ENAE - ENGINEERING, AEROSPACE

ENAE100 The Aerospace Engineering Profession (1 Credit)
Overview of salient aspects of professional practice of Aerospace Engineering. Introduction to the range of technical expertise needed to succeed in the profession and the objectives of the various parts of the Aerospace Engineering program at UMCP in supporting students' efforts in gaining the required knowledge and skills. Familiarization with departmental faculty and their areas of research, creation of links with other students, professional society student chapters, and available resources. Discussion of ethical issues, business requirements, and their interactions with technical developments.
Recommended: ENES100 and MATH140.

ENAE200 Aerospace Engineering Profession II (1 Credit)
Overview of the engineering profession as it pertains to the role of the engineer in society, professional practice and ethical standards, career development, opportunities and need for lifelong learning, importance of safety and standards, effective written, visual, and oral communications, and the impact of the engineering profession on global issues.
Recommended: ENAE100.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.

ENAE202 Computing Fundamentals for Engineers (3 Credits)
Introduction to computer programming for the solution of engineering problems. Python & MATLAB languages including flow control, functions, file handling, arrays, and data structures. Students will be introduced to computing fundamentals, principles of software engineering, object-oriented programming, and algorithms.
Corequisite: MATH141.
Credit Only Granted for: ENAE202 or ENME202.

ENAE203 Introduction to Computer-Aided Design (1 Credit)
Introduces students to the principles of computer-aided design (CAD), with a focus on building core skills in 2D sketching, 3D part modeling, assemblies, and technical documentation. Course covers fundamental CAD techniques, creating and modifying complex geometries, managing design intent through parametric modeling, and producing industry-standard technical drawings. Students will apply these skills to create and refine components, culminating in a fully realized aerospace CAD project by semester's end.
Recommended: ENAE100.
Restriction: Must be in Engineering: Aerospace program.
Credit Only Granted for: ENAE203 or ENME272.

ENAE222 Aerospace Mechanics (4 Credits)
Combines the fundamental concepts of Statics and Mechanics into a single course focused on aerospace applications. Concepts include: equilibrium of forces and moments on a structure, stress & strain, material properties, analysis of axial loads, torsional loads, bending and shear loads, beam deflection, buckling of columns, fatigue analysis, and statically indeterminate structures.
Prerequisite: Minimum grade of C- in MATH141 and PHYS161; and must have completed or be concurrently enrolled in MATH241.
Restriction: Must be in Engineering: Aerospace program.
Credit Only Granted for: ENAE222 or ENES220.

ENAE283 Introduction to Aerospace Systems (3 Credits)
Introduction to airplanes and space vehicles as aerospace systems. Fundamentals that describe these systems. Elements of aerodynamics, airfoils and wings. Airplane performance, stability and control. Aircraft and rocket propulsion. Fundamentals of orbital motion. Aspects of vehicle conceptual design.
Prerequisite: PHYS161, MATH141, and ENES102.
Corequisite: PHYS261 and PHYS260.
Restriction: Must be in Engineering: Aerospace program.
Credit Only Granted for: (ENAE281 and ENAE282) or ENAE283.
Formerly: ENAE281 and ENAE282.

ENAE284 Foundations of Aerospace II (3 Credits)
Continuation of ENAE283. Introduction to the fundamental disciplines of aerospace engineering, and the systems concepts that integrate these into conceptual designs for flight vehicles. Course covers the foundations of aerodynamics, propulsion, aerospace materials, flight mechanics, orbital mechanics, vehicle stability and control.
Prerequisite: Minimum grade of C- in ENAE222, ENAE283, PHYS260, and PHYS261; and must have completed or be concurrently enrolled in ENES232 and MATH243.
Restriction: Must be in Engineering: Aerospace program.

ENAE288 Topics in Aerospace Engineering (1-3 Credits)
Introductory topics in the field of aerospace engineering.
Restriction: Permission of ENGR-Aerospace Engineering Department.
Repeatable to: 6 credits if content differs.

ENAE301 Dynamics of Aerospace Systems (3 Credits)
Kinematics and dynamics of three dimensional motion of point masses and rigid bodies with introduction to more general systems. Primary emphasis on Newtonian methods. Practice in numerical solutions and computer animation of equations of motion using MATLAB.
Prerequisite: PHYS271, MATH461, PHYS270, MATH246, ENAE283, ENAE202, ENES102, and MATH241.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.

