AEROSPACE ENGINEERING

<http://www.aro.csupomona.edu/>

Ali R. Ahmadi, Chair
Donald L. Edberg
Gabriel G. Georgiades

The Aerospace Engineering Department aspires to be a nationally and internationally recognized premier undergraduate aerospace engineering program, enriched by a strong master's degree program.

The goals of the aerospace engineering program are:

- to educate those who will be successful in the aerospace industry as well as national graduate programs;
- to exemplify the linking of theoretical and practical knowledge; and
- to provide the profession with graduates that have a broad-based multidisciplinary understanding of science and engineering fundamentals..

Traditionally the aerospace engineer has been involved with the design and development of high speed vehicles such as aircraft, missiles and spacecraft. Over the years this list has evolved to include ocean vessels and high-speed land vehicles as well. The extreme environments in which these vehicles operate have dictated the construction of the most complex engineering systems devised by man and require integration and application of such disparate fields as aerodynamics and heat transfer, structural mechanics, control system theory and vehicle dynamics. Often the aerospace engineer is confronted with problems that cannot be fully defined but, in spite of this, require imaginative and sophisticated solutions.

This accredited program aims to:

- provide students with a comprehensive education that includes in-depth instruction in aerodynamics, aircraft and spacecraft structures, flight mechanics, orbital mechanics, flight propulsion, and design of aerospace systems;
- provide laboratory and field experience, independent study opportunities; and
- prepare students for graduate studies and careers in aerospace engineering by emphasizing analysis and problem-solving, exposure to open-ended problems and design issues while fostering teamwork, communication skills, and individual professionalism.

Students desiring to major in Aerospace Engineering should have a particularly high aptitude for science and mathematics, and incoming freshmen should have taken substantial college preparatory courses in these disciplines in high school. Incoming transfer students should have completed at least one year of college calculus and one year of college physics (with laboratory) prior to beginning the program at Cal Poly Pomona. The community college student planning to transfer into this department should consult a school counselor or department to determine which courses meet the program requirements.

Graduates of the program will have:

- an understanding of physics, chemistry and mathematics to effectively address real world engineering problems;
- an understanding of engineering science fundamentals that enables them to examine real world engineering problems for the underlying physical principles and decide on appropriate methods of solution;
- the ability to analyze and design aerospace structural elements;
- the ability to perform aerodynamic analysis;
- the ability to analyze air-breathing propulsion systems;
- the ability to analyze the flight dynamics of aircraft and spacecraft and design flight control systems;
- the ability to analyze spacecraft trajectories;
- the ability to work in teams and design complex systems such as aircraft and spacecraft from a conceptual design perspective;
- good oral, written and graphic communications skills; and
- an understanding of the role of the engineer in society and an awareness of ethical, environmental and quality concerns of the engineering profession.

Aerospace engineering students are encouraged to become active in the student branch of the American Institute of Aeronautics and Astronautics, a national society organized for the advancement of aerospace knowledge. Qualified students are invited to join the student chapter of Sigma Gamma Tau, the national aerospace engineering honor society.

CORE COURSES FOR MAJOR

Required of all students. A 2.0 cumulative GPA is required in core courses for the major in order to receive a degree in the major.

