; eigenvalues and eigenvectors, numerical integration of differential equations with aerospace engineering applications. **Prerequisites:** Admitted to major degree sequence in aerospace engineering; grade of C or better in ENGR 102; grade of C or better in MATH 308 or concurrent enrollment.

## AERO 285 Directed Studies

**Credits 0 to 4. 0 Lecture Hours. 0 Lab Hours. 0 to 4 Other Hours.** Directed study of special problems in aerospace engineering. **Prerequisites:** Freshman or sophomore classification, or approval of instructor. May be repeated for credit.

## AERO 289 Special Topics in...

**Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 4 Lab Hours.** Selected topics in an identified area of aerospace engineering. May be repeated for credit. **Prerequisite:** Approval of instructor.

## AERO 291 Research

**Credits 0 to 4. 0 to 4 Other Hours.** Research conducted under the direction of faculty member in aerospace engineering. May be taken three times. **Prerequisites:** Freshman or sophomore classification and approval of instructor.

## AERO 299 Mid-Curriculum Professional Development

**Credits 0. 0 Other Hours.** Participation in an approved high-impact learning practice; reflection on professional outcomes from engineering body of knowledge; documentation and self-assessment of learning experience at mid-curriculum point.

## AERO 301 Theoretical Aerodynamics

**Credits 3. 3 Lecture Hours.** Conservation of mass and momentum; Reynolds transport theorem; fundamentals of incompressible flow, rotationality, potential flow, superposition, circulation, lift, thin airfoil theory, elliptic wing theory and induced drag. **Prerequisite:** Grade of C or better in AERO 201, AERO 212; grade of C or better in AERO 222 and MATH 308, or concurrent enrollment.

## AERO 303 High Speed Aerodynamics

**Credits 3. 3 Lecture Hours.** Fundamentals of compressible flow; governing Euler equations; adiabatic and isentropic flow; normal and oblique shocks and expansion waves, moving shocks, shock interactions, wedge and cone flow; supersonic airfoils, exact and thin theory, choked flow and wind-tunnel design, two-dimensional gas dynamics, and method of characteristics. **Prerequisite:** Grade of C or better in AERO 301.

## AERO 304 Aerospace Structural Analysis I

**Credits 3. 3 Lecture Hours.** Three-dimensional beam theory; applications of elasticity theory to beam extension and compression, bending, torsion and transverse shearing; combined loading; analysis of thin-walled structures; stress concentrations; analysis of stability of aerospace structures; elements of structural failure, buckling; structural design considerations. **Prerequisite:** Grade of C or better in AERO 214 and MATH 308; grade of C or better in AERO 222 or concurrent enrollment.

## AERO 306 Aerospace Structural Analysis II

**Credits 3. 3 Lecture Hours.** Work and energy principles; analysis of indeterminate structures by classical virtual work and finite elements; introduction to elastic stability of columns; application of energy methods to determine stresses, strains and displacements in typical aerospace structures; design considerations in aerospace structures. **Prerequisite:** Grade of C or better in AERO 304.

## AERO 307 Aerospace Engineering Laboratory

**Credits 3. 2 Lecture Hours. 3 Lab Hours.** Intermediate and advanced topics in instrumentation, signal conditioning, data acquisition analysis for aerospace-related measurements; emphasis on technical reporting and data presentation; measurements of materials strain, deformation, pressure, velocity and aerodynamic forces; experimental investigations of static and dynamic response of structures; use of nonintrusive optical techniques; uncertainty analysis; linear regression, Fourier transform and power spectra; tests for statistical significance; design of experiments. **Prerequisites:** Grade of C or better in ENGL 103 or ENGL 104; grade of C or better in AERO 222, AERO 301, AERO 304, AERO 310, ECEN 215, or concurrent enrollment.

## AERO 310 Aerospace Dynamics

**Credits 3. 3 Lecture Hours.** Spatial kinematics; general motion of particles; Euler angles; Newton-Euler methods for translation and rotation of rigid bodies; work-energy and impulse momentum principles applied to aerospace systems; Linear theory of free dynamic response of single and multi-degree of freedom systems; frequency response of first and second order systems with instrumentation applications. **Prerequisite:** Grade of C or better in AERO 211 and MATH 308; grade of C or better in AERO 222 or concurrent enrollment.

