Aerospace Science and Engineering
Aero Option Course Descriptions for for 2015-16 TA Positions

AER201H1 S
Engineering Design
II-AEESCBASE 1/5/-/0.50
Design of integrated, multidisciplinary systems is introduced through a major course project. Project selection and definition of functions and performance objectives for the open-ended design problem will take place early on by teams of students, while learning practical subjects of engineering in lectures and workshops. This process will lead to the preparation of project proposals consisting of identification of design objectives and constraints, generation and evaluation of potential approaches, selection of the most promising design concept, identification of product subsystems, and assignment of responsibilities to team members. Following project approval, the design process will comprise preliminary design, followed by detailed design, prototype construction and testing, and preparation of a final design report. Progress is evaluated weekly, culminating in a prototype demonstration and design review.
Recommended Preparation: ESC102H1, CSC190H1 and ECE159H1
NOTE: AER201 includes a total of 33 hours of lecture. While there is 1 regular lecture hour per week, there are an additional 21 hours scheduled into the first 4 weeks of the course.

AER210H1 F
Vector Calculus & Fluid Mechanics
II-AEESCBASE 3/0.50/2/0.50
The first part of this course covers multiple integrals and vector calculus. Topics covered include: double and triple integrals, derivatives of definite integrals, surface area, cylindrical and spherical coordinates, general coordinate transformations (Jacobians), Taylor series in two variables, line and surface integrals, parametric surfaces, Green's theorem, the divergence and gradient theorems, Stokes's theorem. The second part of the course provides a general introduction to the principles of continuum fluid mechanics. The basic conservation laws are derived in both differential and integral form, and the link between the two is demonstrated. Applications covered include hydrostatics, incompressible and compressible frictionless flow, the speed of sound, the momentum theorem, viscous flows, and selected examples of real fluid flows.
Prerequisite: MAT195H1
Corequisite: MAT292H1
Exclusion: CHE211H1, CHE221H1, CME261H1, CME270H1, MAT291H1 or MIE312H1
Recommended Preparation: PHY180H1

AER301H1 F
Dynamics
III-AEESCBASEA, III-AEESCBASEZ,
I-AEMINRAM 3/-/1/0.50
Reference frames in relative translation and rotation, vector and matrix formulations. Dynamics of a single particle and of systems of particles. Lagrange's equations. D'Alembert's and Hamilton's principle. Orbital dynamics. Rigid body kinematics and dynamics, Lagrangian approach to vibrations of complex systems. Model analysis. Primary Reference: class notes. Reference Books: Greenwood, Principles of Dynamics; Goldstein, Classical Mechanics.
Prerequisite: AER210H1, MAT185H1 and PHY180H1
Exclusion: MIE301H1

AER302H1 S
Aircraft Flight
III-AEESCBASEA, III-AEESCBASEZ 3/-/1/0.50
Basics of aircraft performance with an introduction to static stability and control. Topics covered include: Equations of Motion; Characteristics of the Atmosphere; Airspeed Measurement; Drag (induced drag, total airplane drag); Thurst and Power (piston engine characteristics, gas turbine performance); Climb (range payload); Tunrs; Pull-up; Takeoff; Landing (airborne distance, ground roll); Flight envelope (maneuvering envelope, gust load factors); Longitudinal and lateral static stability and control; Introduction to dynamic stability.
Prerequisite: AER307H1 and AER301H1

AER303H1 F
Aerospace Laboratory I
III-AEESCBASEA -/1/-/0.15
Students will perform a number of experiments in the subject areas associated with the Aerospace Option curriculum, and prepare formal laboratory reports.
Corequisite: AER307H1

AER304H1 S
Aerospace Laboratory II
III-AEESCBASEA -/1/-/0.15
Students will perform a number of experiments in the subject areas associated with the Aerospace Option curriculum, and prepare formal laboratory reports.
Corequisite: AER373H1

AER307H1 F
Aerodynamics
III-AEESCBASEA, III-AEESCBASEZ,
IV-AEMECBASC 3/-/1/0.50
Review of fundamentals of fluid dynamics, potential-flow, Euler, and Navier-Stokes equations; incompressible flow over airfoils, incompressible flow over finite wings; compressibility effects; subsonic compressible flow over airfoils; supersonic flow; viscous flow; laminar layers and turbulent boundary layers and unsteady aerodynamics. Textbook: Anderson, J.D., Fundamentals of Aerodynamics, 3rd Edition, McGraw Hill, 2001.
Prerequisite: AER210H1 or MIE312H1

