AEROSPACE ENGINEERING (AERSP)

AERSP 1: Aerospace Explorer--First-Year Seminar

1 Credits

First-Year Seminar explores aerodynamics, structural mechanics, flight mechanics, rotorcraft systems, high performance computers, air/space propulsion, and space systems. AERSP 1 Aerospace Explorer--First-Year Seminar (1) (FYS) Aerospace Engineering deals with vehicles that fly - airplanes, sailplanes, jets, helicopters, rockets, satellites, the space shuttle, space stations, etc. Students with an interest in these subjects can learn more about the variety of challenges and opportunities in the aerospace field through the small-class environment of the Aerospace Explorer First-Year Seminar. An introduction to both the academic major and career paths in Aerospace Engineering, this seminar deals with the design, analysis and operation of aircraft and space vehicles. Students will learn about aerodynamics, structural mechanics, flight mechanics, rotorcraft systems, high performance computers, air-breathing propulsion, space propulsion, and space systems. The classes will include presentations by the Aerospace Engineering faculty, tours of the Aerospace Engineering laboratories, and presentations by student officers in the Penn State chapters of the American Institute of Aeronautics and Astronautics (AIAA) and the American Helicopter Society (AHS), as well as introductions to the use of scientific plotting, graphing, and analysis software.

First-Year Seminar

AERSP 55: Space Science and Technology

3 Credits

The science and technology of space exploration and exploitation; physical principles; research and development; history, space policy, and social implications.

Cross-listed with: STS 55
Bachelor of Arts: Natural Sciences
Bachelor of Arts: Social and Behavioral Sciences
General Education: Natural Sciences (GN)

AERSP 97: Special Topics

1-9 Credits/Maximum of 9

Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest.

AERSP 204: Flight Vehicle Design and Fabrication I

2 Credits/Maximum of 8

Integrated project management, design, fabrication, testing, and flight evaluation of an advanced composite flight vehicle.

Honors

AERSP 301: Aerospace Structures

3 Credits

Aerospace structural design concepts, flight safety. Stiffness, strength, stability of thin-walled structures under combined loads. Energy methods, finite element analysis. AERSP 301 Aerospace Structures (3) AERSP 301 covers essential topics in aerospace structures. The objectives of the course are to help students: 1) appreciate the roles that structures and structural materials play in aerospace vehicles; 2) understand general design concepts for aerospace structures: vehicles, components, and materials; 3) develop the analysis tools and skills needed to analyze the performance of aerospace structures; and 4) gain experience identifying, formulating, and solving aerospace structural engineering problems. AERSP 301 builds on structural mechanics topics covered in PHYS 211, EMCH 11 & EMCH 13 (or EMCH 210), and EMCH 215 & EMCH 216. It prepares students for study of advanced topics such as plates and shells, composites, structural stability, finite element analysis, structural dynamics, and aeroelasticity. It also provides students with the basic background needed to contribute effectively to multidisciplinary trade studies in vehicle design activities. AERSP 301 begins with an overview of the general features of flight vehicle structures, with emphasis on thin-walled members and advanced materials. Then, the implications of assured safety of flight for structural design are explored, leading to coverage of: load cases, flight envelopes, load factors, factors of safety, kinds of structural failures, and margins of safety. Topics in structural analysis proceed from an initial review of topics in elasticity, structural materials, and beam bending. Then, the deflection and stress responses of thin-walled beams under transverse shear and torsional loading are addressed. More than a third of the course is devoted to energy principles and the development of the finite element method of structural analysis. The course finishes with a treatment of the structural stability of beams and panels, a key topic with respect to the behavior of thin-walled aerospace structures.

Prerequisite: E MCH210 or E MCH213. Prerequisite or concurrent: AERSP313

AERSP 301H: Aerospace Structures I

3 Credits

Analysis of thin-walled beams subjected to combined loads, including bending, torsion, and shear; elastic stability; work and energy principles.

Honors

AERSP 304: Dynamics and Control of Aerospace Systems

3 Credits

Vibrations of single, multiple, and infinite degree-of-freedom systems; operational methods applied to aerospace vehicles; design of controllers.

