AERO - AEROSPACE ENGINEERING

AERO 601 Advanced Aerodynamics

Credits 3. 3 Lecture Hours. Theoretical and approximate solutions for steady and unsteady incompressible flows and steady transonic flows; applications to airfoil, wing and whole-vehicle aerodynamics; approximate methods for boundary layers; introduction to aerodynamic design concepts; design of swept wings and delta wings and control surfaces. **Prerequisite:** Approval of instructor.

AERO 602 The Theory of Fluid Mechanics

Credits 3. 3 Lecture Hours. Entry-level theory of fluid mechanics with emphasis on viscous subsonic flows; governing principles and equations, exact solutions to simple problems of the Navier-Stokes equations, similarity solutions and boundary layer theory; flow stability, transition and turbulence. **Prerequisite:** Graduate classification and approval of instructor.

AERO 603 Continuum Mechanics

Credits 3. 3 Lecture Hours. Development of field equations for analysis of continua (solids as well as fluids); conservation laws; kinematics, constitutive behavior of solids and fluids; applications to aerospace engineering problems involving solids and fluids. **Prerequisite:** Graduate classification. **Cross Listing:** MEMA 602 and MEEN 608.

AERO 604 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; use of Abaqus as a finite element analysis tool. **Prerequisites:** Graduate classification; AERO 306, or approval of instructor.

AERO 605 Theory of Elasticity

Credits 3. 3 Lecture Hours. Analysis of stress and strain in two and three dimensions, equilibrium and compatibility equations, strain energy methods; torsion of noncircular sections; flexure; axially symmetric problems. **Prerequisite:** Mechanics of Materials, Advanced Calc Different Equations. **Cross Listing:** MEEN 603 and MEMA 601.

AERO 606 Multifunctional Materials

Credits 3. 3 Lecture Hours. In-depth analysis of multifunctional materials and composites, and their novel applications. **Prerequisites:** MEMA 602/ AERO 603, MSEN 601. **Cross Listing:** MEMA 606 and MSEN 606.

AERO 607 Aerospace Human Systems Integration - Bioastronautics

Credits 3. 3 Lecture Hours. This course is designed for graduate students and will provide fundamental interdisciplinary topics related to research, engineering, and manufacturing of systems to support humans in spaceflight or similar extreme environments, Human Systems Integration (HSI); engineering design requirements and operations of EVA suits, space stations, and planetary habitats, the changes in human physiology due to microgravity or hypo-gravity; the space environment in LEO, on the Moon and at Mars, thermal, pressure, radiation, micrometeoroids, g-level; design and functions of life support systems; functional components of spacesuits, past, current and future designs of EVA suits; human anthropometric considerations; specific NASA design requirements for Extravehicular Activity (EVA) and Space Habitat Intravehicular Activity (IVA,) with design solution comparisons; discussion of risk and past spacecraft accidents, both US and Russian; may include seminars by Subject Matter Experts (SME) from NASA, academia and industry, subject to availability. **Prerequisite:** Graduate classification or approval of instructor.

AERO 608 Nanomechanics

Credits 3. 3 Lecture Hours. Application of mechanics concepts to nano-scale behavior of materials; review of continuum mechanics; extensions to generalized continua; nonlocal elasticity; nano-scale plasticity; focus on multi-scale modeling - dislocation dynamics; quasi-continuum method; molecular dynamics with introductions to quantum mechanics and statistical mechanics. **Prerequisite:** AERO 603. **Cross Listing:** MEMA 608 and MSEN 608.

AERO 614 Human Performance in Aerospace Environments

Credits 3. 3 Lecture Hours. Introduction to current physiological and psychological aspects affecting human performance during space missions using a quantitative approach and engineering methods. **Prerequisite:** Graduate classification or approval of instructor.

AERO 615 Computational Fluid Dynamics for Aerospace Applications

Credits 3. 3 Lecture Hours. Methods for solving internal and external flow problems; viscous and inviscid compressible flow, Euler, Navier-Stokes and Large Eddy Simulation solvers, boundary conditions. **Prerequisite:** MATH 601 or approval of instructor.