AER310H1 S
Gasdynamics
III-AEESCBASEA 3/-/1/0.50
Basic introduction to compressible gasdynamics. Includes some fundamental thermodynamics, thermal and caloric equations of state, derivation of Euler's equations by control volume approach. Also, includes the theory of steady flows in ducts with area changes, adiabatic frictional flows, duct flows with heat transfer, normal and oblique shock waves, Prandtl-Meyer expansion wave, moving shock and rarefaction waves, shock tubes, and wind tunnels. The lectures are supplemented by problem sets. Reference book: Anderson, J.D., Modern Compressible Flow with Historical Perspective.

Prerequisite: AER307H1

AER315H1 F
Combustion Processes
III-AEESCBASEA 3/-/1/0.50
Scope and history of combustion, and fossil fuels; thermodynamics and kinetics of combustion including heats of formation and reaction, adiabatic flame temperature, elementary and global reactions, equilibrium calculations of combustion products, and kinetics of pollutant formation mechanisms; propagation of laminar premixed flames and detonations, flammability limits, ignition and quenching; gaseous diffusion flames and droplet burning; introduction to combustion in practical devices such as rockets, gas turbines, reciprocating engines, and furnaces; environmental aspects of combustion.
Prerequisite: CHE260H1
Exclusion: MIE516H1

AER336H1 S
Scientific Computing
III-AEESCBASEA, IV-AEESCBASEF,
IV-AEESCBASER, III-AEESCBASEZ 3/-/1/0.50
An introduction is provided to numerical methods for scientific computation which are relevant to the solution of a wide range of engineering problems. Topics addressed include interpolation, integration, linear systems, least-squares fitting, nonlinear equations and optimization, initial value problems, partial differential equations, and relaxation methods. The assignments make extensive use of MATLAB. Assignments also require knowledge of Fortran or C.
Prerequisite: ESC103H1 and MAT185H1

AER372H1 S
Control Systems
III-AEESCBASEA, III-AEESCBASEJ,
III-AEESCBASEZ 3/1.50/1/0.50
An introduction to dynamic systems and control. Models of physical systems. Stability and feedback control theory. Analysis and synthesis of linear feedback systems by “classical” and state space techniques. Introduction to nonlinear and optimal control systems. Digital computer control. Multivariable feedback system design.
Prerequisite: MAT185H1 and MAT292H1
Exclusion: CHE322H1, ECE356H1 or MIE404H1

AER373H1 S
Mechanics of Solids and Structures
III-AEESCBASEA, III-AEESCBASEI 3/-/1/0.50
An Introduction to Solid and Structural Mechanics. Continuum Mechanics: Stress, strain and constitutive relations for continuous systems, Equilibrium equations, Force and Flexibility methods, Introduction to Cartesian Tensors. Variational Principles: Virtual Work, Complementary Virtual Work, Strain Energy and Work, Principle of Stationary Value of the Total Potential Energy, Complementary Potential Energy, Reissner’s Principle, Calculus of Variations, Hamilton’s Principle. Beam and Plate theory. Dynamics of discrete and continuous systems.
Prerequisite: CIV102H1

AER406H1 S
Aircraft Design
IV-AEESCBASEA -/-/3/0.50
This course involves the detailed preliminary design of an airplane. Performance and mission specifications are given, as well as the engine’s characteristics. The class is divided into teams of three to four students who are guided to develop an airplane that can meet these specifications. Individual team members will specialize in areas such as “performance”, “structure”, “systems”, etc., although all team members should be conversant with each other’s results and methodology. Each week, a representative of each team presents a progress lecture on that team’s efforts, which is discussed and critiqued by the class. Also, the teams meet one-on-one with the professor and tutors to discuss specific design questions. At the end of the course each team will present a verbal and written report of sufficient detail to provide a compelling case for the feasibility of their proposed airplane. Text: Raymer, Daniel P., Aircraft Design: A Conceptual Approach, published by the AIAA.
Prerequisite: AER302H1, AER307H1 and AER373H1

AER407H1 F
Space Systems Design
IV-AEESCBASEA, III-AEESCBASEZ,
I-AEMINRAM -/3/-/0.50
Introduction to the conceptual and preliminary design phases for a space system currently of interest in the Aerospace industry. A team of visiting engineers provide material on typical space systems design methodology and share their experiences working on current space initiatives through workshops and mock design reviews. Aspects of operations, systems, electrical, mechanical, software, and controls are covered. The class is divided into project teams to design a space system in response to a Request for Proposals (RFP) formulated by the industrial team. Emphasis is placed on standard top-down design practices and the tradeoffs which occur during the design process. Past projects include satellites such as Radarsat, interplanetary probes such as a solar sailer to Mars, a Mars surface rover and dextrous space robotic systems.

