AEROSPACE ENGINEERING

Jamie Ervin, Department Chairperson Markus Rumpfkeil, Graduate Program Advisor

Doctor of Engineering, Aerospace Engineering (AEE)

See the Doctoral Degree Requirements section on the School of Engineering page and consult with the department chair.

Doctor of Philosophy in Engineering, Aerospace Engineering (AEE)

See the Doctoral Degree Requirements section on the School of Engineering page and consult with the department chair.

Master of Science in Aerospace Engineering (AEE)

The program of study leading to the Master of Science in Aerospace Engineering degree, developed by the student in conjunction with his/her advisor, must include a minimum of 30 semester hours. The program of study must include 18 or more semester hours of AEE/MEE/RCL credits with at least 12 semester hours in AEE and a minimum of 3 semester hours of mathematics. Students may pursue a thesis or non-thesis option. A thesis option requires 6 semester hours of AEE 599 Aerospace Engineering Thesis credits, which includes both an oral defense and a written thesis.

Total Hours			30
	MEE, AEE, RCL SYE 500-599. A	., ECE, EGM, ENM, MAT, CME, EOP, BIE, CPS, CEE, or Also MTH 403, 404, 430, or 500-599.	
	Choose any the Mathematics,	ree graduate-level courses from Engineering, or STEM-related area	
Additional Coursework ⁴			9
	Could include: ECE503, ECE50 MTH403, MTH	MEE500, MEE503, MEE522, CME581, CME582, 68, ECE569, ECE642, ENM500, ENM561, EOP503, 404, MTH430, MTH 500 and above, SYE 521.	
Choose one approved Mathematics course ⁵			3
	AEE 500 thru A	AEE 595 or MEE 500 thru MEE 595	
Cł	100se any two graduate-level AEE/MEE Courses: ⁴		6
	Non-Thesis Op	tion: Choose four courses AEE 500 thru AEE 595.	
	Thesis Option: Choose two courses AEE 500 - 595 and six credit hours AEE 599 Thesis Courses. Work closely with your advisor when registering for Thesis. See Footnote. ³		
Core Courses: Choose graduate-level Aerospace Engineering Courses: ^{3, 4,}			12
In	consultation w	ith your advisor or graduate program director: ^{1,2,4}	
EC	GR 500	Academic Integrity and Responsible Conduct of Research for Engineers	0

See also http://catalog.udayton.edu/graduate/schoolofengineering/ mastersdegreerequirements/ in the catalog and consult with your advisor.

² The program of study leading to the Master of Science in Mechanical Engineering degree, developed by the student in conjunction with their advisor, must include a minimum of 30 semester hours.

- ³ Thesis Hours should be registered for a maximum of three hours midway through your program. Consult with your advisor before registering for the final 3 credits to determine if the Thesis is a viable option or if an alternative may be necessary, such as additional coursework or a project. The Thesis includes both an oral defense and a written Thesis.
- ⁴ Elective courses can be used to earn certificates in other programs, such as Foundations of Engineering Management, Six Sigma, Sustainability and other offerings. A complete list of available certificates can be found in the graduate catalog: http:// catalog.udayton.edu/certificatesaz/
- ⁵ A complete list of approved mathematics courses can be found here: https://porches.udayton.edu/group/engineering/grad

Courses

AEE 500. Introduction to Numerical Methods. 3 Hours

Numerical analysis topics include the solution of systems of linear and nonlinear algebraic equations; matrix eigenvalue problems; ordinary differential equations; optimization techniques; numerical integration and interpolation. Engineering applications presented. Computer programming required.

AEE 501. Fundamental Aerodynamics. 3 Hours

Fundamentals of aerodynamics including compressibility phenomena for subsonic, transonic, and supersonic flow. Emphasis on steady and inviscid force and moment determination for airfoils and finite wings. Prerequisite(s): Fluid mechanics or an equivalent course.

AEE 502. Advanced Aerodynamics. 3 Hours

Advanced analytical development of viscous and compressible aerodynamics as applied to lifting surfaces and slender bodies. Approximations to lifting surface theory and numerical solutions. Introduction to unsteady aerodynamics. Prerequisite(s): AEE 501.

AEE 503. Introduction to Continuum Mechanics. 3 Hours

Tensors, calculus of variations, Lagrangian and Eulerian descriptions of motion. General equations of continuum mechanics, constitutive equations of mechanics, thermodynamics of continua. Specialization to cases of solid and fluid mechanics. Prerequisite(s): EGM 303.