## AERO 321 Dynamics of Aerospace Vehicles

**Credits 3. 3 Lecture Hours.** Derivation of the nonlinear air and space vehicle dynamics equations; attitude representation with Euler angles and quaternions; forces and moments due to aerodynamics, thrust and gravity gradient; linearization; development of state-space models for aircraft and spacecraft; static and dynamic stability analysis for aircraft and satellites; spin and gravity gradient stabilization; stability derivatives; longitudinal and lateral modes and transfer functions for aircraft; aircraft flying qualities; elements of aircraft configuration design; response to control inputs. **Prerequisite:** Grade of C or better in AERO 301 and AERO 310.

## AERO 351 Aerothermodynamics and Propulsion

**Credits 3. 3 Lecture Hours.** Aerothermodynamics of gases; laws of thermodynamics; equilibrium conditions; mixtures of gases; combustion and thermochemistry; compressible internal flows with friction, heat transfer and shock; turbojet cycle analysis and performance; chemical rockets. **Prerequisite:** Grade of C or better in AERO 303.

## AERO 401 Aerospace Design Principles

**Credits 3. 2 Lecture Hours. 3 Lab Hours.** Study of systems engineering; project lifecycle; stakeholder, concept of operations (CONOPS) & requirements definition; cost assessment; risk management; trade studies; decomposition and design of an aerospace system; engineering ethics; technical communications. **Prerequisite:** Grade of C or better in AERO 306, AERO 307, AERO 321, and AERO 351, or concurrent enrollment.

## AERO 402 Aerospace Systems Design

**Credits 2. 6 Lab Hours.** Continuation of AERO 401; detailed design; subsystem integration; realization of the system through prototyping, modeling, and/or simulation; verification and validation through experimentation and analysis; documentation and presentation of results. **Prerequisite:** Grade of C or better in AERO 306, AERO 307, AERO 321, AERO 351, and AERO 401.

## AERO 404 Mechanics of Advanced Aerospace Structures

**Credits 3. 3 Lecture Hours.** Advanced analysis techniques for aerospace structures; material anisotropy, plasticity, fatigue and fracture; laminated materials; solution of plane elasticity, plate and multi-component structural configurations; buckling of beams and plates; application of finite element analysis. **Prerequisites:** Grade of C or better in AERO 304 and junior or senior classification.

## AERO 405 Aerospace Structural Design

**Credits 3. 3 Lecture Hours.** Overall structural integrity of complete aerospace systems; structures subjected to critical loads; design considerations in aerospace structures. **Prerequisite:** Grade of C or better in AERO 306.

## AERO 411 Applications of Fracture Mechanics to Aerospace Structures

**Credits 3. 3 Lecture Hours.** Foundations of linear elastic fracture mechanics of aerospace structure; calculation of stress intensity factors and energy release rates; crack growth under fatigue loading; ASTM standards for fracture testing; the role of fracture mechanics in the analysis and design of aerospace structures. **Prerequisite:** AERO 304 or equivalent with a grade of C or better.

## AERO 413 Aerospace Materials Science

**Credits 3. 3 Lecture Hours.** Relationship between aerospace engineering material properties and microstructure; mechanical and thermal properties; environmental degradation; mechanical failure. **Prerequisite:** Grade of C or better in AERO 304.

## AERO 414 Human Performance in Aerospace Environments

**Credits 3. 3 Lecture Hours.** Current physiological and psychological aspects affecting human performance during space missions using a quantitative approach and engineering methods. **Prerequisite:** Grade of C or better in AERO 321.

## AERO 415 Computational Fluid Dynamics for Aerospace Applications

**Credits 3. 3 Lecture Hours.** Present methods for solving internal and external flow problems for inviscid and viscous compressible flow; Euler, Navier-Stokes and Large Eddy Simulation solvers, boundary conditions formulation, and basics of parallel processing. **Prerequisite:** Grade of C or better in AERO 303 and AERO 351.

## AERO 417 Aerospace Propulsion

**Credits 3. 3 Lecture Hours.** Air breathing propulsion; design and analysis of inlets, compressors, combustors, turbines and nozzles; application to aeronautical and ground transportation. **Prerequisite:** Grade of C or better in AERO 351.