AER501H1 F
Advanced Mechanics of Structures
IV-AEESCBASEA 3/-/1/0.50
Introduction to the Finite Element Method and Structural Optimization. Review of linear elasticity: stress, strain and material constitutive laws, Variational Principles. The Finite Element technique: problem formulation - methods of Ritz and Galerkin, element properties - C0 and C1 formulations, static and dynamic problems: applications to bar, beam, membrane and plate problems. Structural Optimization: Overview of problems, Optimal Design problem formulation, solution strategies - gradient search techniques, Sensitivity analysis for static and dynamic problems, Optimization problems using commercial finite element codes. Text: Shames & Dym, Energy and Finite Element Methods in Structural Mechanics.
Prerequisite: AER373H1
Recommended Preparation: AER373H1

AER503H1 S
Aeroelasticity
IV-AEESCBASEA 3/-/1/0.50
Static aeroelastic phenomena are studied, including divergence of slender wings and control reversal. Various methods of solution are considered such as closed form, matrix format iteration and

the Rayleigh-Ritz approach. A Study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters which affect flutter speed.
Prerequisite: AER307H1 and AER501H1

AER506H1 F
Spacecraft Dynamics and Control
IV-AEESCBASEA 3/-/1/0.50
Planar "central force" motion; elliptical orbits; energy and the major diameter; speed in terms of position; angular momentum and the conic parameter; Kepler's laws. Applications to the solar system; applications to Earth satellites. Launch sequence; attaining orbit; plane changes; reaching final orbit; simple theory of satellite lifetime. Simple (planar) theory of atmospheric entry. Geostationary satellite; adjustment of perigee and apogee; east-west stationkeeping. Attitude motion equations for a torque-free rigid body; simple spins and their stability; effect of internal energy dissipation; axisymmetric spinning bodies. Spin-stabilized satellites; long-term effects; sample flight data. Dual-spin satellites; basic stability criteria; example-CTS. "active" attitude control; reaction wheels; momentum wheels; controlmoment gyros; simple attitude control systems.
Prerequisite: AER301H1 and AER372H1

AER507H1 F
Introduction to Fusion Energy
I-AECERNUC, IV-AEESCBASEA, IV-AEESCBASEJ, IV-AEESCBASEP, IV-AEESCBASER, I-AEMINENR 3/-/1/0.50
Nuclear reactions between light elements provide the energy source for the sun and stars. On earth, such reactions could form the basis of an essentially inexhaustible energy resource. In order for the fusion reactions to proceed at a rate suitable for the generation of electricity, the fuels (usually hydrogen) must be heated to temperatures near 100 million Kelvin. At these temperatures, the fuel will exist in the plasma state. This course will cover: (i) the basic physics of fusion, including reaction cross-sections, particle energy distributions, Lawson criterion and radiation balance, (ii) plasma properties including plasma waves, plasma transport, heating and stability, and (iii) fusion plasma confinement methods (magnetic and inertial). Topics will be related to current experimental research in the field.

AER510H1 S
Aerospace Propulsion
IV-AEESCBASEA 3/-/1/0.50
Scope and history of jet and rocket propulsion; fundamentals of air-breathing and rocket propulsion; fluid mechanics and thermodynamics of propulsion including boundary layer mechanics and combustion; principles of aircraft jet engines, engine components and performance; principles of rocket propulsion, rocket performance, and chemical rockets; environmental impact of aircraft jet engines.
Prerequisite: AER310H1

AER521H1 S
Mobile Robotics and Perception
IV-AEESCBASEA, IV-AEESCBASER, IV-AEESCBASEZ, I-AEMINRAM 3/1.50/1/0.50
The course addresses fundamentals of mobile robotics and sensor-based perception for applications such as space exploration, search and rescue, mining, self-driving cars, unmanned aerial vehicles, autonomous underwater vehicles, etc. Topics include sensors and their principles, state estimation, computer vision, control architectures, localization, mapping, planning, path tracking, and software frameworks. Laboratories will be conducted using both simulations and hardware kits.
Prerequisite: AER372H1

