Aerospace Engineering (AE)

Courses

AE 201 Aerospace Flight Vehicles 3 Credits (3,0)
History of atmospheric and exo-atmospheric flight, aircraft and spacecraft anatomy, fundamental aerodynamic properties, hydrostatics, properties of the atmosphere, fluid conservation equations, concepts of internal and external fluid flows, dimensional analysis, airfoil shapes, introduction to viscous flows, aerodynamic forces and moments, experimental results of airfoil and wing behavior, vehicle propulsion including reciprocating engines and gas turbines, airplane and rocket vehicle performance, summary of supersonic and hypersonic flight.
Prerequisites: EGR 115 and ES 201

AE 210 Air Vehicle Performance 1 Credit (1,0)
Introduction to aircraft performance. Power-producing and thrust-producing propulsion systems. Propeller performance characteristics. Steady-state aircraft performance, including climb rate, climb angle, range and endurance, of airplanes with power-producing and thrust-producing engines. Best rate-of-climb, best angle-of-climb, maximum range and maximum endurance. Accelerated maneuvers such as steady, coordinated turns, and loops.
Prerequisites: EGR 115 and ES 201

AE 299 Special Topics in Aerospace Engineering 1-6 Credit
Individual independent or directed studies of selected topics.

AE 301 Aerodynamics I 3 Credits (3,0)
******OFFERED ON PRESCOTT CAMPUS ONLY******The atmosphere. Incompressible and compressible one-dimensional flow. Airspeed measurement. Two-dimensional potential flow. Circulation theory of lift. Thin airfoil theory. Viscous flow. Boundary layers. Finite wing theory. Drag in incompressible flow. Wing-body interactions.
Prerequisites: ES 204 and ES 206 and MA 345

AE 302 Aerodynamics II 3 Credits (3,0)
******OFFERED ON PRESCOTT CAMPUS ONLY****** Study of both compressible flow and viscous flow. Compressible flow topics of supersonic flow, shock waves, expansion fans, shock-expansion theory, thin airfoil theory, thermo-dynamics of gas flow, reversible and irreversible processes, Isentropic duct flow and flow through a nozzle. Viscous flow topics of basic anatomy of a boundary layer, laminar and turbulent flows, transition points, determination of skin friction drag on an airfoil, solutions to the boundary layer equations.
Prerequisites: AE 301 and ES 305

AE 307 Incompressible Aerodynamics 3 Credits (3,0)
Conservation equations and fundamental fluid dynamic principles, elementary solutions of inviscid incompressible flows, methods of predicting flows around airfoils and wings including thin airfoil theory, panel methods, lifting line theory, viscous flows and turbulence, Navier-Stokes equations, laminar and turbulent boundary layers.
Prerequisites: AE 201 and ES 204 and MA 441

AE 308 Compressible Aerodynamics 3 Credits (3,0)
Review of thermodynamics, compressibility, governing equations for compressible flow, normal shock waves, one-dimensional flow with heat addition and friction. Raleigh Fanno curves, oblique shock waves and expansion waves, compressible flow through nozzles, diffusers and wind tunnels, subsonic and supersonic flow around airfoils, including linear theories, elements of hypersonic flow, conical flow, method of characteristics, and unsteady one-dimensional flow.
Prerequisites: AE 201 and ES 305

AE 313 Space Mechanics 3 Credits (3,0)
Vector-based solution of the two-body problem and the solution for the position and time problem, Kepler's equations, used to analyze orbits, ground tracks, orbit transfer, interplanetary trajectories, and interception and rendezvous.
Prerequisites: EGR 115 and ES 204 **Corequisites:** MA 345

AE 314 Experimental Aerodynamics 1 Credit (1,0)
Wind tunnel design, instrumentation, scaling effects, data acquisition, and data reduction as well as good experimental practices. The Experimental Aerodynamics Lab AE 315 must be taken during the same semester as AE 314.
Prerequisites: COM 221 and (AE 307 and AE 308) or AE 319
Corequisites: AE 315

AE 315 Experimental Aerodynamics Laboratory 1 Credit (0,3)
Sequence of experiments that demonstrate basic aerodynamic theory while developing skills in the use of classic and modern experimental apparatus, the practice of good experimental technique, and the writing of experimental reports along with the requirements of designing an experiment. Specific experiments depend on the apparatus availability and instructor preference. The Experimental Aerodynamics Lab, AE 315, must be taken during the same semester as AE 314.
Prerequisites: COM 221 and (AE 307 and AE 308) or AE 319
Corequisites: AE 314

