Institute for Aerospace Studies
UNIVERSITY OF TORONTO

Posting date: June 1 2021

Teaching Assistantship Positions 2021-2022

Teaching Assistantship applications for Aerospace courses are now being accepted for the 2021-2022 academic year. Applicants must apply now to be considered for any position that may arise during the 2021-22 academic year. Opportunities may become available for any course at any time.
Please complete the application form and submit it along with your CV, transcript (if required), and any other associated documents by 11:59 p.m., Friday July 23, 2021 to TAapplication@utias.utoronto.ca. Your complete submission must be in a single pdf file.

Qualifications, Duties, and Hours of Work

All applicants are expected to include an undergraduate transcript. Applicants who did not receive their B.A.Sc. from UofT Engineering are required to include scans or URL links for their course calendar descriptions (in English) for relevant courses. You will be contacted via email if an interview is required. Familiarity with the course content, progress of lectures and preparation of material for the respective course are the necessary requirements. Teaching assistants are required to supervise laboratory sessions and/or mark and grade reports, assignments, and notebooks as necessary, and assist in the examinations. The total duty time for courses in the enclosed list is typically 35-80 hours, depending on the projected class size and marking/laboratory requirements. AER210F, AER303F, AER372S, AER406S, AER407F, AER525F, ESC194F, ESC195S, ROB301F and ROB521 require regular student contact time on the main (St. George) campus.

The hourly rate of pay is $46.70 (fall term) or $47.17 (winter term) for both graduate and undergraduate students. The rates are in accordance with the collective agreement between the University of Toronto and the Canadian Union of Public Employees, Local 3902 Unit 1 representing teaching assistants. First-time teaching assistants will be paid to attend a mandatory training session, typically during the beginning of the fall semester. Details of the training session will be posted in due course. Please note that should rates stipulated in the collective agreement vary from rates stated in this posting, the rates stated in the collective agreement shall prevail.

The University of Toronto is strongly committed to diversity within its community. The University especially welcomes applications from visible minority group members, women, Aboriginal persons, persons with disabilities, members of sexual minority groups, and others who may contribute to further diversification of ideas.

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Course Number	Course Title	Instructor	Enrolment Estimate	Number & Type of Positions	Term of Appointment
ESC194F	Calculus I	P.C. Stangeby/ J.W. Davis	300	6 tutorial	September
ESC384F	Partial Differential Equations	M. Yano	50	1 marking	September
AER210F	Vector Calculus & Fluid Mechanics	A. Ekmekci	200	6 tutorial & 4 lab	September
AER301F	Dynamics	G. D'Eleuterio	50	1 marking	September
AER303F	Aerospace Laboratory I	P. Lavoie	20	2 lab	September
AER307F	Aerodynamics	P. Lavoie	30	1 marking	September
AER315F	Combustion Processes	O.L. Gulder	20	1 marking	September
AER407F	Space Systems Design	C.J. Damaren	20	2 lab	September
AER501F	Advanced Mechanics of Structures	P.B. Nair	30	1 marking	September
AER506F	Spacecraft Dynamics and Control	M.R. Emami	20	1 marking	September
AER507F	Introduction to Fusion Energy	J.W. Davis	15	1 marking	September
AER525F	Robotics	M.R. Emami	50	1 marking & 1 lab	September
ROB301F	Introduction to Robotics	G. D'Eleuterio	50	1 marking & 2 lab	September
ROB310F	Mathematics for Robotics	T.D. Barfoot	50	1 marking	September
ROB501F	Computer Vision for Robotics	S.L. Waslander	50	1 marking	September
AER1202F	Advanced Flight Dynamics	H.T. Liu	10	1 marking	September
AER1304F	Fundamentals of Combustion	O.L. Gulder	15	1 marking	September
AER1216F	Fundamentals of UAVs	P.R. Grant	25	1 marking	September
AER1316F	Fundamentals of CFD	D.W. Zingg	20	1 marking	September
AER1410F	Topology Optimization	C.S. Steeves	20	1 marking	September