AERO 617/MEMA 625 Micromechanics

Credits 3. 3 Lecture Hours. Eigenstrains; inclusions, and inhomogeneities; Eshelby's solution for an ellipsoidal inclusion; Eshelby's equivalent inclusion method; effective elastic properties of composites; composite spheres and cylinders models; bounds on effective moduli; Hashin-Shtrikman bounds; applications to fiber, whisker and particulate reinforced composites; introduction to micromechanics of inelastic composites and solids with damage. **Prerequisites:** MEMA 602, or AERO 603, AERO 605. **Cross Listing:** MEMA 625/AERO 617.

AERO 618/MEMA 626 Mechanics of Active Materials

Credits 3. 3 Lecture Hours. Introduction to coupled field theories: constitutive response of materials with thermal and electromagnetic coupling; microstructural changes due to phase transformations; shape memory alloys; piezoelectric and magnetostrictive materials; active polymers and solutions; micromechanics of active composites. **Prerequisites:** MEMA 602. **Cross Listing:** MEMA 626/AERO 618.

AERO 622 Spacecraft Dynamics and Control

Credits 3. 3 Lecture Hours. Elements of analytical dynamics; modeling different types of spacecraft and control systems, sensors, and actuators; stability; control system design; effects of flexibility; attitude and orbital coupling; environmental effects. **Prerequisites:** AERO 422 or ECEN 420.

AERO 623 Optimal Spacecraft Attitude and Orbital Maneuvers

Credits 3. 3 Lecture Hours. Application of optimization and optimal control techniques to spacecraft maneuver problems; computation of open loop and feedback controls for linear and nonlinear spacecraft dynamical systems; low-thrust and impulsive control, discretization methods, case studies. **Prerequisite:** AERO 423 or equivalent.

AERO 624 Celestial Mechanics

Credits 3. 3 Lecture Hours. Analytical and numerical methods for computing spacecraft orbits under the influence of gravitational, aerodynamic, thrust and other forces; Keplerian two-body problem, perturbation methods, orbit determination, navigation and guidance for aerospace vehicles. **Prerequisite:** AERO 423 or equivalent.

AERO 625 Modern Control of Aerospace Systems

Credits 3. 3 Lecture Hours. Linear and nonlinear controllers for aircraft and spacecraft; state and output feedback of sampled-data control systems; feedback linearization and dynamic inversion; direct sampled-data design using optimal MIMO techniques; sensing considerations, sources and modeling of uncertainties unique to aircraft and spacecraft, robustness analysis. **Prerequisite:** AERO 422 or equivalent.

AERO 626 Estimation of Dynamic Systems

Credits 3. 3 Lecture Hours. Traditional concepts and recent advances in estimation related to modern dynamic systems found in aerospace disciplines; least squares estimation, state estimation, nonlinear filtering, aircraft position and velocity tracking, attitude determination of spacecraft vehicles, gyro bias estimation and calibration. **Prerequisites:** AERO 310 or equivalent; STAT 211 or equivalent.

AERO 629 Experimental Aerodynamics

Credits 3. 3 Lecture Hours. Review of fundamental principles in aerodynamics; basics of instrumentation, electronics, data-acquisition; experimental techniques in aerodynamics/fluid mechanics; pressure, skin friction, force and velocity measurement techniques in wind and water-tunnel testing; conventional and novel techniques in data-processing and systems modeling; smart systems in experimental aerodynamics. **Prerequisite:** AERO 601.

AERO 630 Introduction to Random Dynamical Systems

Credits 3. 3 Lecture Hours. Building on basic probability theory, course covers theory and applications of discrete and continuous random processes; particular attention shall be paid to the response of dynamical systems (discrete, linear and non-linear), to random input processes and their application to Engineering Systems. **Prerequisite:** Graduate classification.