Introduction to Aeronautics	ARO	101L	(1)
Introduction to Astronautics	ARO	102L	(1)
Introduction to Aerospace Propulsion	ARO	103L	(1)
Aerospace Engineering Computer Graphics Lab	ARO	127L	(1)
Fundamentals of Systems Engineering	ARO	201L	(1)
Fundamentals of Aeronautics	ARO	202L	(1)
Fundamentals of Astronautics	ARO	203L	(1)
Fluid Dynamics	ARO	301	(4)
Low-Speed Aerodynamics	ARO	305	(4)
Astronautics Spacecraft Design	ARO	309	(3)
Gas Dynamics	ARO	311	(3)
Aircraft Jet Propulsion	ARO	312	(4)
Aerospace Feedback Control Systems	ARO	322/L	(4)
Aerospace Structural Mechanics I/Lab	ARO	326/L	(4)
Aerospace Structural Mechanics II	ARO	327	(3)
Aerospace Structural Analysis and Design	ARO	329	(3)
Fluid Dynamics/Heat Transfer Lab	ARO	351L	(1)
Aerodynamics and Jet Propulsion Lab	ARO	352L	(1)
Aerospace Structures Laboratory	ARO	357L	(1)
Heat, Mass and Moment Transfer	ARO	401	(4)
High-Speed Aerodynamics	ARO	404	(3)
Aircraft Stability and Control	ARO	405	(4)
Dynamics of Aerospace Systems	ARO	406	(4)
Senior Project	ARO	461	(2)
Senior Project	ARO	462	(2)
Aerosciences	ARO	490L	(1)
Aerospace Vehicle Design Lab I	ARO	491L	(2)
Aerospace Vehicle Design Lab II	ARO	492L	(2)
Aerospace Vehicle Design Lab III	ARO	493L	(2)
Advisor Approved Electives			(12)

SUPPORT AND ELECTIVE COURSES

(Required of all students)

Analytic Geometry and Calculus I*	MAT	114	(4)
Analytic Geometry and Calculus II	MAT	115	(4)
Analytic Geometry and Calculus III	MAT	116	(4)
Calculus of Several Variables	MAT	214	(3)
Calculus of Several Variables	MAT	215	(3)
Differential Equations	MAT	216	(4)
Mathematical Analysis of Engineering Problems	MAT	318	(3)

Materials Science and Engineering	MTE	207	(3)
General Physics*	PHY	131/L	(4)
General Physics	PHY	132/L	(4)
General Physics	PHY	133/L	(4)
Elements of Electrical Engineering/Lab	ECE	231/L	(4)
Vector Statics	ME	214	(3)
Vector Dynamics	ME	215	(4)
CME Thermodynamics I	CHE	302	(4)
General Chemistry/Lab*	CHM	121/L	(4)
Freshman English I*	ENG	104	(4)
Advocacy and Argument*	COM	204	(4)
Freshman English II*	ENG	105	(4)
Introduction to Philosophy*	PHL	201	(4)
Introduction to American Government*	PLS	201	(4)
United States History*	HST	202	(4)
Principles of Economics*	EC	201	(4)
General Psychology*	PSY	201	(4)

Courses marked with an asterisk (*) may be used to satisfy GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 198 units.

GENERAL EDUCATION COURSES

An alternate pattern from that listed here for partial fulfillment of Areas A, C, and D available for students in this major is the Interdisciplinary General Education (IGE) Program. Please see the description of IGE elsewhere in this catalog.

Area A Communication and Critical Thinking (12 units)

1. Written Communication
2. Oral Communication
3. Critical Thinking

Area B Mathematics and Natural Sciences (16 units)

1. Math/Quantitative Reasoning
2. Physical Science
3. Biological Science
4. Science and Technology Synthesis*

Area C Humanities (16 units)

1. Fine and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis*

Area D Social Sciences (20 units)

1a. and 1b. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic, and Gender Studies
4. Social Science Synthesis*

Area E Lifelong Understanding and Self-development (4 units)

Lifelong Understanding

*Consult Department

COURSE DESCRIPTIONS

ARO 101L Introduction to Aeronautics (1)

History of fixed- and rotary-wing aircraft development; characteristics of current aircraft. Contributions of aerospace engineering to society. Units and dimensions, dimensionless coefficients. Forces, pressures, generation of lift. Radio-controlled aircraft project. Aerospace structural materials. Preliminary aircraft sizing. 1 three-hour laboratory. Corequisite: MAT 105

ARO 102L Introduction to Astronautics (1)

History of missile, rocket, and spacecraft development; characteristics of current launch vehicles and spacecraft. The role of the aerospace engineer in industry, government, and the university. Launch performance, trajectories, and orbits. Solid-propelled rocket project. Spacecraft mission design and configuration. 1 three-hour laboratory. Corequisite: MAT 105.