AER1513F	State Estimation for Aerospace Vehicles	T.D. Barfoot	30	1 marking	September
AER1515F	Perception for Robotics	S.L. Waslander	20	1 marking	September
ESC195S	Calculus II	J.W. Davis	250	5 tutorial	January
AER302S	Aircraft Flight	H.T. Liu	20	1 marking	January
AER304S	Aerospace Laboratory II	C.A. Steeves	20	2 lab	January
AER310S	Gas Dynamics	C.P.T. Groth	20	1 marking	January
AER336S	Scientific Computing	M. Yano	20	1 marking	January
AER372S	Control Systems	M.R. Emami	60	1 marking & 2 lab	January
AER373S	Mechanics of Solids and Structures	C.A. Steeves	20	1 marking	January
AER406S	Aircraft Design	P.R. Grant	20	3 lab	January
AER503S	Aeroelasticity	P.R. Grant	15	1 marking	January
AER510S	Aerospace Propulsion	S. Chaudhuri	20	1 marking	January
ROB311S	Artificial Intelligence	TBD	40	1 marking	January
ROB313S	Introduction to Learning from Data	TBD	50	1 marking	January
ROB521S	Mobile Robotics & Perception	S.L. Waslander	80	1 marking & 2 lab	January
AER1217S	Design of UAVs	H. Liu	15	1 marking	January
AER1303S	Advanced Fluid Mechanics	A. Ekmekci	15	1 marking	January
AER1403S	Advanced Aerospace Structures	C.A. Steeves	15	1 marking	January
AER1415S	Computational Optimization	P.B. Nair	20	1 marking	January
AER1516S	Motion Planning	TBD	20	1 marking	January
AER1517S	Control for Robotics	TBD	20	1 marking	January

NOTE
1. The positions posted above are tentative, pending final course determinations, enrolments, and subsequent appointments.
2. The above positions are posted in accordance with the CUPE 3902 Collective Agreement.

Undergraduate Aerospace, Engineering Science and Robotics Course Descriptions for 2021-22 TA Positions

AER210H1 F	Vector Calculus & Fluid Mechanics	
		3/0.50/2/0.50

II-AEESCBASE

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: ESC195H1
Corequisite: MAT292H1
Exclusion: CHE211H1, CHE221H1, CME261H1, CME270H1, MAT291H1 or MIE312H1
Recommended Preparation: PHY180H1

AER301H1 F	Dynamics	
		3/-/1/0.50

III-AEESCBASEA, III-AEESCBASEZ,
I-AEMINRAM

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	
		3/-/1/0.50

III-AEESCBASEA, III-AEESCBASEZ

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	

3/-/1/0.50

III-AEESCBASEA

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	

3/-/1/0.50

III-AEESCBASEA, IV-AEESCBASEF,
I-AEESCBASEL, IV-AEESCBASER,
III-AEESCBASEZ, I-AEMINAIEN

Introduces 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, and partial differential equations. The assignments require programming of numerical algorithms.

Prerequisite: ESC103H1 and MAT185H1

AER372H1 S	Control Systems	

3/1.50/1/0.50

III-AEESCBASEA, III-AEESCBASEJ,
III-AEESCBASEZ

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	

3/-/1/0.50

III-AEESCBASEA, III-AEESCBASEI

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	

-/-/3/0.50

IV-AEESCBASEA

Teams of 3 or 4 students design, build, and fly a remotely piloted aircraft. The aircraft is designed and built to maximize a flight score, which is a complex function of many factors – payload fraction, payload type, flight time, takeoff distance, etc. Teams are provided with identical motors, batteries, radio equipment, and flight instrumentation. Weekly sessions consist of a combination of lectures and one-on-one meetings with the tutors and professor to discuss each teams' progress. Evaluations are based on the weekly reports, preliminary and final design presentations and reports, an as-built report, and measured flight performance.

Prerequisite: AER302H1, AER307H1 and AER373H1

AER407H1 F	Space Systems Design	

-/3/-/0.50

IV-AEESCBASEA, III-AEESCBASEZ,
I-AEMINRAM

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.

Prerequisite: AER301H1, AER372H1

AER501H1 F	Computational Structural Mechanics and Design Optimization	

3/-/1/0.50

IV-AEESCBASEA

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	

3/-/1/0.50

IV-AEESCBASEA

Static aeroelastic phenomena are studied, including divergence of 2D sections and slender 3D wings, as well as control reversal of 3D wings. Various methods of solution are considered such as closed form, discrete element, and the Rayleigh-Ritz approach. A study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters that affect flutter speed. Classical, k, and p-k methods for flutter estimation are presented.

Prerequisite: AER307H1 and AER501H1

AER506H1 F	Spacecraft Dynamics and Control	

3/-/1/0.50

IV-AEESCBASEA

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	

3/-/1/0.50

I-AECERNUC, IV-AEESCBASEA,
IV-AEESCBASEJ, IV-AEESCBASEP,
IV-AEESCBASER, I-AEMINENR

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	

3/-/1/0.50

IV-AEESCBASEA

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

AER525H1 F	Robotics	

3/1.50/1/0.50

IV-AEESCBASEA, IV-AEESCBASER,
IV-AEMECBASC, IV-AEMINADVM

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

ESC194H1 F	Calculus I	

3/-/1/0.50

I-AEESCBASE

Topics include: theory and applications of differential and integral calculus, limits, basic theorems and elementary functions. An introduction to differential equations is also included.