## AERO 419 Chemical Rocket Propulsion

**Credits 3. 3 Lecture Hours.** Nozzles and heat transfer in rockets, liquid and solid propellant systems; combustion and combustion stability; flight performance including trajectories, multistaging and exchange rate curves; rocket testing. **Prerequisite:** Grade of C or better in AERO 351.

## AERO 420 Aeroelasticity

**Credits 3. 3 Lecture Hours.** Classical analysis of fundamental aeroelastic phenomena with application to aerospace vehicles; flutter, divergence, control effectiveness. **Prerequisites:** Grade of C or better in AERO 303, AERO 306, and AERO 310.

## AERO 422 Active Controls for Aerospace Vehicles

**Credits 3. 3 Lecture Hours.** Introduction to the Theory of Automatic Control specifically applied to aerospace vehicles; techniques for analysis and synthesis of linear control systems, stability criteria, systems response and performance criteria; design studies of active controls to improve aerospace vehicle performance. **Prerequisite:** Grade of C or better in AERO 321.

## AERO 423 Orbital Mechanics

**Credits 3. 3 Lecture Hours.** Two-body problem, restricted three-body problem, orbital perturbations, orbital maneuvers, interplanetary trajectories, orbit determination and other selected topics. **Prerequisite:** Grade of C or better in AERO 310.

## AERO 424 Spacecraft Attitude Dynamics and Control

**Credits 3. 3 Lecture Hours.** Introduces fundamental concepts of satellite attitude dynamics and control; includes derivations of environmental disturbances due to gravity gradient, aerodynamic, and solar radiation pressure; includes treatments of attitude control subsystems, such as thrusters, reaction wheels, CMGs, and magnetic torquers, and their designs. **Prerequisites:** Grade of C or better in AERO 321.

## AERO 425 Flight Test Engineering

**Credits 3. 2 Lecture Hours. 3 Lab Hours.** Application of performance and stability and control theory to flight test measurements; standard atmosphere and airspeed equations for pilot-static system calibrations; flight test methods for evaluating performance, stability and control, and stall-spin characteristics; laboratory practice in planning and conducting small flight test project. **Prerequisite:** Grade of C or better in AERO 321.

## AERO 426 Space System Design

**Credits 3. 3 Lecture Hours.** Introduces prevailing practices and processes used in modern space system design; applies knowledge in component engineering disciplines to a design challenge of interest to NASA or DoD; utilizes instruction in systematic methods of design and on dynamics of teamwork; when possible concludes with detailed design using an engineering design facility. **Prerequisites:** Grade of C or better in AERO 306, AERO 321, AERO 351.

## AERO 428 Electromagnetic Sensing for Space-Borne Imaging

**Credits 3. 3 Lecture Hours.** Study IR and Visible range imaging systems to obtain high resolution imaging of objects from space; this area has numerous applications and areas of advanced development; following instruction in needed background on optics, telescopes, and interferometry, perform preliminary design of imaging system with a different imaging design offered each year. **Prerequisites:** Grade of C or better in AERO 306, AERO 321, AERO 351.

## AERO 430 Numerical Simulation

**Credits 3. 3 Lecture Hours.** Numerical and analytical simulation of physical problems in sciences and engineering using applied methods; developing and using numerical techniques for physical problems described by nonlinear algebraic equations, ordinary and partial differential equations. **Prerequisite:** Grade of C or better in AERO 222 or MATH 417.

## AERO 435 Aerothermochemistry

**Credits 3. 3 Lecture Hours.** Composition of chemically reacting gases (air and propellant); thermodynamic functions based on classical and quantum mechanical theories; calculation of gas temperatures; equilibrium, frozen and non-equilibrium flows through nozzles and shock waves. **Prerequisite:** Grade of C or better in AERO 303.

## AERO 436/ISEN 432 Human Factors Engineering for Aerospace Designs

**Credits 3. 3 Lecture Hours.** Physiological and psychophysiological issues encountered in aviation and space environments and their effect on human cognitive and physical performance; survey methods for human workload and performance evaluations; apply human-systems design principles to an aerospace design project. **Prerequisites:** Junior or senior classification. **Cross Listing:** ISEN 432/AERO 436.