Prerequisite: AERSP313, E MCH212

AERSP 305: Aerospace Technology Laboratory

3 Credits

Experiments in measurement systems, aerodynamics, aerospace structures, dynamics and control, and propulsion, technical report writing and presentations. AERSP 305 Aerospace Technology Laboratory (3) AERSP 305 is a junior-level experimental laboratory course in Aerospace Engineering. The purpose of this course is to expose students to the key principles and methods of experimentation as related to the field of
aerospace engineering. Students learn the fundamentals of measurement
techniques to determine quantities such as temperature, force, pressure,
displacement, velocity, acceleration and strain in various laboratory
situations. The course employs weekly set-up; experiments that provide an opportunity for students to familiarize themselves with
modern measurement techniques and gain valuable experience regarding
the calibration and use of aerospace engineering research equipment.
Students are expected to apply their knowledge of mathematics, science,
and engineering in order to complete successfully the experiments
encountered in the laboratory. The subsequent interpretation and
analysis of the laboratory data requires the use of standard engineering
tools and practices. Students work in lab groups to process data and
then identify, formulate, and solve engineering questions associated
with the experimental results. Throughout the semester, students
communicate their knowledge and understanding of the course material
through a series of class assignments, written technical reports, and one
final exam. Because writing and revising laboratory reports significantly
enhances the understanding and interpretation of the research data, this
course is writing-intensive. As such, students are expected to
improve their writing skills as they gain experience writing abstracts,
informal reports and formal reports. Peer review of reports helps students
to recognize good writing, and to learn how to provide constructive
criticism. The course instructor provides written feedback for revised
formal reports, and the quality of writing is a factor in determining final
grades.

Prerequisite: Prerequisite or concurrent: AERSP301 , AERSP311 ,
ENGL 202C
Writing Across the Curriculum
AERSP 306: Aeronautics
3 Credits
Lift and drag characteristics of aircraft; propulsion systems; airplane
performance; introduction to stability and control.

Prerequisite: AERSP311 , AERSP313
AERSP 308: Mechanics of Fluids
3 Credits
Kinetics and dynamics of fluids; perfect fluid theory using complex
variables; introduction to viscous flow theory; fundamentals of compressible flow.

Prerequisite: E MCH212 or E MCH212H ; MATH 251
AERSP 309: Astronautics
3 Credits
Introduction to space and space flight; laws of particle mechanics;
orbits and trajectories; space vehicles and propulsion. AERSP 309
Astronautics (3) This course, required for aerospace engineering majors,
focuses primarily on the dynamics of spacecraft, including both orbital
and attitude (orientation) motion of spacecraft. Topics include: three-
dimensional rotational kinematics (direction cosine matrices, vector
components in different coordinate systems, Euler angles, the angular
velocity vector, and velocity and acceleration in different reference frames),
three-dimensional particle dynamics (Newton's laws of particle motion,
energy, angular momentum, and systems of particles), two-
body orbital mechanics (Newton's law of universal gravitation, the
orbit equation, conic sections and orbit terminology, Kepler's equation,
classical orbital elements, and representations of satellite position
and velocity), orbital maneuvers and transfers (impulsive maneuvers,
Hohmann transfers, simple inclination changes, and relative motion
between spacecraft), rigid-body dynamics (angular momentum and
energy, the inertia matrix, principal-axis system, Euler's equations of rigid-
body motion, torque-free motion, and effects of external torques), rocket
performance (the rocket equation, specific impulse, estimating propellant
requirements for a mission, and a survey of propulsion technology),
and the space environment (standard atmosphere, simple radiative
heat-transfer analysis, the Van Allen radiation belts, meteors and debris
hazards). The course relies upon a sound understanding of mechanics,
matrix algebra and vector calculus. Assignments include analytical and
numerical problems, some of which require computer programming.

Prerequisite: E MCH212 , MATH 250 ; CMPSC201 or CMPSC202
AERSP 309H: Astronautics
3 Credits
Introduction to space and space flight; laws of particle mechanics; orbits
and trajectories; space vehicles and propulsion.