AERO 632 Design of Advanced Flight Control Systems - Theory and Application

Credits 3. 3 Lecture Hours. Modeling, analysis, design and implementation of advanced flight control problems, specifically aerospace engineering applications; includes choice of controlled variables, reduction of controlled variables, design methodology, computational framework, implementation issues, and software environments using various toolboxes. **Prerequisites:** Graduate classification and approval of instructor.

AERO 633 Advanced Aerospace Multibody Dynamics

Credits 3. 3 Lecture Hours. Techniques for modeling, simulation, and analyzing multibody dynamical systems; includes development of kinematic expressions for articulating bodies, adding and constraining degrees of freedom through mappings; familiarization with industry codes, such as DISCOS; appreciation of learned techniques on various systems, including omni-directional vehicles, Stewart platforms, and gyroscopically-stabilized walking robots. **Prerequisites:** AERO 622 or graduate classification and approval of instructor.

AERO 636/ISEN 632 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:** Graduate classification or approval of instructor. **Cross Listing:** ISEN 632/AERO 636.

AERO 640/OCEN 640 Turbulence Processes

Credits 3. 3 Lecture Hours. Fundamentals of conservation, Lagrangian, transformation, variance properties; flow features: laminar, transition, turbulence regimes, characteristics, spectrum; statistical (filter/average) description: scales, Reynolds, arbitrary averaging, realizability; elementary turbulence processes: viscous, advective/inertial, role of pressure; elementary process models, viscous RDT, RDT for velocity gradients, equipartion of energy, restricted Euler equations; isotropic, homogeneous turbulence. May be repeated two times for credit. **Cross Listing:** OCEN 640/AERO 640.

AERO 641 High-Speed Combustion for Propulsion

Credits 3. 3 Lecture Hours. Study topics in combustion relevant to high-speed subsonic/supersonic air-breathing propulsion; emphasis on the structure of detonations and the operation of combustors under supersonic conditions; structure of shock-waves and the mixing/chemical kinetics that take place in high speeds. **Prerequisite:** Graduate classification.

AERO 642 Laser Diagnostics for Combustion and Propulsion

Credits 3. 3 Lecture Hours. Laser diagnostics topics as applied to combustion and propulsion: brief exposition of fundamental electromagnetic theory; practice of basic experimental laser techniques used to measure thermochemistry; basic implementation of Raman and Rayleigh scatterings; Laser-Induced Fluorescence (LIF); detection methods, optical systems, noise contributions, and signal enhancement techniques will be discussed. **Prerequisite:** Graduate classification.

AERO 643 High-Performance Computational Fluid Dynamics

Credits 3. 3 Lecture Hours. Numerical simulations of fluid dynamics problems on massively parallel computers; focus on Direct Numerical Simulations (DNS) where all dynamically relevant scales are resolved; elements of both high-performance computing (HPC) and numerical methods to solve incompressive and compressible flows. **Prerequisite:** AERO 615 or approval of instructor.

AERO 645/MSEN 645 Failure Mechanics of Engineering Materials

Credits 3. 3 Lecture Hours. Introduction and integration of key experimental, theoretical and computational aspects of failure in engineering materials, including metals, alloys and polymers; brittle fracture, ductile fracture and brittle-to-ductile transitions. **Prerequisites:** Graduate classification; MSEN 601. **Cross Listing:** MSEN 645/AERO 645.

AERO 649/MEMA 649 Generalized Finite Element Methods

Credits 3. 3 Lecture Hours. Systemic introduction to the theory and practice of generalized finite element (FE) methods, including GFEM, the hp-cloud method, particle methods, and various meshless methods with similar character; precise formulation of the methods are presented; known theoretical results for convergence; important issues related to implementation, issues of numerical integration. **Prerequisite:** Graduate classification. **Cross Listing:** MEMA 649/AERO 649.

AERO 650 Spacecraft Attitude Determination

Credits 3. 3 Lecture Hours. Spacecraft attitude determination systems; attitude and error parameterizations, attitude sensors, data processing and calibration; introduction to single- and three- axis attitude determination and to optimal attitude and error estimation: ECI motion and time definitions. **Prerequisite:** AERO 423 or equivalent.