ENAE310 Incompressible Aerodynamics (3 Credits)
First course of a two-course sequence in fluid mechanics for aerospace engineers. Topics covered include basic governing equations of incompressible fluid flow, potential flow theory, analysis of elementary 2D incompressible flows using superposition of elementary flows, analysis of airfoils using conformal mapping and classical thin airfoil theory, introduction to Helmholtz vortex theorems and Biot-Savart Law, aerodynamics of finite span wings and Prandtl lifting line theory.
Prerequisite: Minimum grade of C- in PHYS270, PHYS271, MATH241, MATH243, ENES232, ENAE202, and ENAE284.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department; and junior standing or higher.
Credit Only Granted for: ENAE310 or ENAE414.
Formerly: ENAE414.

ENAE311 Compressible Aerodynamics (3 Credits)
Fundamentals of aerodynamics. Elements of compressible flow. Normal and oblique shock waves. Flows through nozzles, diffusers and wind tunnels. Elements of the method of characteristics and finite difference solutions for compressible flows. Aspects of hypersonic flow.
Prerequisite: PHYS271, (MATH240 or MATH461), PHYS270, MATH246, ENAE283, ENES220, ENAE202, MATH241, and ENES232.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department; and junior standing or higher.
Credit Only Granted for: ENAE410 or ENAE311.

ENAE324 Aerospace Structures (4 Credits)
Analysis of torsion, beam bending, plate bending, buckling and their application to aerospace.
Prerequisite: ENES220.
Restriction: Must be in Engineering: Aerospace program.
Credit Only Granted for: ENAE324 or ENAE325.

ENAE325 Aerospace Structures (3 Credits)
Modeling and analysis of aerospace structures. Topics include bending and torsion of plates, beams, and thin-walled structures, buckling, and damage tolerance. Introduction to finite element modeling and composite structures.
Prerequisite: ENAE222 and ENAE284.
Restriction: Must be in Engineering: Aerospace program.
Credit Only Granted for: ENAE324 or ENAE325.

ENAE362 Aerospace Instrumentation and Experimentation (3 Credits)
Basic instrumentation electronics including DC electronics, AC electronics, semiconductors, electro-optics and digital electronics. Sensing devices used to carry out experiments in Aerospace Engineering includes metrology, machine tool measurements, bridge circuits, optical devices, and introduction to computer based data acquisition. Topics chosen to support measurements in aerodynamics, flight structures and flight control.
Prerequisite: MATH246 and ENAE283.
Restriction: Must be in Engineering: Aerospace program; and junior standing or higher.

ENAE364 Aerospace Engineering Laboratory (3 Credits)
Application of fundamental experimental methods and measurement technologies for aerospace engineering. Includes experiments in compressible and incompressible aerodynamics, structures, signal processing, dynamics and control. Correlation of theory with experimental results.
Prerequisite: Minimum grade of C- or better in ENAE310 and ENAE362; and must have completed or be concurrently enrolled in ENAE325, ENAE410, and ENAE432.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.
Credit Only Granted for: ENAE364 or ENAE464.
Formerly: ENAE464.

ENAE380 Flight Software Systems (3 Credits)
Avionics using advanced sensor and computing technologies are at the heart of every modern Aerospace vehicle. Advanced software systems to improve cockpit safety and enable unmanned and deep-space missions. Object-oriented programming and software engineering concepts required to design and build complex flight software systems. Software validation, verification and real-time performance analysis to assess flight software system reliability and robustness. Human-machine interface design for piloted systems. Automatic onboard data acquisition and decision-making for unmanned air and space vehicles.
Prerequisite: ENAE283 and ENAE202.
Restriction: Must be in Engineering: Aerospace program; and junior standing or higher.

ENAE398 Honors Research Project (1-3 Credits)
Planned sequence of steps in aerospace honors research in which students take three (3) consecutive semesters of this course in partial fulfillment of aerospace engineering honors program requirements. The first semester consists of a series of seminars and meetings with faculty mentors on honors research; two semesters consist of undergraduate honors research project and paper conducted under the direction of an aerospace engineering faculty member to be presented at a conference.
Prerequisite: Must be accepted into Aerospace Honors Program.
Restriction: Must be in Engineering: Aerospace program.
Repeatable to: 3 credits if content differs.

ENAE403 Aircraft Flight Dynamics (3 Credits)
Study of motion of aircraft, equations of motion, aerodynamic force representation, longitudinal and lateral motions, response to controls and to atmospheric disturbances, handling qualities criteria and other figures of merit.
Prerequisite: ENAE414 and ENAE432.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.