AE 316 Aerospace Engineering Materials 3 Credits (3,0)
Structure, properties, and processing of engineering materials. Crystal structure, defects, imperfections, and strengthening mechanisms. Mechanical properties, fracture mechanics, fatigue and creep, and material failures. Phase diagrams and transformations. Degradation of materials. Characteristics of ferrous and nonferrous metals and alloys, ceramics, polymers, and composite materials. Emphasis on materials and process used in the aerospace industry.
Prerequisites: ES 202 and CHM 110 and CHM 110L

AE 318 Aerospace Structures I 3 Credits (3,0)
Methods of stress analysis of statically determinate lightweight structural systems. Applications include space structures and semimonocoque structures. Inertia force and load factor computation. Thermal Stresses. Three-dimensional beam bending. Shear flow. Materials considerations. Finite element modeling and computer-aided analysis.
Prerequisites: ES 202

AE 319 Aerodynamics 3 Credits (3,0)
Conservation equations and fundamental fluid dynamic principles, elementary solutions of inviscid incompressible flows, Fourier series, flows around airfoils and wings, introduction to viscous flow and turbulence. Review of thermodynamics to understand compressibility, normal shock waves, oblique shock waves and expansion waves, compressible flow through nozzles, subsonic and supersonic flow around airfoils, including linear theories, elements of hypersonic flow.
Prerequisites: AE 201 and ES 305

AE 323 Spacecraft Systems 3 Credits (3,0)
Fundamentals of design and implementation of spacecraft systems and systems engineering principles. Power, telemetry, communications, thermal control, attitude determination and control, mechanisms, and navigation. Life support systems, integration, testing, and operations are introduced.
Prerequisites: AE 201

AE 350 Project Engineering 3 Credits (3,0)
Role of the engineer in project management with emphasis on systematic evaluation of the benefits and costs of projects involving engineering design and analysis. Proposal preparation and presentation, engineering contracts, negotiation techniques. Value engineering. Pre-Requisite: Junior standing
Prerequisites: Junior standing

AE 399 Special Topics in Aerospace Engineering 1-6 Credit
Individual independent or directed studies of selected topics.

AE 403 Jet Propulsion 3 Credits (3,0)
Introduction to jet propulsion and the gas turbine engine. Topics include control volumes, the conservation equations, combustion processes, efficiencies, fuel consumption, ideal and real ramjets, gas turbine engine cycles, diffuser and nozzle flows, and preliminary component analysis.
Prerequisites: AE 307 and AE 308

AE 409 Aircraft Composite Structures 3 Credits (3,1.5)
Introduction to reinforced plastic composite structural materials and their use in modern aircraft. Discussion of basic material properties, testing procedures, design and analysis using classical lamination theory, and fabrication techniques, including some hands-on demonstrations.
Prerequisites: ES 202 and AE 316

AE 411 Advanced Experimental Aerodynamics 3 Credits (2,3)
******OFFERED ON PRESCOTT CAMPUS ONLY****** This course is a technical elective and consists of a series of advanced experiments using the wind tunnel. Model design and construction, testing procedure, control surface testing, propeller testing, use of wind tunnel data, scale effects, complete model testing. Includes introduction to supersonic testing.
Prerequisites: AE 314 and AE 315

AE 413 Airplane Stability and Control 3 Credits (3,0)
Development of longitudinal, lateral and directional stability and control equations. Control surface design. Control effectiveness and size requirements. Dynamic control theory. Handling characteristics and maneuvering stability of aircraft.
Prerequisites: AE 307

AE 414 Space Propulsion 3 Credits (3,0)
Introduction to the basic principles of liquid and solid propulsion systems. Flight performance parameters for single and multi-stage vehicles. Thermo-chemistry of the combustion process. Performance enhancements of nuclear rockets and electric propulsion.
Prerequisites: AE 319 or (AE 307 and AE 308)

AE 415 In-Flight Laboratory 3 Credits (2,3)
Development of longitudinal and lateral-directional, static and dynamic stability and excess power, rate of climb, turn rate, and load factor performance theory, with laboratory concept validation.
Prerequisites: AE 413

AE 416 Aerospace Structures and Instrumentation 1 Credit (1,0)
Lecture-based course to support the Structures and Instrumentation Laboratory. Course emphasizes aerospace vehicle testing through instrumentation, data acquisition, and data reduction. Test plans and design are utilized.
Prerequisites: COM 221 and AE 316 and EE 327 and EE 328
Corequisites: AE 417

