AEROSPACE ENGINEERING (AENG)

AENG 1001 - Introduction to Aerospace & Mechanical Engineering
1 Credit
This course will introduce aerospace and mechanical engineering. Through hands-on activities, students will learn the basics of engineering design and entrepreneurship. Working in teams, students will build aerospace and mechanical systems, practice entrepreneurial thinking, and develop the personal and professional skills needed to engage in lifelong learning. This course is open to non-majors.

AENG 1002 - Computer-Aided Engineering Design
1 Credit
This course is an introduction to engineering drawing and computer aided design (CAD) and 3D solid modeling. Students will learn to interpret engineering drawings, create engineering drawings, and create 3D models of mechanical systems.

AENG 2000 - Intro to Aeronautics & Astron
3 Credits
The nature of aerodynamic forces; incompressible and compressible fluid flow; lift and drag; introduction to performance, stability and control; propulsion; structures; rocket performance and orbits. The design process.
Prerequisite(s): ((AENG 1002*, MENG 1002*, or ESCI 1020*); PHYS 1610*)

* Concurrent enrollment allowed.

AENG 2020 - Introduction to Aero and Astro Engineering
1 Credit
An introduction to the aerospace profession and aerospace design, including aerospace history, aircraft and rocket performance, stability and control, propulsion, and structures, with an emphasis on design projects. (Offered in Fall)
Prerequisite(s): Minimum Earned Credits of 15

AENG 2910 - Co-op with Industry
1-3 Credits (Repeatable for credit)
A full-time supervised work experience with an agency, firm or organization that employs persons in this degree field. This course is used for the first experiential learning session. Grading system is determined by department offering course. (Offered every Fall, Spring and Summer)
Prerequisite(s): (CORE 1000 or UUC Ignite Seminar Waiver with a minimum score of S); CORE 1500*

* Concurrent enrollment allowed.
Restrictions:
Students with a classification of Freshman may **not** enroll.

Attributes: UUC:Reflection-in-Action

AENG 2930 - Special Topics
3 Credits (Repeatable for credit)

AENG 2980 - Independent Study
1 or 3 Credits (Repeatable for credit)

AENG 3000 - Performance
3 Credits
Aircraft performance characteristics, level flight, rate-of-climb, range and endurance, take-off and landing, turn performance, energy state approximation, propeller theory and analysis, constraint analysis, carpet plots and design methodology.
Prerequisite(s): (AENG 2000 or AENG 2020)

AENG 3050 - Design of Space Missions
3 Credits
The requirements-driven aerospace design process. Design and sizing of spacecraft subsystems to meet mission objectives. The space environment and its effect on spacecraft performance.
Prerequisite(s): AENG 3150*

* Concurrent enrollment allowed.

AENG 3100 - Computer Aided Engineering
3 Credits
The course outlines the principles of Computer Aided Engineering. The computer applications to structural design, kinematic synthesis and design optimization are explored.
Prerequisite(s): CSCI 1060; (ESCI 3100, MENG 3105, or CVNG 3105X)

AENG 3150 - Astrodynamics
3 Credits
Space environment; two-body problem and introduction to orbit mechanics; rigid body dynamics; satellite dynamics, rocket performance; re-entry dynamics. (Offered every Spring)
Prerequisite(s): (AENG 2000 or AENG 2020)

AENG 3230 - Compressible Flow
3 Credits
Fundamental equations for gas dynamics, normal and oblique shockwaves, isentropic flow, quasi 1D flow, flow with heat transfer, flow with friction, supersonic thin airfoil theory, Newtonian impact theory, method of characteristics.
Prerequisite(s): (ESCI 3200 or MENG 3200); (ESCI 2300 or MENG 2310); MATH 3270*

* Concurrent enrollment allowed.

AENG 3240 - Aerodynamics and Boundary Layer Flow
3 Credits
Circulation and vorticity; irrotational flows and potential flow theory; KuttaJoukowski Theorem; subsonic thin airfoil and finite wing theory; subsonic compressible aerodynamics; compressible aerodynamic design; boundary layer flow and drag.
Prerequisite(s): (AENG 3210 or AENG 3230); MATH 3270*

* Concurrent enrollment allowed.