ESC195H1 S	Calculus II	

3/-/1/0.50

I-AEESCBASE

Topics include: techniques of integration, improper integrals, sequences, series, Taylor's theorem, as well as an introduction to vector functions, functions of several variables, partial derivatives and the optimization of multivariable functions.

Prerequisite: ESC194H1
Exclusion: MAT187H1/APS163H1

ESC384H1 F	Partial Differential Equations	

3/-/1/0.50

III,IV-AECPEBASC, III,IV-AEELEBASC,
III-AEESCBASEA, III-AEESCBASEF,
III-AEESCBASEP, IV-AEESCBASER,
IV-AEESCBASET, III-AEESCBASEZ

Introduces analytical techniques for partial differential equations (PDEs). Concepts covered include Fourier series, Sturm-Liouville theory, Green's functions, characteristics, and Laplace transform method. Applications are in model PDEs in continuum mechanics: diffusion, transport, heat, and wave equations.

Prerequisite: MAT290H1/MAT292H1

ROB301H1 F	Introduction to Robotics	

3/1.50/1/0.50

III-AEESCBASEZ

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.

Prerequisite: AER201H1

ROB310H1 F	Mathematics for Robotics	

3/-/1/0.50

III-AEESCBASEA, III-AEESCBASEZ,
I-AEMINRAM

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.

Prerequisite: MAT185H1, MAT292H1
Recommended Preparation: ESC103H1, ECE286H1

ROB311H1 S	Artificial Intelligence	

3/-/1/0.50

I-AECERAIEN, III-AEESCBASEL,
I-AEMINAIEN, I-AEMINRAM

An introduction to the fundamental principles of artificial intelligence from a mathematical perspective. The course will trace the historical development of AI and describe key results in the field. Topics include the philosophy of AI, search methods in problem solving, knowledge representation and reasoning, logic, planning, and learning paradigms. A portion of the course will focus on ethical AI, embodied AI, and on the quest for artificial general intelligence.

Prerequisite: Prerequisite: ECE286H1/ECE302H1 and ECE345H1/ECE358H1/CSC263H1

ROB313H1 S	Introduction to Learning from Data	

3/-/2/0.50

I-AECERAIEN, III-AEESCBASEZ,
I-AEMINAIEN, I-AEMINRAM

This course will introduce students to the topic of machine learning, which is key to the design of intelligent systems and gaining actionable insights from datasets that arise in computational science and engineering. The course will cover the theoretical foundations of this topic as well as computational aspects of algorithms for unsupervised and supervised learning. The topics to be covered include: The learning problem, clustering and k-means, principal component analysis, linear regression and classification, generalized linear models, bias-variance tradeoff, regularization methods, maximum likelihood estimation, kernel methods, the representer theorem, radial basis functions, support vector machines for regression and classification, an introduction to the theory of generalization, feedforward neural networks, stochastic gradient descent, ensemble learning, model selection and validation.

Prerequisite: ECE286H1, MAT185H1, MAT195H1, CSC263H1/ECE358H1
Exclusion: ECE421H1, CSC411H1

ROB501H1 F	Computer Vision for Robotics	

3/-/1/0.50

I-AEESCBASEL, IV-AEESCBASEZ,
I-AEMINAIEN

An introduction to aspects of computer vision specifically relevant to robotics applications. Topics include the geometry of image formation, basic image processing operations, camera models and calibration methods, image feature detection and matching, stereo vision, structure from motion and 3D reconstruction. Discussion of moving object identification and tracking as time permits.

Prerequisite: ROB301H1
Exclusion: CSC420H1
Recommended Preparation: CSC263H1

ROB521H1 S	Mobile Robotics and Perception	

3/1.50/1/0.50

IV-AEESCBASEA, IV-AEESCBASER,
IV-AEESCBASEZ, I-AEMINRAM

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: ROB310H1, AER372H1

Aerospace and Robotics Graduate Course Descriptions for 2021-22 TA Positions

AER 1202H Advanced Flight Dynamics

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 1216H Fundamentals of UAVs

Unpiloted aircraft, known as UAVs, drones or aerial robots, are very quickly becoming a major sector of the aerospace industry. They are increasingly used in aerial photography, inspection of infrastructure, delivery of small packages and other applications requiring inexpensive and flexible flight. The basic physical, scientific and engineering principles necessary to design a remote-controlled fixed-wing or quad-rotor UAV are explained in this course. These include aerodynamics, propulsion, structures and control. A key part of this course will be a group project to create a detailed design of a UAV that is capable of performing a specific function.

AER 1217H Development of Autonomous UAS

This course is the second part of the CARRE core courses, following AER1216: Fundamentals of UAVs, which covers the fundamental principles related to UAV design: structures, aerodynamics and control. AER1216 is the prerequisite of this course, unless approved by the instructor. In AER 1217, the focus is placed on the development of unmanned aerial systems (UAS), with the theme of autonomy in navigation and control, as well as flight performance analysis and evaluation.