AER525H1 F
Robotics
IV-AEESCBASEA, IV-AEESCBASER, IV-AEMECBASC 3/1.50/1/0.50
The course addresses fundamentals of analytical robotics as well as design and control of industrial robots and their instrumentation. Topics include forward, inverse, and differential kinematics, screw representation, statics, inverse and forward dynamics, motion and force control of robot manipulators, actuation schemes, task-based and workspace design, mobile manipulation, and sensors and instrumentation in robotic systems. A series of experiments in the Robotics Laboratory will illustrate the course subjects.
Prerequisite: AER301H1 and AER372H1
Exclusion: ECE470H1

ROB301H1 F
Introduction to Robotics
III-AEESCBASEZ 3/1.50/1/0.50
The course is intended to provide an introduction and a very interdisciplinary experience to robotics. The structure of the course is modular and reflects the perception-control-action paradigm of robotics. The course, however, aims for breadth, covering an introduction to the key aspects of general robotic systems, rather than depth, which is available in later more advanced courses. Applications addressed include robotics in space, autonomous terrestrial exploration, biomedical applications such as surgery and assistive robots, and personal robotics. The course culminates in a hardware project centered on robot integration.
Recommended Preparation: AER201H1

ROB310H1 F
Mathematics for Robotics
III-AEESCBASEZ 3/-/1/0.50
The course addresses advanced mathematical concepts particularly relevant for robotics. The mathematical tools covered in this course are fundamental for understanding, analyzing, and designing robotics algorithms that solve tasks such as robot path planning, robot vision, robot control and robot learning. Topics include complex analysis, optimization techniques, signals and filtering, advanced probability theory, and numerical methods. Concepts will be studied in a mathematically rigorous way but will be motivated with robotics examples throughout the course.
Recommended Preparation: ESC103H1, MAT185H1, STA286H1 and MAT292H1

Aerospace Graduate Course Descriptions for 2015-16 TA Positions

AER 1202H Advanced Flight Dynamics
Lecture Course
Introduction to the dynamics of aircraft. Topics considered include derivation of equations of motion; small perturbation methods;

stability derivative estimation; longitudinal and lateral static stability and dynamic stability; response to control input(open-loop control); and closed-loop flight control system design.

AER 1304H Fundamentals of Combustion
Lecture Course
This course starts with a review of chemical thermodynamics, statistical mechanics, equilibrium chemistry, chemical kinetics, and conservation equations. Then, the following subjects are covered: chemical and dynamic structure of laminar premixed, diffusion, and partially premixed flames; turbulent premixed combustion; turbulent diffusive combustion in one and two-phase flows; aerodynamics and stabilization of flames; ignition, extinction and combustion instabilities; non-intrusive combustion diagnostics and flame spectroscopy.

AER 1315H Sustainable Aviation
Lecture Course
This course will cover topics relating to the impact of aircraft on the environment, including noise, local and global emissions, and lifecycle analysis. Students will be exposed to means of quantitative assessment of the impact of aviation noise and emissions as well as metrics for assessing global climate effects. Current and future technologies for mitigating environmental problems will be covered.

AER 1316H Fundamentals of Computational Fluid Dynamics
Lecture Course
This course presents the fundamentals of numerical methods for inviscid and viscous flows. The following topics are covered: finite-difference and finite-volume approximations, structured and unstructured grids, the semidiscrete approach to the solution of partial differential equations, time-marching methods for ordinary differential equations, stability of linear systems, approximate factorization, flux-vector splitting, boundary conditions, relaxation methods, and multigrid.

AER 1403H Advanced Aerospace Structures
Lecture course
This course will provide instruction in three areas crucial to aerospace structural design: thin walled structures, fiber composite materials, and finite element methods. All three will be taught in a manner such that their interrelation is made clear. The course will being with general theories of shells and thin walled structures, which are essential to aircraft design. Composite mechanics and fabrication will be addressed in the context of thin walled structures. Finally, finite element methods of use in modelling thin walled structures and composites will be described. No specific background in any of these three topics is required, but a good knowledge of solid and structural mechanics will be assumed.