Honors
AERSP 311: Aerodynamics I
3 Credits
Fluid statics and kinematics; fluid dynamics of inviscid and viscous
flows; Navier-Stokes equations; introduction to boundary layers.
AERSP 311 Aerodynamics I (3) This is a first course in incompressible
inviscid and viscous flows. It includes an introduction to fluids, fluid
statics and hydrostatics. Fluid kinematics, including Eulerian versus
Lagrangian viewpoint, steady versus unsteady flows, volume and mass
flow rates, vorticity and circulation, and streamlines are described.
Derivation of the governing equations for the conservation of mass,
momentum and energy is presented. Dimensional analysis is covered.
Potential flow with and without the effects of viscosity is analyzed. A
derivation and exact solutions of the Navier-Stokes equations are given
and boundary layers are introduced. This is the first of a two course
sequence in aerodynamics, where both courses are required for senior-
year propulsion and design courses. Evaluation of student performance
will be by two midterm exams worth approximately 25% each, a final
exam worth approximately 35% and weekly homework assignments
worth approximately 15%.

Prerequisite: E MCH212 , MATH 250 , CMPSC201 or CMPSC202
AERSP 312: Aerodynamics II
3 Credits
Fluid mechanics of viscous and compressible flows, laminar boundary
layers, turbulent flows, isentropic flows, shock waves, supersonic life
and drag. AERSP 312 Aerodynamics II (3) Exact solutions of the Navier-
Stokes equations for unsteady flow. Boundary layers solved by the
methods of Blasius, Falkner-Skan and Thrall's. Boundary layer stability
and transition to turbulence. Turbulent flow and solution methods.
Fluid flow measurement techniques and numerical methods. Derivation
of the governing equations for the conservation of mass, momentum
and energy for compressible flow. Steady one-dimensional isentropic
flow. Normal, traveling and oblique shock waves. Compressible flow
with area change and converging-diverging nozzle flows. Prandtl-Meyer
expansions and supersonic life and drag. One-dimensional flow with
friction or heat transfer. Unsteady and linearized compressible flow. Introduction to the method of characteristics. This is the second of a two course sequence in aerodynamics and is a prerequisite for senior level courses in propulsion and design. Evaluation of student performance will be by two midterm exams worth approximately 25% each, a final exam worth approximately 35% and weekly homework assignments worth approximately 15%.

**Prerequisite:** AERSP311, AERSP313, M E 201

AERSP 313: Aerospace Analysis

3 Credits

Mathematical methods applied to aerospace engineering: Fourier series, ordinary and partial differential equations, complex variables, numerical methods, data analysis. AERSP 313 Aerospace Analysis (3)

This course is designed to reinforce the mathematical concepts learned in the prerequisite mathematics and computer science courses and to present new mathematical material that is necessary for aeronautics, astronautics, dynamics and control, and fluid dynamics analysis. In practice, analytical and numerical approaches to problems solving are complementary, hence, this course will emphasize a combined analytical and numerical treatment.

**Prerequisite:** MATH 220, MATH 230, MATH 250; CMPSC201 or CMPSC202

AERSP 397: Special Topics

1-18 Credits/Maximum of 18

Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest.

AERSP 399: Foreign Studies

1-12 Credits/Maximum of 12

Courses offered in foreign countries by individual or group instruction.

International Cultures (IL)

AERSP 401A: Spacecraft Design—Preliminary

3 Credits

Conceptual and preliminary design of a spacecraft, its constituent subsystems, and related systems, to satisfy a given set of specifications. AERSP 401A Spacecraft Design - Preliminary (3) AERSP 401A is the first of a two-semester sequence of senior capstone design courses. In this course, students will begin to learn the design process, complete a conceptual design, and to begin a preliminary design of a spacecraft, working in teams. This process is inherently multidisciplinary, requiring the use of engineering practices in such subjects as structures, dynamics, electrical and thermal systems, propulsion, controls, and information systems. In addition to the technical design content, this course seeks to enhance students’ skills in verbal and written communications, ethical thinking, and the team approach to design, which is widely used in industry and government. Classes (115 minutes each, twice weekly) include lecture and time for team meetings. Students are evaluated on the technical merit of the designs (presented in written and oral reports), as well as their ability to function on a team.