## AERO 438/MEEN 407 Intuitive and Counter-Intuitive Mechanisms

**Credits 3. 2 Lecture Hours. 2 Lab Hours.** Spatial descriptions and transformations; forward and inverse kinematics of mechanical manipulators; manipulation; dexterity and manipulability; principles of manipulator-mechanism design; mobility; motion planning; control, reachability and complexity measures; workspace analysis. **Prerequisites:** Senior classification. **Cross Listing:** MEEN 407/AERO 438.

## AERO 440 Cockpit Systems and Displays

**Credits 3. 3 Lecture Hours.** Design, development, and implementation of cockpit systems and multi-function displays; cockpit system requirements and specifications; human-machine interfaces, Flight Management Systems, navigation and guidance systems; 3-D real-time displays of weather, traffic, and terrain; characteristics and missions of air vehicles; project design and cost analysis. **Prerequisite:** Grade of C or better in AERO 321 or junior or senior classification in computer science.

## AERO 445 Vehicle Management Systems

**Credits 3. 3 Lecture Hours.** Introduction to vehicle management systems for manned and unmanned air and space vehicles; system centric concepts, requirements definition, specifications, and architectures; reliability analysis, health monitoring, and mission management; SISO digital design of integrated flight control, propulsion control and structural control; introduction to vehicle autonomy; design and analysis methods, industrial examples. **Prerequisite:** Grade of C or better in AERO 422.

## AERO 451 Human Spaceflight Operations

**Credits 3. 3 Lecture Hours.** Essential aspects of human spaceflight operations as performed by NASA; in-depth understanding of the state-of-the-art in spacecraft operations, including spacecraft systems, ground and launch operations, mission management and on-orbit activities such as science, robotics, spacewalking and human health maintenance; applications to future space systems. **Prerequisite:** Grade of C or better in AERO 310 or equivalent; senior classification.

## AERO 452 Heat Transfer and Viscous Flows

**Credits 3. 3 Lecture Hours.** Navier-Stokes and boundary layer equations; exact and approximate solutions; laminar boundary layers; basic concepts of transition and turbulence; turbulent boundary layers; one and two dimensional heat transfer; methods for steady and transient heat conduction; thermal boundary layers; convection; radiation. **Prerequisite:** Grade of C or better in AERO 303 and AERO 351.

## AERO 455 Helicopter Aerodynamics

**Credits 3. 3 Lecture Hours.** Hovering theory, hovering and vertical flight performance, factors affecting hovering and vertical flight performance, auto-rotation in vertical descent, concepts of blade motion and control, aerodynamics of forward flight, forward flight performance, operational envelope and introduction to conceptual design of helicopters. **Prerequisites:** Grade of C or better in AERO 222, AERO 301, and AERO 310.

## AERO 472 Airfoil and Wing Design

**Credits 3. 3 Lecture Hours.** Subsonic airfoil design and analysis, subsonic wing design and analysis, swept and delta wings, vortex lift, transonic flow methods, viscous transonic phenomena, transonic airfoil and wing design, optimization and advanced topics such as supersonic panel methods. **Prerequisite:** Grade of C or better in AERO 303.

## AERO 478 Low Temperature Plasma - Theory, Modeling, Applications

**Credits 3. 3 Lecture Hours.** Basic theory and fundamentals of low-temperature plasma, elements of plasma kinetic theory, equilibrium and non-equilibrium plasma, modeling approaches, plasma discharges. **Prerequisites:** Grade of C or better in AERO 303 and MATH 308.

## AERO 481 Seminar

**Credit 1. 1 Lecture Hour.** Readings, reports, conferences and discussion. Must be taken on a satisfactory/unsatisfactory basis. **Prerequisite:** Senior classification in aerospace engineering.

## AERO 485 Directed Studies

**Credits 0 to 4. 0 to 4 Other Hours.** Special problems in aerospace engineering assigned to individual students or groups. **Prerequisite:** Junior or senior classification or approval of instructor.

## AERO 489 Special Topics in...

**Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 4 Lab Hours.** Selected topics in an identified field of aerospace engineering. May be repeated for credit. **Prerequisite:** Approval of instructor.

## AERO 491 Research

**Credits 0 to 4. 0 to 4 Other Hours.** Research conducted under the direction of faculty member in aerospace engineering. May be repeated 3 times for credit. **Prerequisites:** Junior or senior classification and approval of instructor.