AERO 651 Human Spaceflight Operations

Credits 3. 3 Lecture Hours. Essential aspects of human spaceflight operations as performed 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:** Graduate classification.

AERO 655 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; graduate classification.

AERO 660 Nonlinear Flight Dynamics

Credits 3. 3 Lecture Hours. Nonlinear equations of motion for coupled aircraft motions; coupled aerodynamic phenomena; application of the direct method of Lyapunov to nonlinear aircraft motions; elastic airplane equations of motion. **Prerequisite:** AERO 421 or approval of instructor.

AERO 661 Optical Methods in Aerospace Engineering

Credits 3. 3 Lecture Hours. Analysis and design of imaging and interferometric instruments for flight in and above the atmosphere and ground-based observation of orbiting objects; assessment of optical component and system performance. **Prerequisite:** Graduate classification.

AERO 666 Systems Analysis

Credits 3. 3 Lecture Hours. Signals and systems; linear vector space analysis, inner product spaces, orthogonality, projection theorem, orthogonal polynomials, Fourier series and transform theory, dynamical systems, error analysis, estimation and control, linear operators, adjoints and introduction to optimization. **Prerequisite:** Graduate classification or approval of instructor.

AERO 670 Turbulence Modeling

Credits 3. 3 Lecture Hours. Identification of physical features that render Navier-Stokes equation difficult to compute or model; includes Reynolds-averaged and filtered Navier-Stokes equations for unresolved stresses; development of closure models for pressure-strain correlation, dissipation and turbulent transport Reynolds; algebraic Reynolds stress modeling, Large Eddy Simulations (LES) and hybrid methods; validation and prediction studies. **Prerequisites:** AERO 640/OCEN 640 and graduate classification or approval of instructor.

AERO 672 Perturbation Methods in Mechanics

Credits 3. 3 Lecture Hours. Develop approximate solutions to algebraic, differential, and integral equations; analysis of nonlinear oscillations, nonlinear waves, and boundary-layers; emphasis on combined numerical/perturbations techniques and reducing Partial Differential Equation (PDE) to Ordinary Differential Equation (ODE). **Prerequisites:** Graduate classification in aerospace, mechanical or civil engineering.

AERO 673 Boundary Layer Stability and Transition

Credits 3. 3 Lecture Hours. Analytical, numerical, and experimental methods for the stability of bounded shear flows; includes techniques for estimating transition to turbulence and the control of transition through laminar flow control. **Prerequisites:** Graduate classification and AERO 601, 602, or 603 or approval of instructor.

AERO 674 Hypersonic Flow

Credits 3. 3 Lecture Hours. Theoretical formulation of hypersonic flow theory; techniques for hypersonic flowfield analysis; high temperature effects, including both equilibrium and nonequilibrium flows; classical and modern computational methods. **Prerequisite:** AERO 303 or equivalent.

AERO 676 Aerothermochemistry

Credits 3. 3 Lecture Hours. Fundamentals of kinetic theory, chemical thermodynamics and statistical mechanics; applications to high temperature chemically reacting equilibrium and nonequilibrium aerodynamic flows. **Prerequisite:** AERO 303 or equivalent.

AERO 678 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:** Graduate classification or approval of instructor.

AERO 681 Seminar

Credit 1. 1 Lecture Hour. Selected research topics presented by the faculty, students and outside speakers. **Prerequisite:** Graduate classification.

AERO 684 Professional Internship

Credits 1 to 4. 1 to 4 Other Hours. Engineering research and design experience at government or industry facilities away from the Texas A&M campus; design projects supervised by faculty coordinators and personnel at these locations; projects selected to match student's area of specialization. **Prerequisites:** Graduate classification and approval of committee chair and department head.

AERO 685 Directed Studies

Credits 1 to 12. 1 to 12 Other Hours. Special topics not within scope of thesis research and not covered by other formal courses. **Prerequisite:** Graduate classification in aerospace engineering.

AERO 689 Special Topics in...

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

AERO 691 Research

Credits 1 to 23. 1 to 23 Other Hours. Technical research projects approved by department head.