AENG 3410 - Analysis and Control of Linear Systems
3 Credits
Linear vibration theory; control system block diagrams; analog and digital simulation; frequency and time domain analysis techniques; state space; and introduction to optimal control theory. Spring semester.
Prerequisite(s): (ESCI 3110 or MENG 3110)

AENG 3910 - Co-op with Industry
1-3 Credits (Repeatable for credit)
A full-time supervised work experience with an agency, firm or organization that employs persons in this degree field. This course is used for the second experiential learning session. Grading system is determined by department offering course. (Offered every Fall, Spring and Summer)
Prerequisite(s): AENG 2910; (CORE 1000 or UUC Ignite Seminar Waiver with a minimum score of S); CORE 1500*

* Concurrent enrollment allowed.
Attributes: UUC:Reflection-in-Action

AENG 3915 - Internship with Industry
1-3 Credits (Repeatable for credit)
A work experience with an agency, firm or organization that employs persons in this degree field. This experience may be full time or part-time as required by the industry sponsor. This course is used for the first experiential learning session. Grading system is determined by department offering course. (Offered every Fall, Spring and Summer)
Prerequisite(s): (CORE 1000 or UUC Ignite Seminar Waiver with a minimum score of S); CORE 1500*

* Concurrent enrollment allowed.
Restrictions:
Enrollment limited to students with a classification of Junior or Senior.

Attributes: UUC:Reflection-in-Action

AENG 3930 - Special Topics
3 Credits (Repeatable for credit)

AENG 3980 - Independent Study
1 or 3 Credits (Repeatable for credit)

AENG 4004 - Flight Vehicle Analysis and Design I
3 Credits
Application of aerospace engineering to the design methodology of a flight vehicle. (Offered every Fall)
Prerequisite(s): AENG 3000 and AENG 4400*; Minimum Earned Credits of 60; (CORE 1000 or UUC Ignite Seminar Waiver with a minimum score of S); CORE 1900; CORE 1500; CORE 1200*; CORE 2500*; CORE 1000; CORE 1500*

* Concurrent enrollment allowed.
Attributes: UUC:Collaborative Inquiry, UUC:Self in the World

AENG 4014 - Flight Vehicle Analysis and Design II
3 Credits
Application of aerospace engineering to the detail design of a flight vehicle, model design, fabrication testing, evaluation and analysis. (Offered every Spring)
Prerequisite(s): AENG 4004; CORE 1900
Attributes: UUC:Creative Expression, UUC:Writing Intensive

AENG 4050 - Space Mission Analysis and Design
3 Credits
Basic spacecraft types and their applications. Major subsystems of a spacecraft system. Space environment, propulsion system, power system, structural design, spacecraft dynamics and attitude control, orbit mechanics, thermal control, communications, and ground segments, command and data handling. Spacecraft integration and testing.

AENG 4110 - Flight Vehicle Structures
3 Credits
Introduction to theory of elasticity; behavior of materials including composites; torsional and bending shear flows in thin walled structures; shear center; analysis of semi-monocoque structures; joints and fittings; elastic and inelastic buckling; and fatigue analysis. Application of FEM methods.
Prerequisite(s): AENG 3000 and MENG 3105

AENG 4111 - Aerospace Laboratory
1 Credit
Experimental studies in subsonic and supersonic air flows. Measurements of strains and deflections in aerospace structures under simulated loading conditions; static and dynamic measurements. Design of experiments, collection, reduction, evaluation and comparison of data. (Offered every Fall)
Prerequisite(s): AENG 3000; AENG 4110*

* Concurrent enrollment allowed.

AENG 4140 - Hypersonics
3 Credits
Introduction to hypersonics. Newtonian and Busemann Theory; slender body theory; shock expansion theory; small disturbance theory and supersonic similitude; blast wave theory. Thin shock layer theory.
Prerequisite(s): AENG 3210

AENG 4150 - Orbital Mechanics
3 Credits
Orbital dynamics of space vehicles with emphasis on engineering design and application to specific mission analysis. Orbit determination and maneuvers; interplanetary transfer and trajectory optimization; proximity operations; perturbation effects.
Prerequisite(s): AENG 3150

AENG 4190 - Planetary Climates
3 Credits
Investigation of the physics and chemistry of planetary climates, including understanding what data is available, how the data is obtained, how the data is analyzed, and what we do and do not yet understand. Techniques and missions for exploring non-Earth planets are presented in the context of comparative planetology, with an emphasis on how one develops knowledge when observations and experiments are limited by feasibility and practicality.
Prerequisite(s): (PHYS 1610, CHEM 1110, or 0 Course from CSCI 1000-1999); MATH 1520; CORE 1000; Minimum Earned Credits of 60; (CORE 1000 or UUC Ignite Seminar Waiver with a minimum score of S); CORE 1500*

* Concurrent enrollment allowed.
Attributes: UUC:Collaborative Inquiry

AENG 4210 - Propulsion
3 Credits
Ramjet, turbojet, turbofan and turboshaft cycle analysis; component analysis and matching; turbojet off-design performance. Aircraft/engine integration. (Offered every Fall)
Prerequisite(s): (AENG 3210 or AENG 3230)