ARO 103L Introduction to Aerospace Propulsion (1)

History of aircraft engine and rocket development; characteristics of current aircraft piston, turbine and rocket engines. Ethical factors, standards and expectations in aerospace engineering. Generation of thrust. Propulsion system performance. Compressed-air thrust project. 1 three-hour laboratory. Corequisites: MAT 105.

ARO 127L Aerospace Engineering Computer Graphics Laboratory (1)

Computer-aided graphics and engineering design fundamentals. Sketching, line drawing, dimensioning, simple wire frame, solid modeling and projection theory. Airplane general arrangement, layout, and inboard profile drawings. Use of AUTOCAD. 1 three-hour laboratory.

ARO 201L Fundamentals of Systems Engineering (1)

History and purpose of systems engineering. System design exercise. Team design. Needs analysis; consideration of social, economic and environmental factors. System-design process. Role of the engineer in system design. Program planning and control. Engineering documentation. 1 three-hour laboratory. Prerequisites: ENG 104 or equivalent, C or better in ARO 101L.

ARO 202L Fundamentals of Aeronautics (1)

Aircraft manufacturing methods. Aerodynamic drag. Aircraft controls and piloting techniques. Aircraft performance. Aeroelasticity concepts. Preliminary aircraft structural design. 1 three-hour laboratory. Prerequisite: C or better in ARO 101L.

ARO 203L Fundamentals of Astronautics (1)

Spacecraft manufacturing methods. Spacecraft mission analysis. Spacecraft guidance and control techniques. Booster design. Boost and reentry trajectory simulation. Problems of hypersonic flight. 1 three-hour laboratory. Prerequisite: C or better in 102L.

ARO 299/299A/299L Special Topics for Lower Division Students (1-4)

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lectures/problem-solving, laboratory, or a combination.

ARO 301 Fluid Dynamics (4)

Pressure distribution in a fluid. Control volume and differential approaches to fluid flow analysis. Development and application of Navier-Stokes equations. Potential flow theory. Dimension analysis and similarity. Viscous flow in ducts. Working knowledge of a high-level computer language is required. 4 lectures/problem-solving. Prerequisites: ENG 104, C or better in MAT 216 and ME 215. Corequisites: MAT 318, CHE 302.

ARO 305 Low-Speed Aerodynamics (4)

Boundary-Layer theory. Biot-Savart law. Panel methods. Thin airfoil theory. Lifting-line theory. Numerical aerodynamics of airfoils and wings. Skin friction drag. Induced drag. Propeller theories. Airplane performance. 4 lectures/ problem-solving. Prerequisite: C or better in ARO 301.

ARO 309 Astronautics and Spacecraft Design (3)

Space Environment. Mission design. Lagrange's equation. Kepler's laws, orbits, escape trajectories, interplanetary transfers, gravity assists and atmospheric entry. Configuration and structural design of spacecraft. Propulsion. Spacecraft dynamics and attitude control. Power systems. Thermal control. 3 lectures/problem-solving. Prerequisite: ENG 104, C or better in ME 215.

ARO 311 Gas Dynamics (3)

Governing equations of fluid dynamics for compressible flow. Normal shock waves. Oblique shock waves. Expansion waves. Quasi-one-dimensional flow. Fanno flow. Rayleigh flow. Unsteady wave motion. High-temperature gases and flows. Applications. 3 lectures/problem-solving. Prerequisite: C or better in ARO 301.

ARO 312 Aircraft Jet Propulsion (4)

Ideal cycle analysis of ramjet, turbojet, turbofan and turboprop. After burning. Cycle analysis with losses. Nonrotating components: diffusers, nozzles and combustors. Compressor, fans and turbines. Component matching and engine performance. Aircraft engine noise. Hypersonic engines. 4 lectures/problem-solving. Prerequisite: C or better in ARO 311.