**Prerequisite:** AERSP309. Prerequisite or concurrent: AERSP450

AERSP 401B: Spacecraft Design—Detailed

2 Credits

Detailed design of the constituent subsystems and related support systems for a spacecraft. AERSP 401B Spacecraft Design – Detailed (2) AERSP 401B is the second of a two-semester sequence of senior capstone design courses. In this course, students work in teams, completing the design process begun in AERSP 401A. This process is inherently multidisciplinary, requiring the use of engineering practices in such subjects as structures, dynamics, electrical and thermal systems, propulsion, controls, and information systems. In addition to the technical design content, this course seeks to enhance students’ skills in verbal and written communications, and the team approach to design, which is widely used in industry and government. Classes (115 minutes each, twice weekly) include lecture and time for team meetings.

**Prerequisite:** AERSP301, AERSP401A

AERSP 402A: Aircraft Design—Preliminary

3 Credits

Conceptual and preliminary design of an aircraft, its constituent subsystems, and related systems, to satisfy a given set of specifications. AERSP 402A Aircraft Design – Preliminary (3) AERSP 402A is the first of a two-semester sequence of senior capstone design courses. In this course, students will complete the preliminary design for an aircraft such that it satisfies the assigned specifications. Students completing this course will have the ability to design a system, component, or process to meet desired needs in aircraft systems; they will have the ability to function on multi-disciplinary teams; and they will have the ability to identify, formulate, and solve engineering problems. In addition, students will have the background to help determine what the ethical responsibilities are to themselves, to employers, and to society. Classes (115 minutes each, twice weekly) include lecture and time for team meetings.

**Prerequisite:** AERSP306. Prerequisite or concurrent: AERSP413

AERSP 402B: Aircraft Design—Detailed

2 Credits

Detailed design of the constituent subsystems and related support systems for an aircraft. AERSP 402B Aircraft Design - Detailed (2) AERSP 402B is the second of a two-semester sequence of senior capstone design courses. In this course, students will complete the detailed design for an aircraft, and all of its constituent and related support systems, such that it satisfies the assigned specifications. Students completing this course will have the ability to design a system, component, or process to meet desired needs in aircraft systems; they will have the ability to function on multi-disciplinary teams; and they will have the ability to identify, formulate, and solve the associated engineering problems. Classes (115 minutes each, twice weekly) include lecture and time for team meetings.

**Prerequisite:** AERSP301, AERSP402A

AERSP 404: Flight Vehicle Design and Fabrication II

3 Credits/Maximum of 12

Project management, design, fabrication, aerodynamic and structural testing, and flight evaluation of an advanced composite flight vehicle.
AERSP 407: Aerodynamics of V/STOL Aircraft

3 Credits

Rotary wing aircraft; VTOL and STOL performance; propeller-wing combinations; jet flap; high lift devices.

Prerequisite: AERSP312

AERSP 410: Aerospace Propulsion

3 Credits

Analysis and performance characteristics of reciprocating engine, turbo-jet, turbo-prop, turbo-fan, ram-jets, and chemical rockets.

Aerothermodynamics of inlets, combustors, and turbomachinery.

Prerequisite: AERSP312

AERSP 410H: Aerospace Propulsion

3 Credits

Analysis and performance characteristics of reciprocating engine, turbo-jet, turbo-prop, turbo-fan, ram-jets, and chemical rockets.

Aerothermodynamics of inlets, combustors, and turbomachinery.

Honors

AERSP 412: Turbulent Flow

3 Credits

Homogeneous turbulence; spectral transfer of energy, viscous dissipation; turbulent shear flow; mixing-length theory, eddy viscosity, scaling laws, energy budget.

Prerequisite: one course in fluid mechanics

AERSP 413: Stability and Control of Aircraft

3 Credits

Static and dynamic stability and control of aircraft; open and closed loop systems.

Prerequisite: AERSP304, AERSP305

AERSP 420: Principles of Flight Testing

3 Credits

In-flight and analytical studies of airplane performance, stability, and control; reduction of data; instrumentation; flight test techniques.