ENAE404 Space Flight Dynamics (3 Credits)
Three-dimensional motion under central fields. Solutions to orbital motion, orbital elements, time elements. Kepler's laws. Orbital maneuvering, rendezvous and station-keeping. Rigid-body attitude dynamics, spacecraft attitude dynamics.
Prerequisite: ENAE301.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.

ENAE410 Compressible Aerodynamics (3 Credits)
Second course of a two-course sequence in fluid mechanics for aerospace engineers. Topics covered include basic equations of compressible flow, definitions of compressibility, shock waves, expansion waves, flows through nozzles and diffusers, subsonic flow over airfoils, linearized supersonic flow over airfoils, basic equations of viscous flow, internal flow, boundary layers, introduction to turbulence.
Prerequisite: Minimum grade of C- in ENES232, MATH241, and ENAE310.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department; and junior standing or higher.
Credit Only Granted for: ENAE410 or ENAE311.
Formerly: ENAE311.

ENAE414 Incompressible Aerodynamics (3 Credits)
Aerodynamics of inviscid incompressible flows. Aerodynamic forces and moments. Fluid statics/buoyancy force. Vorticity, circulation, the stream function and the velocity potential. Bernoulli's and Laplace's equations. Flows in low speed wind tunnels and airspeed measurement. Potential flows involving sources and sinks, doublets, and vortices. Development of the theory of airfoils and wings.
Prerequisite: PHYS271, (MATH240 or MATH461), PHYS270, MATH246, ENAE283, ENES220, ENAE202, MATH241, and ENES232.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department; and junior standing or higher.
Credit Only Granted for: ENAE310 or ENAE414.

ENAE420 Computational Structural Mechanics (3 Credits)
Introductory of finite element methods for aerospace engineering modeling and analysis; equips students with ability to understand manuals of commercial finite element analysis software.
Prerequisite: ENES220 and MATH241; and must have completed a course in linear algebra.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.

ENAE423 Vibration and Aeroelasticity (3 Credits)
Dynamic response of single and multiple degrees of freedom systems, finite element modeling, wing divergence, aileron reversal, wing and panel flutter.
Prerequisite: ENAE324.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.

ENAE425 Mechanics of Composite Structures (3 Credits)
Introduction to structures composed of composite materials and their applications in aerospace. In particular, filamentary composite materials are studied. Material types and fabrication techniques, material properties, micromechanics, anisotropic elasticity, introduction to failure concepts.
Prerequisite: MATH246, ENAE324, ENES220, and MATH241.

ENAE432 Control of Aerospace Systems (3 Credits)
An introduction to the feedback control of dynamic systems. Laplace transforms and transfer function techniques; frequency response and Bode diagrams. Stability analysis via root locus and Nyquist techniques. Performance specifications in time and frequency domains, and design of compensation strategies to meet performance goals.
Prerequisite: Minimum grade of C- in ENAE301 and ENAE283.
Restriction: Junior standing or higher; and must be in Engineering: Aerospace program.

ENAE441 Space Navigation and Guidance (3 Credits)
Principles of navigation. Celestial, radio, and inertial navigation schemes. Navigational and guidance requirements for orbital, planetary, and atmospheric entry missions. Fundamentals of communications and information theory. Link budgets, antennas and telemetry systems.
Prerequisite: ENAE404 and ENAE432.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.

ENAE450 Robotics Programming (3 Credits)
Introduces students to the Robot Operating System (ROS) as well as to many of the available tools commonly used in robotics. Lectures focus on theory and structure, whereas laboratory sections will focus on applications and implementations. Students learn how to create software and simulations, interface to sensors and actuators, and integrate control algorithms. The course works through exercises involving a number of autonomous robots (i.e., ground and air vehicles) that students will eventually use in their subsequent RAS minor courses. Topics include: ROS architecture, console commands, ROS packages, simulation environments, visualizations, autonomous navigation, manipulation, and robot vision.
Prerequisite: ENME480 or ENAE380.
Restriction: Must be in the Robotics and Autonomous Systems (RAS) minor; or permission of department.
Additional Information: Students in the Robotics and Autonomous Systems minor should take ENME480 as a prerequisite; Aerospace Engineering students not in the minor should take ENAE380.

ENAE455 Aircraft Propulsion and Power (3 Credits)
Thermodynamic cycle analysis, aerothermochemistry of fuels and propellants, operating principles of piston, turbojet, fanjet, and other variations of airbreathing aircraft power units.
Prerequisite: ENES232, ENAE414, and ENAE311.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.