ARO 322/L Aerospace Feedback Control Systems/Laboratory (3/1)

Mathematical models of systems. Feedback control systems: characteristics, performance, stability. Root locus method. Frequency response methods. Stability in the frequency domain. Time domain analysis. Design and compensation of aerospace feedback control systems. 3 lectures/problem-solving; 1 three-hour laboratory. Prerequisite: ENG 104, C or better in MAT 216.

ARO 326/L Aerospace Structural Mechanics I/Laboratory (3/1)

Vector analysis of two-dimensional kinetic motion of aerospace vehicles. Plane kinematics including absolute and relative motion. Force and moment equilibrium in three dimensions using free body diagrams and vector algebra. Internal loads in engine mount, landing gear and fabric-covered wing structures. Shear and bending-moment diagrams. Centroids, center of gravity, moments of area, and moments of inertia. Analysis of stress in members subject to axial, torsional, bending, and shearing loading. 3 lectures/problem-solving; 1 three-hour laboratory. Prerequisite: ENG 104, C or better in PHY 131/L. Corequisite: MAT 214.

ARO 327 Aerospace Structural Mechanics II (3)

External loads on aircraft, inertia forces and load factors, design loads, factor of- and margin of-safety, V-n diagrams. Strain energy. Analysis of deformation in members subject to axial, torsional, bending, shearing, and combined loading using Castigliano' s theorem. Statically indeterminate structures. Shear flow in closed and open thin-walled sections. Bending and shear stresses in beams with unsymmetrical cross-sections. Principles and analysis of stressed skin construction. 3 lectures/problem-solving. Prerequisite: C or better in ARO 326.

ARO 328 Aerospace Structures (4)

Aerospace structural analysis in the design process. Elementary aeroelasticity. Axial constraint. Design of members in tension, torsion, bending, or shear. Design of compression members. Design of webs in shear. Detailed design. 4 lectures/problem-solving. Prerequisite: C or better in ARO 329.

ARO 329 Aerospace Structural Analysis and Design (3)

Work and energy methods. Numerical analysis and introduction to the finite element method. Thin plate theory and structural stability. Elastic and aeroelastic instabilities. Design of Aerospace structures. 3 lectures/problem-solving. Prerequisite: C or better in ARO 327.

ARO 351L Fluid Dynamics and Heat Transfer Laboratory (1)

Selected experiments in fluid dynamics and heat transfer in aerospace engineering, such as vortex flows, transition from laminar to turbulent flow and potential flow simulations. Team work. Laboratory report writing. 1 three-hour laboratory. Corequisite: ARO 401.

ARO 352L Aerodynamics and Jet Propulsion Laboratory (1)

Selected experiments in low- and high-speed aerodynamics, gas dynamics and jet propulsion using subsonic and supersonic wind tunnels and an instrumented jet engine. Computer-based data acquisition. Team work. Laboratory report writing. 1 three-hour laboratory. Prerequisites: C or better in ARO 312, ARO 404.

ARO 357L Aerospace Structures Laboratory (1)

Experimental stress analysis of structures subject to axial, torsional, bending, shearing and combined loading. Statically indeterminate structures. Application of the electrical resistance strain gage and photoelastic methods. Technical communication and engineering report writing. 1 three-hour laboratory. Prerequisite: C or better in ARO 327.

ARO 400 Special Study for Upper Division Students (1–2)

Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter. Prerequisite: ENG 104.

ARO 401 Heat, Mass and Momentum Transfer (4)

Conduction, convection and radiation heat transfer. Heat diffusion equation. 1-D, 2-D and 3-D conduction. Transient conduction. Finite-difference methods. Heat, mass and momentum transfer by convection in external and internal flows. Radiation heat transfer analysis. 4 lectures/problem-solving. Prerequisite: C or better in ARO 301.