Prerequisite: AERSP306

AERSP 423: Introduction to Numerical Methods in Fluid Dynamics

3 Credits

Finite difference methods applied to solving viscid/inviscid fluid dynamics problems, error control, numerical stability.

Prerequisite: AERSP312 or M E 320; MATH 250 or MATH 251; CMPSC201 or CMPSC202

AERSP 424: Advanced Computer Programming

3 Credits

Engineering and scientific programming topics: object oriented programming, parallel programming, and various modern languages (e.g. C++, Java, and Ada). AERSP 424 Advanced Computer Programming (3) This course presents an advanced view of computer programming, mainly using Java, C++, and Ada95. The use of current operating systems (e.g. Linus and Unix) and compilers (e.g. gcc) will also be presented. Object Oriented Programming will also be discussed in
Prerequisite: CMPSC201 or CMPSC202 ; MATH 220

AERSP 425: Theory of Flight
3 Credits
Advanced wing and airfoil theory, conformal mapping, slender body theory.
Prerequisite: AERSP306

AERSP 430: Space Propulsion and Power Systems
3 Credits
Analysis and performance of chemical and nuclear rockets, electric propulsion systems. Introduction to solar, chemical, thermoelectric, and nuclear power sources.
Prerequisite: AERSP410 or M E 432

AERSP 440: Introduction to Software Engineering for Aerospace Engineers
3 Credits
Software engineering for safety- and mission-critical systems, including requirements, management, processes, designs, programming, validation/ verification, and other aspects of software development. AERSP 440 Introduction to Software Engineering for Aerospace Engineers (3) This course is an introduction to software engineering. Software engineering includes all aspects of professional software production, and is especially important for safety-critical and mission-critical software. It includes documentation, management, processes, requirements, design models, computer programs, validation, verification, and other aspects of the development process.Aerospace systems, including aircraft, spacecraft, onboard avionics, ground-based systems, flight simulators, and air transportation systems, rely heavily on software. Software is a major cost of all aerospace systems. For example, the Boeing 777 has more than 1000 onboard processors and more than 4 million lines of software which is primarily written in Ada. The F/A-22 fighter has more than 2 million lives of software onboard, and much of this is Ada also.Aerospace systems also demand a level of reliability far beyond that of most other systems, which means the software must be designed using rigorous mission-critical and safety-critical procedures. It makes the software quite unique compared to most other software. The FAA and DOD are both involved in certifying aircraft software, for example, through the DO-178B and DOD-2168 standards.This course is required in Aerospace Engineering (take one of AERSP 440, EE 305, or EE 210). If not taken to satisfy that requirement, it can be used as a technical elective. This course is required in Aerospace Engineering (take one of AERSP 440, EE 305, or EE 210). If not taken to satisfy that requirement, it can be used as a technical elective.
Prerequisite: CMPSC201 or CMPSC202

AERSP 450: Orbit and Attitude Control of Spacecraft
3 Credits
Principles of mechanics and vector analysis applied to basic concepts of satellite motion and control, rocket ballistics, and gyroscopic instruments.
Prerequisite: AERSP304 , AERSP309

AERSP 450H: Orbit and Attitude Control of Spacecraft
3 Credits
Principles of mechanics and vector analysis applied to basic concepts of satellite motion and control, rocket ballistics, and gyroscopic instruments.
Honors

AERSP 460: Aerospace Control Systems
3 Credits
Design and analysis of feedback control systems for aerospace applications; stability, root locus, time- and frequency-domain, state-space methods. AERSP 460 Aerospace Control Systems (3) This course is an introduction to the design and analysis of feedback control systems as applied to aerospace systems. The course covers control theory that is commonly used in the aerospace industry and presents practical applications of this theory to aerospace systems. The course does not emphasize rigorous mathematical derivation, but instead emphasizes the application of control theory. It provides a comprehensive overview of classical control theory and single-input/single-output (SISO) design methods. The course also presents an introduction to modern control theory and multi-input/multi-output (MIMO) design methods. Aerospace examples and applications are emphasized throughout the course. The course builds upon a required junior-level course in system dynamics and controls (AERSP 304), which provides students with basic dynamic system theory and a brief introduction to feedback control. The course also supplements required senior-level courses in either aircraft or spacecraft dynamics (AERSP 413 and 450) which provides background on vehicle dynamics. AERSP 460 provides an additional level of depth in dynamics and control theory, and prepares students for entry-level work or graduate studies involving the design of automatic control systems for aircraft and spacecraft.
Prerequisite: AERSP304