AE 417 Aerospace Structures and Instrumentation Laboratory 1 Credit (0,3)
Principles of modern aerospace vehicle testing and instrumentation. Basic electrical measurements and devices such as strain gages, piezoelectric sensors, and thermocouples. Topics could include measurement of fluid pressure and flow; temperature; thermal and transport properties; strain; motion; vibration; force and torque. Experimental static and dynamic analysis of structures. Processing and analyzing experimental data; report writing and data presentation.
Prerequisites: COM 221 and AE 316 and EE 327 and EE 328
Corequisites: AE 416

AE 418 Aerospace Structures II 3 Credits (3,0)
Deflection and stress analysis of determinate and indeterminate aerospace structures under axial, bending, and torsion loads. Topics covered include work and energy principles, non-idealized structures, idealized semi-monocoque structures, some discussion of plate buckling, finite element modeling and computer-aided analysis.
Prerequisites: AE 318

AE 420 Aircraft Preliminary Design 4 Credits (3,3)
Conceptual and preliminary design of an aircraft. Conceptual sizing and configuration studies. Analysis of a candidate design, resulting in a design package consisting of performance specifications, aerodynamic calculations, internal arrangement, weight and balance, stability and control predictions, and structural sizing and layout.
Prerequisites: COM 219 and AE 314 and AE 315 and AE 403 and AE 413

AE 421 Aircraft Detail Design 4 Credits (3,3)
Detail design of aircraft, which may include component part or test article design. Design of an aircraft or test article from the general layout to the design of its detail parts and necessary tools.
Prerequisites: AE 316 and AE 418 and AE 420.

AE 426 Spacecraft Attitude Dynamics 3 Credits (3,0)
Fundamentals of spacecraft attitude dynamics including attitude parameterization, determination, disturbances in space, stability analysis, numerical simulations to predict the attitude change under the influence of disturbance torques, and methods to control the spacecraft attitude for space missions.
Prerequisites: AE 313 and (MA 432 or MA 441)

AE 427 Spacecraft Preliminary Design 4 Credits (3,3)
Application of spacecraft preliminary design principles to meet mission objectives. Design of a complete space-related system to meet industry preliminary design standards, resulting in a design package consisting of objectives, requirements, specifications, calculations, CAD drawings, weight and various other system and subsystem budgets, a series of trade studies, and design reviews and reports.
Prerequisites: AE 314 and AE 315 and AE 414 and AE 426 and COM 219 and (AE 323 or (AE 307 and AE 308))

AE 429 Space Environmental Applications 3 Credits (3,0)
Fundamentals of the space environment, scientific applications, and heat transfer as applied to spacecraft. Atmosphere, gravity gradients, and radiation. Introduction to plasma physics, planetary surface operations, and effects on spacecraft operations.
Prerequisites: EE 327 and EE 328

AE 430 Control System Analysis and Design 3 Credits (3,0)
******OFFERED ON PRESCOTT CAMPUS ONLY****** Modeling, analysis, and control of dynamical systems. Transfer functions, block diagram algebra. Routh Hurwitz stability criteria. Introduction to system design using various tools and techniques such as root locus, Bode plots, and Nyquist diagrams.
Prerequisites: MA 345 and ES 204

AE 432 Flight Dynamics and Control 3 Credits (3,0)
Aircraft equations of motion. State variable representation of the equations of motion. Longitudinal motion (stick fixed) and lateral motion (stick fixed). Aircraft response to atmospheric inputs. Automatic control theory. Application of classical and modern control theory to aircraft autopilot design.
Prerequisites: AE 413

AE 433 Aerodynamics of the Helicopter 3 Credits (3,0)
******OFFERED ON PRESCOTT CAMPUS ONLY****** The development of rotating-wing aircraft and the helicopter. Hovering theory and vertical flight performance analysis. Auto-rotation, physical concepts of blade motion and control, aerodynamics and performance of forward flight. Blade stall, stability and vibration problems. Design problems.
Prerequisites: AE 307 and MA 441

AE 434 Spacecraft Control 3 Credits (3,0)
A review of spacecraft equations of motion and state variable representation of the equations of motion. Automatic control theory, the classical approach as well as the modern control approach. Attitude control with thrusters, attitude control with reaction wheels, and attitude stabilization with spin. Attitude control during thrust maneuvers. Control of translational motion.
Prerequisites: AE 426 and (MA 432 or MA 441)