AENG 4230 - Intro to Comp. Fluid Dynamics
3 Credits
This course is designed to establish the fundamentals of computational fluid dynamic schemes and methods to solve the PDEs. The students will learn how various schemes are applied to proposed to model equations, and analyze the resulting solutions.
Prerequisite(s): (ESCI 3200 or MENG 3200)

AENG 4250 - Compressible Computational Fluid Dynamics
3 Credits
This course is designed to establish the fundamentals of compressible computational fluid dynamics schemes and methods to solve the governing partial differential equations. The students will learn how common numerical schemes are applied to proposed model equations and how to analyze the resulting solutions.

AENG 4400 - Stability and Control
3 Credits
Static stability and aircraft control; equations of motion, dynamic stability; closed loop control. (Offered every Fall)
Prerequisite(s): AENG 3000; (AENG 3410* or ESCI 3410*)

* Concurrent enrollment allowed.

AENG 4410 - Flight Simulation
3 Credits
Overview of various types of simulators; introduction to major software and hardware components of state-of-the-art simulators; development of computer models of aircraft systems and performance characteristics and interfacing the models with each other to achieve high-fidelity, real time aircraft simulation. Use of reconfigurable flight simulator, whenever possible.
Prerequisite(s): AENG 4400

AENG 4700 - Aeroelasticity
3 Credits
Aerodynamic loads on a flexible surface. General formulation of aeroelastic problems. Control effectiveness and reversal. Wing divergence. Two - and three dimensional flutter theory. Empennage vibration and flutter analysis. Flutter prevention. Testing techniques.
Prerequisite(s): AENG 4110; ESCI 3110

AENG 4800 - Systems Engineering
3 Credits
Processes and tools for engineering large-scale, complex systems: architecture, requirements, risk management, evaluation criteria, concept exploration, decision making, tradeoff studies, lifecycle models, decomposition, system coupling, test, verification, validation, system modeling, business process re-engineering, sensitivity analysis, teamwork, process maturity and documentation.

AENG 4810 - Model-based Systems Engineering
3 Credits
This course is designed to provide students with the foundations of model-based systems engineering. Students will develop skills in the areas of fundamental requirements/needs analysis, logical, behavioral, and functional architecture representations of engineered systems. Topics include introduction to systems engineering process, systems requirements engineering, interface design and modeling, system architecting, system verification and testing, and system simulation. Emphasis is placed on modeling engineering systems using modern MBSE principles, methods, and tools.
Restrictions:
Students with a classification of Freshman or Sophomore may **not** enroll.

AENG 4910 - Co-op with Industry
0 Credits (Repeatable for credit)
A full-time supervised work experience with an agency, firm or organization that employs persons in this degree field. This course is used for the third experiential learning session. Grading system is determined by department offering course. (Offered every Fall, Spring and Summer)
Prerequisite(s): AENG 3910; CORE 1500*; (CORE 1000 or UUC Ignite Seminar Waiver with a minimum score of S)

* Concurrent enrollment allowed.
Attributes: UUC:Reflection-in-Action

AENG 4915 - Internship with Industry
1-3 Credits (Repeatable for credit)
A work experience with an agency, firm or organization that employs persons in this degree field. This experience may be full time or part-time as required by the industry sponsor. Grading system is determined by department offering course. (Offered every Fall, Spring and Summer)
Prerequisite(s): (CORE 1000 or UUC Ignite Seminar Waiver with a minimum score of S); CORE 1500*

* Concurrent enrollment allowed.
Attributes: UUC:Reflection-in-Action

AENG 4930 - Special Topics in Aerospace Engineering
3 Credits (Repeatable for credit)
Selected topics of special interest to aerospace engineering majors.

AENG 4980 - Advanced Independent Study in Aerospace Engineering
1-3 Credits (Repeatable for credit)
Credit to be arranged. Independent study on an aerospace engineering topic under the direction of a faculty member.

AENG 5009 - Seminar
1 Credit (Repeatable for credit)
Presentations of current research by students, faculty, and guests. Registration required in the first semester for graduate students. Seminar attendance expected in subsequent semesters.

AENG 5050 - Space Mission Analysis and Design
3 Credits
Basic spacecraft types and their applications. Major subsystems of a spacecraft system. Space environment, propulsion system, power system, structural design, spacecraft dynamics and attitude control, orbit mechanics, thermal control, communications, and ground segments, command and data handling. Spacecraft integration and testing.