ENAE457 Space Propulsion and Power (3 Credits)
Thermodynamic cycle analysis, aerothermochemistry of fuels and propellants, operating principles of rocket, ion, and other exoatmospheric power units.
Prerequisite: PHYS271, ENES232, PHYS270, and ENAE311.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department. And senior standing.

ENAE464 Aerospace Engineering Laboratory (3 Credits)
Application of fundamental measuring techniques to measurements in aerospace engineering. Includes experiments in aerodynamics, structures, propulsion, flight dynamics and astrodynamics. Correlation of theory with experimental results.
Prerequisite: ENAE324, ENAE362, ENAE311, and ENAE432.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.
Credit Only Granted for: ENAE464 or ENAE364.

ENAE467 Advanced Space Propulsion and Power (3 Credits)
Charged particle motion, drift mechanisms, plasma sheaths, creation of plasmas. Representative electrothermal, electrostatic, and electromagnetic propulsion technologies. Power production and direct-drive thrust generation using fusion as time permits.
Prerequisite: ENAE457.
Jointly offered with: ENAE667.
Restriction: Permission of Instructor.
Credit Only Granted for: ENAE488I, ENAE467, or ENAE667.
Formerly: ENAE488I.

ENAE471 Aircraft Flight Testing (3 Credits)
Provides basic instruction to aircraft flight testing and demonstrates need for systematic, well-proven technique to allow for accurate airplane performance. Concepts of aerodynamics, airplane performance, and stability and control. Emphasis on single-engine general aviation type aircraft.
Prerequisite: ENAE414.
Corequisite: ENAE403.
Restriction: Must be in Engineering: Aerospace program.

ENAE472 Introduction to Hypersonics (3 Credits)
Introduces students to the various key aspects of flight at hypersonic speeds. Critical aerodynamic phenomena to be covered includes the qualitative behavior of flow fields in the high-Mach-numberlimit, approximate methods for quantifying surface pressure, and estimates of viscous drag and heating. High-speed air-breathing propulsion systems will be discussed, including cycle analysis and performance metrics for propulsion, with a main emphasis onthe fundamentals of ramjet and scramjet engines. Key Guidance, Navigation and Control (GNC) concepts for various hypersonic vehicle types will also be introduced, including the design of appropriate flight trajectories and control algorithms to achieve mission goals. Finally, students will be provided with an overview of high-temperature materials, structures, and thermal protection systems.
Prerequisite: ENAE311 or enrolled in hypersonics graduate certificate program.
Corequisite: ENAE481 or ENAE483 (if not enrolled in hypersonics graduate certificate program).
Restriction: Students must be in the Hypersonic Graduate Certificate Program (code: Z165) or receive permission from the department.
Credit Only Granted for: ENAE488N or ENAE472.
Formerly: ENAE488N.

ENAE480 Fundamentals of Aerospace Design (2 Credits)
Principles of aerospace systems analysis and design. Vehicle performance analysis and optimization. Introduction to systems analysis and design, including design optimization and trade studies, sensitivity analysis, mass and cost estimation, multivariate design optimization, and risk analysis. Aerospace human physiology and impact on the design process. Design of vehicle systems including avionics, power, propulsion, life support, human factors, structures, actuator and mechanisms, and thermal control.
Prerequisite: Minimum grade of C- in ENAE301, ENAE310, ENAE325, and ENAE362; and must have completed or be concurrently enrolled in ENAE491 or ENAE493.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.

ENAE481 Principles of Aircraft Design (3 Credits)
Aircraft design principles blending both synthesis and analysis. The iterative nature of the design process. Applied aerodynamics. Elements of aircraft performance calculation and optimization. Design of aircraft including payload, crew and avionics provisions, propulsion selection and sizing, aerodynamic configuration optimization, mass properties, stability and control characteristics, and vehicle subsystems. Individual student projects in aircraft design.
Prerequisite: ENAE324, ENAE362, and ENAE432.
Corequisite: ENAE414.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.
Credit Only Granted for: ENAE481 or ENAE491.

ENAE482 Aeronautical Systems Design (3 Credits)
Senior capstone design course in the aeronautics track. Introduction of computerized methods for sizing and performance analysis. More comprehensive methods to predict weight, aerodynamics and propulsion system characteristics. Consideration in design disciplines such as vulnerability, maintainability, produceability, etc. Groups of students will complete, brief and report on a major design study to specific requirements.
Prerequisite: ENAE455, ENAE423, ENAE403, and ENAE481.
Restriction: Must be in Engineering: Aerospace program; and senior standing or higher.