AERSP 470: Advanced Aerospace Structures
3 Credits
Design and analysis of aerospace structures. Plates and sandwich panels; composite materials; structural dynamics; aerelasticity; damage tolerance. AERSP 470 Advanced Aerospace Structures (3) AERSP 470 covers important topics in aerospace structures beyond basic stress and deflection analysis of thin-walled beams. The objectives of the course are to help students: 1) appreciate the roles that structures and structural materials play in aerospace vehicles; 2) understand general design concepts for aerospace structures: vehicles, components, and materials; 3) develop the analysis tools and skills needed to analyze the static and dynamic performance of aerospace structures; and 4) gain experience identifying, formulating, and solving aerospace structural engineering problems. AERSP 470 builds on structural, dynamics, and aerodynamics topics covered in PHYS 211, EMCH 11 & EMCH 13 (or
EMCH 210, EMCH 215 & EMCH 216, AERSP 301, AERSP 306, and AERSP 304. It prepares students for entry-level work or graduate study in the analysis and design of aerospace structures. It also provides students with the strong background needed to contribute effectively to multidisciplinary trade studies in vehicle design activities. AERSP 417 begins with a review of the general features of flight vehicle structures and aerospace structural design concepts. Then, the deflection and stress responses of flat plates and sandwich panels under lateral and in-plane loading are addressed. About a third of the course is devoted to the behavior of advanced composite panels, and another third to structural dynamics and aeroelasticity. The course finishes with treatments of joining and damage tolerance, both key topics with respect to the design of aerospace structures.

**Prerequisite:** AERSP301. Prerequisite or concurrent: AERSP304, EMCH315

AERSP 473: Composites Processing

3 Credits

An introduction to the principles of mechanics governing manufacturing, computer-aided design, and testing of composite materials and structures.

**Prerequisite:** EMCH471
Cross-listed with: EMCH 473

AERSP 490: Introduction to Plasmas

3 Credits

Plasma oscillations; collisional phenomena; transport properties; orbit theory; typical electric discharge phenomena.

**Prerequisite:** EE 330 or PHYS 467
Cross-listed with: EE 471, NUCE 490

AERSP 492: Space Astronomy and Introduction to Space Science

3 Credits

The physical nature of the objects in the solar system; the earth's atmosphere, ionosphere, radiation belts, magnetosphere, and orbital mechanics.

**Prerequisite:** EE 330 or PHYS 400
Cross-listed with: EE 472

AERSP 494: Aerospace Undergraduate Thesis

1-12 Credits/Maximum of 12

Individual problem investigations reported in written thesis and seminar lectures. Cooperative research with faculty guidance on topics of current interest.

**Prerequisite:** seventh-semester standing

AERSP 494H: Aerospace Undergraduate Thesis

1-3 Credits/Maximum of 6

Individual problem investigations reported in written thesis and seminar lectures. Cooperative research with faculty guidance on topics of current interest.

AERSP 496: Independent Studies

1-18 Credits/Maximum of 18

Creative projects, including research and design, which are supervised on an individual basis and which fall outside the scope of formal courses.

**Prerequisite:** seventh-semester standing

Honors

AERSP 496H: Independent Studies

1-3 Credits/Maximum of 6

Creative projects, including research and design, which are supervised on an individual basis and which fall outside the scope of formal courses.

Honors

AERSP 497: Special Topics

1-9 Credits/Maximum of 9

Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest.

AERSP 498: Special Topics

1-9 Credits/Maximum of 9

Formal courses given infrequently to explore, in depth, a comparatively narrow subject that may be topical or of special interest.

AERSP 499: Foreign Studies

1-12 Credits/Maximum of 12

Courses offered in foreign countries by individual or group instruction. International Cultures (IL)