AENG 5150 - Orbital Mechanics
3 Credits
Orbital dynamics of space vehicles with emphasis on engineering design and application to specific mission analysis; orbit determination and maneuvers; interplanetary transfer and trajectory optimization; proximity operations; perturbation effects.
Prerequisite(s): AENG 3150

AENG 5190 - Planetary Atmospheres
3 Credits
Investigation of the physics and chemistry of planetary atmospheres, including understanding what data is available, how the data is obtained, and how the data it is analyzed. This course covers the physical processes governing planetary atmospheres with the focus on non-Earth planets, including observational, analytical, and computational techniques.
Prerequisite(s): CHEM 1110; MATH 3550; PHYS 1610

AENG 5230 - Introduction to Computational Fluid Dynamics
3 Credits
This course is designed to establish the fundamentals of computational fluid dynamic schemes and methods to solve the governing PDEs. The students will learn how various schemes are applied to proposed model equations, and analyze the resulting solutions.
Prerequisite(s): (ESCI 3200 or MENG 3200)
Attributes: BME Graduate Elective

AENG 5240 - Hypersonics
3 Credits
This course covers the history of hypersonic efforts; characteristics of hypersonic flow; slender body theory; hypersonic similitude; viscous interactions; transition to turbulence; high-temperature gas dynamics; thermal protection systems; and hypersonic propulsion systems.

AENG 5250 - Compressible Computational Fluid Dynamics
3 Credits
This course is designed to establish the fundamentals of compressible computational fluid dynamics schemes and methods to solve the governing partial differential equations. The students will learn how common numerical schemes are applied to proposed model equations and how to analyze the resulting solutions.

AENG 5260 - Unsteady Aerodynamics of Bluff Bodies
3 Credits
This course is an introduction to the aerodynamics of non-streamlined (i.e. bluff) bodies in both the steady and unsteady regimes. Topics include: aerodynamics of bodies in accelerated motion vs. steady motions; structure of the near and far wakes behind flat plates (in normal flows). Several examples shall be discussed in depth as well, encompassing examples from both engineering and natural worlds: 1) blimp flight and the role of apparent mass; 2) parachute under descent; 3) inflating parachutes; 4) spacecraft drag during atmospheric re-entry; 5) wake re-contact during decelerating motion 6) wave-generated drag on ocean piles; 7) engulfment drag by whales; 8) fast start by shrimp.
Prerequisite(s): MATH 5102

AENG 5280 - Applied Aerodynamics
3 Credits
This course introduces students to analytical and numerical methods applicable to airfoils and wings. Student will be able to model two- and three-dimensional flows. Student will understand how to estimate lift and drag of wings using analytically and numerically methods. Students will have an understanding of high-lift systems and of rotor aerodynamics.

AENG 5400 - Guidance, Navigation and Estimation for Dynamic Vehicles
3 Credits
This course covers three aspects of advanced control of dynamic vehicles. The Estimation module is concerned with topics in automatic control theory related to the modeling of a vehicle state: observability, noise and uncertainty, filtering theory (Weiner Filters, Standard and Extended Kalman Filtering), and simulation. The Guidance module complements Estimation with respect to control: controllability, linear quadratic regulation, as well as a review of rotational dynamics and orbital mechanics. The Navigation module covers real-world examples of sensors and actuators, including inertial systems and GPS, with an emphasis again on noise and uncertainty. Students will develop complete dynamic simulations of real vehicles, including state estimation and control.

AENG 5410 - Flight Simulation
3 Credits
Overview of various types of simulators; introduction to major software and hardware components of state-of-the-art simulators; development of computer models of aircraft systems and performance characteristics and interfacing the models with each other to achieve high-fidelity, real time aircraft simulation. Field trips to area flight simulation facilities. Use of, and projects in, reconfigurable flight simulator.

AENG 5460 - Modern Control Systems
3 Credits
Introduction to system theory, state variables and state space description to dynamic systems, linear vector space and dependence. Jordan canonical forms, Cayley-Hamilton theorem, system stability, controllability and observability, relation between state-space and transfer function models. A brief introduction to Nonlinear systems, Lyapunov stability theory will be provided. This course will give the basic knowledge for more advanced control courses, such as nonlinear control, robust control, optimal control, adaptive control.