ARO 402 Numerical Methods (4)

Numerical methods in engineering. Algorithms. Interpolating polynomials, difference formulas, numerical differentiation and integration. Matrix methods. Non-linear systems. Solution of differential equations. Applications to engineering problems. Working knowledge of a high-level computer language required. 4 lectures/problem-solving. Prerequisites: ENG 104, C or better in MAT 216.

ARO 404 High-Speed Aerodynamics (3)

Governing laws of high-speed flows. The velocity potential equation. Taylor-Maccoll equation. Conical flow. Compressibility correction rules for subsonic flows. Transonic flow. Wing sweep. Area ruling. Airfoils and wings in supersonic flight. Wave drag. Hypersonic flight. Design considerations for high-speed aircraft. 3 lectures/problem-solving. Prerequisite: C or better in ARO 311.

ARO 405 Aircraft Stability and Control (4)

Static Stability. Stability derivatives. Airplane controls. Airplane equations of motion. Dynamic stability. Transfer functions. Airplane response and simulation. Flying qualities. Automatic control and autopilots. 4 lectures/problem-solving. Prerequisites: C or better in ARO 305, 322/322L.

ARO 406 Advanced Dynamics of Aerospace Systems (4)

Vector dynamics of aerospace systems; 3-D particle and rigid-body dynbamics; linear and angular momentum; Lagrangian dynamics; method of Euler; introduction to space vehicle motion. 4 lectures. Prerequisites: ENG 104, C or better in ME 215, MAT 318.

ARO 407 Flight Dynamics (4)

Three dimensional rigid body motion methods of Newton and Lagrange. Euler transformations. Performance analysis of aircraft, missiles and spacecraft. 4 lectures/problem-solving. Prerequisites: C or better in ARO 305, 406.

ARO 408 Finite Element Structures (4)

Theoretical development of one- and two-dimensional finite elements. Analysis and design of truss, frame and semimonocoque structures using the direct stiffness and energy formulation of the finite element method. Computer-aided design and analysis projects using commercial finite element software. 4 lectures/problem-solving. Prerequisite: C or better in ARO 329.

ARO 409 Astrodynamics (4)

Space environment. Kepler's laws of motion and satellite orbits, orbital transfers. Space vehicle motion, de-spinning of satellites. Performance and optimization of single and multistage rocket. 4 lectures/problem-solving. Prerequisite: C or better in ARO 309, 406.

ARO 412 Wing Theory (4)

Potential flow theory. Complex mappings; Kutta-Joukowski transformation. Chordwise pressure distributions; thin airfoil theory. Sectional force and moment coefficients. Symmetric and asymmetric spanwise loading; basic and additional lift effects. Twist. Wing force and moment coefficients. High lift devices. 4 lectures/problem-solving. Prerequisite: C or better in ARO 305.

ARO 414 Rocket Propulsion (4)

Principles of rocket propulsion. Combustion chemistry. Liquid-fuel rocket engines. Solid-fuel rocket engines. Electrical propulsion. 4 lectures/ problem-solving. Prerequisite: C or better in ARO 311.

ARO 418 Space EnviroHazard (4)

Introduction to the science of the space environment. Overview of the range of environments and the impacts of these environments on spacecraft and satellite operations. Spacecraft Environmental Hazards and mitigation strategies. 4 lectures/ problem-solving. Prerequisite: C or better in ARO 309.

ARO 419 Computational Fluid Dynamics (4)

Classification of partial differential equations. Elements of finite-difference methods. Stability analysis. Algorithms for numerical solution of parabolic, elliptic and hyperbolic partial differential equations. Finite volume and finite element methods. Applications in fluid dynamics, gas dynamics and heat transfer. Working knowledge of a high-level computer language required. 4 lectures/problem-solving. Prerequisites: C or better in ARO 301. Corequisite: ARO 311.

ARO 420 Aerospace Engineering Management (4)

Aerospace industry fundamentals. Introduction to various management roles in technical fields. Gain insight into the roles of Program Management, Project Management and Functional Management in aerospace companies. Understand government agencies and customer interactions. Role of discretionary R&D and proposal development. Career path development and expected skills requirements. 4 lectures/problem-solving. Prerequisite: ENG 104. Co-requisite: ARO 490L.