ENAE483 Principles of Space Systems Design (3 Credits)
Principles of space systems analysis and vehicle design. Launch vehicle performance analysis and optimization. Design of vehicle systems including avionics, power, propulsion, life support, human factors, structures, actuator and mechanisms, and thermal control. Design processes and design synthesis. Individual student projects in vehicle design.
Prerequisite: ENAE404, ENAE324, ENAE362, and ENAE432.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.
Credit Only Granted for: ENAE483 or ENAE493.

ENAE484 Space Systems Design (3 Credits)
Senior capstone design course in the space track. Group preliminary design of a space system, including system and subsystem design, configuration control, costing, risk analysis, and programmatic development. Course also emphasizes written and oral engineering communications.
Prerequisite: ENAE423, ENAE483, ENAE441, and ENAE457.
Restriction: Must be in Engineering: Aerospace program.

ENAE488 Topics in Aerospace Engineering (1-4 Credits)
Technical elective taken with the permission of the student's advisor and instructor. Lecture and conference courses designed to extend the student's understanding of aerospace engineering. Current topics are emphasized.
Prerequisite: Permission of student's advisor required.
Restriction: Permission of instructor.

ENAE491 Principles of Aircraft Design (2 Credits)
Companion course to ENAE480, focusing on topics specific to aeronautical systems, and starting the team design exercise to be continued in ENAE492 in the Spring. Aircraft design principles blending both synthesis and analysis. Applied aerodynamics, elements of aircraft performance calculation and optimization. Design of aircraft including payload, crew and avionics provisions, propulsion selection and sizing, aerodynamic configuration optimization, mass properties, stability and control characteristics, and vehicle subsystems.
Prerequisite: Minimum grade of C- in ENAE325; and must have completed or be concurrently enrolled in ENAE403, ENAE455, and ENAE480.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.
Credit Only Granted for: ENAE481 or ENAE491.

ENAE492 Aeronautical Systems Design (3 Credits)
Senior capstone design course in the aeronautics track. Introduction of computerized methods for sizing and performance analysis. More comprehensive methods to predict weight, aerodynamics and propulsion system characteristics. Consideration in design disciplines such as vulnerability, maintainability, produceability, etc. Groups of students will complete, brief and report on a major design study to specific requirements.
Prerequisite: ENAE403, ENAE423, ENAE455, and ENAE491.
Restriction: Must be in Engineering: Aerospace program; and senior standing or higher.
Credit Only Granted for: ENAE482 or ENAE492.
Formerly: ENAE482.

ENAE493 Principles of Space Systems Design (2 Credits)
Companion course to ENAE480, focusing on topics specific to space systems, and starting the team design exercise to be continued in ENAE494. Space systems design principles, including design of life support systems, spacecraft internal layout for habitability and functionality, airlock design and extravehicular activity, interplanetary and planetary surface navigation, communications link budgets, structural margins of safety calculations, design of spacecraft power generation and energy storage, propulsion system design including reaction control systems, and spacecraft thermal control system design and analysis.
Prerequisite: Minimum grade of C- in ENAE325; and must have completed or be concurrently enrolled in ENAE404, ENAE457, and ENAE480.
Restriction: Must be in Engineering: Aerospace program; or permission of ENGR-Aerospace Engineering department.
Credit Only Granted for: ENAE483 or ENAE493.

ENAE494 Space Systems Design (3 Credits)
Senior capstone design course in the space track. Group preliminary design of a space system, including system and subsystem design, configuration control, costing, risk analysis, and programmatic development. Course also emphasizes written and oral engineering communications.
Prerequisite: ENAE404, ENAE423, ENAE457, and ENAE493 .
Restriction: Must be in Engineering: Aerospace program; and senior standing or higher.
Credit Only Granted for: ENAE484 or ENAE494.
Formerly: ENAE484.

ENAE499 Elective Research (3 Credits)
Undergraduate research project and paper conducted under the direction of an aerospace engineering faculty member to be presented at a conference or competition.
Prerequisite: Permission from student's advisor required.
Restriction: Senior standing or higher; and must be in Engineering: Aerospace program; and permission of instructor; and permission of ENGR-Aerospace Engineering department.
Repeatable to: 6 credits if content differs.