The course curriculum will be delivered in both lectures and development projects, including flight tests. The contents include: quadrotor or fixed-wing UAV dynamics and control; sensing and estimation for UAVs; navigation and path planning; instrumentation and sensor payloads; computer vision. A development project will be given to students who will use the UAV platform to design an autonomous system to accomplish a specific flying mission, to be demonstrated by flight experiments.

Prerequisite:

AER 1216H “Fundamentals of UAVs” or equivalent with permission of the instructor

AER 1303H Advanced Fluid Mechanics

This course is intended to be a first graduate-level course in fluid mechanics, and assumes that students have had at least one introductory fluid mechanics course at the undergraduate level. The course starts with a review of vectors, tensors and related theorems; flow kinematics; derivations of the differential forms of the governing equations of fluid motion. Then the following subjects are covered: exact solutions (solutions with parallel boundaries, solutions with circular symmetry, pulsating flows, stagnation-point flows, etc); special forms of governing equations (Kelvin’s theorem, vorticity transport theorem, equations for inviscid flow (Euler); and boundary layer theory (boundary layer equations, boundary layer on a flat plate: Blasius solution, approximate solutions, effect of pressure gradient, separation, perturbation techniques, stability of boundary layers, etc.

AER 1304H Fundamentals of Combustion

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 1316H Fundamentals of Computational Fluid Dynamics

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

This course will provide instruction in three areas crucial to aerospace structural design: fiber composite materials, thin walled structures, and finite element methods. All three will be taught in a manner such that their interrelation is made clear. The course will begin with a composite materials, their mechanics and application. General theories of shells and thin walled structures, which are essential to aircraft design, will next be discussed. Finally, finite element methods of use in modelling aircraft 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.

AER 1410H Topology Optimization

Topology optimization is a relatively new method for the computational design of structures that enables optimal structural design beyond traditional size and shape optimization. Specifically, topology optimization identifies where to put material and where to put holes within the design domain. This course will examine the background to topology optimization, the theory and algorithms necessary to build a topology optimization code, and the two main approaches to topology optimization. At the conclusion of the course, students will be able to program a basic topology optimization code and use a common commercial software package.

AER 1415H Computational Optimization

This is an introductory graduate-level course on computational optimization and it is assumed that students have had undergraduate level training in multivariable calculus, linear algebra and MATLAB programming. The topics to be covered in this course include: formulation of optimization problems, non-gradient and stochastic search techniques, gradient-based optimization algorithms for unconstrained and constrained problems, numerical methods for sensitivity analysis, surrogate modeling, surrogate-assisted optimization frameworks, applications of optimization algorithms to design, parameter estimation and control.

AER 1513H State Estimation for Aerospace Vehicles

This course introduces the fundamentals of state estimation for aerospace vehicles. Knowing the state (e.g., position, orientation, velocity) of a vehicle is a basic problem faced by both manned and autonomous systems. State estimation is relevant to aircraft, satellites, rockets, landers, and rovers. This course teaches some of the classic techniques used in estimation including least squares and Kalman filtering. It also examines some cutting edge techniques for nonlinear systems including unscented Kalman filtering and particle filtering. Emphasis is placed on the ability to carry out state estimation for vehicles in three-dimensional space, which is complicated by vehicle attitude and often handled incorrectly. Students will have a chance to work with datasets from real sensors in assignments and will apply the principles of the course to a project of their choosing.

AER 1515H Perception for Robotics

This course presents the fundamentals of robotic perception based on a foundation of probability, statistics and information theory. Common sensor types and their probabilistic modeling are surveyed, including computer vision, Lidar, radar, GNSS/INS and odometry. Methods for feature extraction, description & matching, direct photometric and point cloud registration, outlier rejection are presented in the context of a robotic localization and mapping front end. Object detection and tracking, semantic segmentation and prior maps are fused to form a complete perceptual view of dynamic environments for a wide range of robotic applications.

AER 1516H Motion Planning

A rigorous mathematical study of the motion planning problem for aerial, ground, and mobile manipulator robot platforms and for multi-robot systems. Geometric representations and the robot configuration space. Sampling-based motion planning. Feedback motion planning in continuous spaces. Planning under sensor uncertainty and with differential constraints.Course project involving the implementation of modern planning algorithms in simulation and (potentially) on a real mobile manipulator.

AER 1517H Control for Robotics

This course presents optimal, adaptive and learning control principles from the perspective of robotics applications. Working from the Hamilton-Jacobi-Bellman formulation, optimal control methods for aerial and ground robots are developed. Real world challenges such as disturbances, state estimation errors and model errors are addressed and adaptive and reinforcement learning approaches are derived to address these challenges. Course project involves simulated control of an aerial vehicle, with aerodynamic models and wind disturbances.