ARO 421 Helicopter Aerodynamics(4)

The development of rotary-wing aircraft and the helicopter. Review of blade element/momentum theory; hovering and vertical flight theory; autorotation; performance in forward flight. 4 lectures/problem-solving. Prerequisite: C or better in ARO 305.

ARO 422 Advanced Aerospace Control Systems (4)

Review of classical controls. Control system design. Compensators. Nonlinear systems. Describing functions. 4 lectures/problem-solving. Prerequisite: C or better in ARO 322.

ARO 426 Aerospace Surface Systems (4)

Aerospace fundamentals of high speed surface systems. Station-to-station concepts. Air cushion and tubeflight systems. Airload determination. Drag reduction. Propulsion systems and braking. Guideway considerations. Stability and control. 4 lectures/problem-solving. Prerequisite: C or better in ARO 301.

ARO 427 Aeroacoustics (4)

Scales and units of noise measurement. Sources and characteristics of aircraft noise. Traffic and vehicular noise. Airport noise. Noise abatement; aircraft, road vehicles, airports, highways. Sonic boom effects. 4 lectures. Prerequisite: ENG 104, C or better in CHE 302.

ARO 431 Intermediate Finite Element Structures (4)

Structural dynamics, structural stability and advanced elements in the finite element method. Basic theory will be augmented strongly by computer applications. 4 lectures/problem-solving. Prerequisite: C or better in ARO 408.

ARO 435L Experimental Techniques in Aerodynamics (2)

Test plan formulation. Pressure, temperature and loads measurements. Test section calibration and correction. Subsonic wind tunnel applications. 2 three-hour laboratories. Prerequisites: C or better in ARO 305.

ARO 436 Mechanics of Composite Materials (4)

Mechanical behavior of composite materials. Stress/strain relations in anisotropic materials. Strength criteria and stiffness. Interlaminar stresses. Systems applications. Bending, buckling and vibration of laminated plates. 4 lectures/problem-solving. Prerequisite: C or better in ARO 327.

ARO 461, 462 Senior Project (2) (2)

Selection and completion of an aerospace engineering project, including a literature search and use of one or more of the following approaches: theoretical, computational or experimental. Project results presented in a final, formal individual report. Project to be arranged by the student with an appropriate Aerospace Engineering faculty member who is the project supervisor. Minimum of 120 hours total time. Prerequisite: ENG 104.

ARO 490L Aerosciences (1)

Comprehensive review of basic principles of aerodynamics, propulsion, vehicle dynamics, and structures for application in the conceptual and preliminary design of aerospace vehicles. A comprehensive exam will be administered on the above subjects. 1 three-hour laboratory. Corequisite: ARO 491L.

ARO 491L Aerospace Vehicle Design Laboratory I (2)

Design philosophy. Conceptual design of vehicles. Oral and written presentations of system design. Environmental considerations. Trade-studies; statistical design, parameter estimation. Manufacturing, facilities, cost, aircraft, spacecraft. 2 three-hour laboratories. Prerequisites: C or better in ARO 309, 312, 329, 401, 404, 406. Corequisite: ARO 405.

ARO 492L Aerospace Vehicle Design Laboratory II (2)

Preliminary design of vehicles. Design tradeoffs in multi-disciplined systems. Participation in team design projects. Oral and written presentations of system design. Oral briefing to an industry/government review panel. 2 three-hour laboratories. Prerequisite: C or better in ARO 491L.

ARO 493L Aerospace Vehicle Design Laboratory III (2)

Participation in and completion of ARO 492L. Team design projects. Preparation of final project report together with an oral briefing to an industry/government review panel. 2 three-hour laboratories. Prerequisite: C or better in ARO 492L.

ARO 499/499A/499L Special Topics for Upper Division Students (1–4)

Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture, laboratory, or a combination. Prerequisite: ENG 104.