AE 435 Jet Propulsion Preliminary Design 4 Credits (3,3)
Preliminary design, subject to specifications, of a jet engine for aircraft propulsion. A complete engine is designed and presented with proposed engine layout, cycle calculations, installed performance, and engine sizing information. Calculations demonstrating that the proposed engine satisfies requirements are also presented.
Prerequisites: AE 314 and AE 315 and COM 219 and AE 403

AE 436 Introduction to Optimization 3 Credits (3,0)
******OFFERED ON PRESCOTT CAMPUS ONLY****** This course will cover mathematical optimization methods, problem formulation, and optimality criteria, linear programming methods for optimality problems, numerical methods for unconstrained and constrained problems, sequential linear programming, genetic algorithms, and hybrid optimal control.
Prerequisites: EGR 115 and MA 345

AE 437 Advanced Space Propulsion 3 Credits (3,0)
******OFFERED ON PRESCOTT CAMPUS ONLY****** Advanced Space Propulsion covers the exotic propulsion concepts beyond the typical existing liquid, hybrid, solid and electric propulsion systems. The course emphasizes the advanced concepts to orbit and also emphasizes deep space travel including interstellar and propulsion at relativistic speeds. Topics include fusion propulsion, Bussard ramjets, matter-antimatter propulsion, antigravity, space drives, warp drives and faster-than-light travel.
Prerequisites: AE/ME students must have C or better in AE 408 or AE 414 or ME 309

AE 440 Jet Propulsion Detail Design 4 Credits (3,3)
Design of the various components of a jet engine, starting with the general layout. Student teams design of a major component (inlet, fan, compressor, combustor, turbine, nozzle, support systems). The components are then integrated to verify that they function together.
Prerequisites: AE 435

AE 441 Rocket Propulsion Preliminary Design 4 Credits (3,3)
Rocket engine preliminary design principles needed to meet mission objectives. Design a complete rocket engine system, consisting of specifications, calculations, CAD drawings, weight and various subsystem budgets and a series of trade-off studies, reviews and design reports.
Prerequisites: AE 314 and AE 315 and AE 414 and (AE 323 or (AE 307 and AE 308))

AE 442 Experimental Dynamics and Control 1 Credit (1,0)
Linear Control. Open loop and closed loop system feedback analysis. Modeling, linearization and parameter system identification and validation of dynamical systems. State space system representation, system block diagrams, feedback and transfer functions. Control design based on transient and steady state specifications. Concepts of stability and controllability. Stability criteria. Control design and analysis of dynamical systems in time and frequency domains.
Prerequisites: COM 221 and AE 432 or AE 434 **Corequisites:** AE 443

AE 443 Experimental Dynamics and Control Laboratory 1 Credit (0,3)
Laboratory for the dynamics and control of systems. Dynamical systems testing through instrumentation, amplifiers, analog-to-digital converters, boolean algebra, logic gates and microprocessors, data acquisition and data analysis. Modeling of dynamics for flexible link systems, rotational systems including electrical servos and transformers; experimental determination of the system natural frequency. Control design and implementation based on time domain transient and steady state requirements; pole placement and state feedback control design and implementation. Full-state-feedback vs. partial-state-feedback analysis. Finding first- and second-order system parameters. System response analysis to various input types. Sensor bias removal techniques and actuator saturation. Processing and analysis of experimental and simulated data; report writing and data presentation.
Prerequisites: COM 221 and AE 432 or AE 434 **Corequisites:** AE 442

AE 445 Spacecraft Detail Design 4 Credits (3,3)
Principles of spacecraft detail and subsystem design, analysis, modeling, manufacture, and test are covered and incorporated into projects to give actual experience in the detail design and integration of space-related subsystems and systems. Integration of multiple subsystems into a single functional model is a key component of the course.
Prerequisites: AE 318 and AE 427 and AE 434

AE 451 Rocket Propulsion Detail Design 4 Credits (3,3)
Principles of rocket engine detail and subsystem design, analysis, modeling. Manufacture and test are covered for experience in the detail design and integration of rocket engine subsystems and systems. Integration of multiple subsystems into a single functional model.
Prerequisites: AE 318 and AE 441

AE 455 Computational Aerodynamics 3 Credits (3,0)
Theory and application of computational fluid dynamics for aerodynamics. Topics include governing and model equations for fluid and heat flow, finite-difference approximation, numerical discretization of model equations, stability analysis, explicit and implicit methods. Lab portion emphasizes practical CFD modeling for aerodynamics applications, including grid generation and visualization techniques.
Prerequisites: AE 307 and AE 308

AE 499 Special Topics in Aerospace Engineering 1-6 Credit
Individual independent or directed studies of selected topics.