AENG 5470 - Advanced Control Systems
3 Credits
Introduction to nonlinear systems. Differences between linear and nonlinear systems. Mathematical preliminaries. Equilibrium points of nonlinear systems. Phase plane analysis and limit cycles. Stability definitions for nonlinear systems. Lyapunov's indirect and direct methods. Stability of autonomous and non-autonomous systems. Describing function analysis. Brief introductions to modules on nonlinear control design including adaptive and nonlinear robust control. Applications of nonlinear control design.
Prerequisite(s): AENG 5460

AENG 5700 - Aeroelasticity
3 Credits
This course presents the fundamentals of Aeroelasticity involved with divergence, flutter and control surface reversal of primary lifting surfaces and empennage on aircraft and missiles. Beam vibration, aeroelastic equations and their solutions, unsteady aerodynamics, quasi-steady aerodynamics and finite state aerodynamics..

AENG 5800 - Systems Engineering
3 Credits
This course is aimed at developing students' capability of systems thinking by introducing classical and advanced systems engineering theory, methods, and tools for engineering large-scale, complex systems.

AENG 5810 - Model-based Systems Engineering
3 Credits
This course is designed to provide students with the foundations of model-based systems engineering. Students will develop skills in the areas of fundamental requirements/needs analysis, logical, behavioral, and functional architecture representations of engineered systems. Topics include introduction to systems engineering process, systems requirements engineering, interface design and modeling, system architecting, system verification and testing, and system simulation. Emphasis is placed on modeling engineering systems using modern MBSE principles, methods, and tools.

AENG 5850 - Space Mission Failures
3 Credits
Space systems are designed to operate in the presence of multiple failures. And yet, occasionally, systems will still fail spectacularly. Reasons for failure include operator error, incorrect design, and manufacturing defects. The odds of these failures occurring can be significantly reduced through good systems engineering practice. But, in some cases, the very systems engineering practices themselves directly contribute to the failure. This course will introduce the fundamentals of good systems engineering practice. A series of case studies in failures (rockets, spacecraft, rovers, etc.) will be used to illustrate these principles and the new vulnerabilities they introduce.

AENG 5910 - Co-op with Industry
1-6 Credits
A full-time supervised work experience with an agency, firm or organization that employs persons in this degree field. This course is used for experiential learning session. Grading system is determined by department offering course. Offered every semester. 0-3 credit hours. DEPARTMENT PERMISSION NEEDED FOR ENROLLMENT.

AENG 5915 - Internship with Industry
1-3 Credits
A work experience with an agency, firm or organization that employs persons in this degree field. This experience may be full time or part-time as required by the industry sponsor. Grading system is determined by department offering the course. Offered every semester. 0-3 credit hours.

AENG 5930 - Special Topics
1-3 Credits (Repeatable for credit)
A one-time course on a particular topic, or a trial course that is expected to become a standard course with its own unique course number.

AENG 5964 - Masters Project
1-3 Credits
Theoretical/computational/experimental work that leads to a Project Report and defense of the Project.

AENG 5974 - Research Topics
1-3 Credits

AENG 5980 - Graduate Independent Study in Aerospace Engineering
1 or 3 Credits (Repeatable for credit)

AENG 5984 - Graduate Independent Study in Aerospace Engineering
1-3 Credits (Repeatable for credit)
A non-classroom course in which a student explores a topic that is related to the student's graduate work and career goals.

AENG 5994 - Masters Thesis Research
0-6 Credits (Repeatable for credit)
Research that leads to a Masters Thesis and final defense of the Thesis.

AENG 6910 - Co-op with Industry
1-6 Credits
A full-time supervised work experience with an agency, firm or organization that employs persons in this degree field. This course is used for experiential learning session. Grading system is determined by department offering the course. Offered every semester. 0-3 credit hours. DEPARTMENT PERMISSION NEEDED FOR ENROLLMENT.

AENG 6915 - Internship with Industry
1-3 Credits
A work experience with an agency, firm or organization that employs persons in this degree field. This experience may be full time or part-time as required by the industry sponsor. Grading system is determined by department offering the course. Offered every semester. 0-3 credit hours. DEPARTMENT PERMISSION NEEDED FOR ENROLLMENT.

AENG 6930 - Special Topics
3 Credits (Repeatable for credit)

AENG 6974 - Advanced Research Topics in Aerospace Engineering
1-3 Credits
Theoretical or Computational or experimental work that is not part of the Dissertation.

AENG 6980 - Graduate Independent Study in Aerospace Engineering
1 or 3 Credits (Repeatable for credit)

AENG 6984 - Graduate Independent Study in Aerospace Engineering
1-3 Credits (Repeatable for credit)
A non-classroom course in which a student explores a topic that is related to the student's doctoral work and career goals.

AENG 6994 - Doctoral Dissertation Research
0-6 Credits (Repeatable for credit)
A non-classroom course in which a student explores a topic that is related to the student's doctoral work and career goals.