AEE 504. Fundamentals of Fluid Mechanics. 3 Hours

An advanced course in fluid mechanics with emphasis on the derivation of conservation equations and the application of constitutive theory. Navier-Stokes equations. Ideal fluid approximation. Exact and approximate solutions to classical viscous and inviscid problems. Compressible and incompressible flows. Corequisite(s): MEE 503 or AEE 503.

AEE 505. Advanced Aerospace Systems Design & Integration. 3 Hours Considers iterative aircraft design process through to preliminary design. A project based course, specific topics will vary but will apply to cutting edge aerospace systems integration and design problems. Students will take a set of requirements from conceptual design through to preliminary design, analysis, component testing, and integration on a systems level. Prerequisite(s): (MEE 425 or equivalent) or permission of instructor.

AEE 506. Mechanical Behavior of Materials. 3 Hours

Fudamental relationships between the struture and mechanical behavior of materials. Includes fundamentals of stress and strain, the physical basis for elastic deformation, elementary dislocation theory and plastic deformation, strengthening mechanisms, yield criteria and their application to biaxial and multi-axial behavior and failure, fracture and toughening mechanisms, creep and creep rupture,behavior and failure of cellualr solids, and fatigue. Prerequisite(s): (MAT 501, MAT 502) or consent of instructor.

AEE 507. Orbital Dynamics. 3 Hours

Solution of the two-body problem; coordinate systems; time measurement; orbital elements. Basic orbital maneuvers; transfers; rendezvous; ground-tracks. Methods of orbit determination. Restricted three-body problem and introduction to artificial satellite theory. Prerequisite(s): MTH 219, EGM 202, or equivalent.

AEE 508. Aircraft Performance & Control. 3 Hours

Elementary development of aircraft equations of motion; performance in level flight; climbing and descending performance; turning performance; takeoff and landing performance; static stability and control in all three axes. Prerequisite(s): AEE 501.

AEE 509. Experimental Aerodynamics. 3 Hours

Fundamentals of wind tunnel components and design, wind tunnel characterization, blockage corrections, calibration of six component force balances, flow visualization methods, optical flow diagnostic techniques such as Particle Image Velocimetry (PIV). Use of equipment such as hot-wire anemometer, steady and unsteady pressure transducers, six component force sensors, multi-hole probes, high speed cameras and associated equipment for PIV. Prerequisites: (MEE 401 or AEE 501 or equivalent) or permission of instructor.

AEE 510. Introduction to the Finite Element Method. 3 Hours

Introductory development of the Finite Element Method (FEM), and solution of one- and two-dimensional field problems from fluid, solid, and thermal mechanics. Principles of virtual work and Hamilton; approximate methods; description of stiffness, nodal force, and mass matrices; matrix assembly procedures. Course emphasis on a broad understanding of FEM theory and applications. Not open to Aircraft Structures majors. Prerequisite(s): EGM 303.

AEE 511. Principles of Corrosion. 3 Hours

Theoretical and practical application of electrochemical principles to the field of corrosion covering thermodynamics, kinetics, forms of corrosion and methods for characterizing and controlling corrosion in areas of biomedical engineering, aerospace, automotive, and marine environments. Prerequisite(s): MAT 501.

AEE 513. Propulsion. 3 Hours

Principles of propulsive devices, aerothermodynamics diffuser and nozzle flow, energy transfer in turbo-machinery, turbojet, turbo-fan, prop-fan engines, turbo-prop and turboshaft engines. RAM and SCRAM jet analysis and a brief introduction to related materials and air frame-propulsion interaction.

AEE 517. Radiation Heat Transfer. 3 Hours

Fundamental relationships of radiation heat transfer. Radiation characteristics of surfaces. Geometric considerations in radiation exchange between surfaces. Emissivity and absorptivity of gases. Introduction to radiative exchange in gases.

AEE 519. Analytical Dynamics. 3 Hours

Dynamical analysis of a system of particles and rigid bodies. Lagrangian and Hamiltonian formulation of equations of motion; classical integrals of motion. Stability analysis of linear and nonlinear systems. Prerequisite(s): EGM 202, MTH 219, or equivalent.

AEE 520. Theoretical Kinematics. 3 Hours

Introduction to the mathematical theory underlying the analysis of general spatial motion. Analysis of mechanical systems including robots, mechanisms, walking machines and mechanical hands using linear algebra, quaternion and screw formulations. Fundamental concepts include forward and inverse kinematics, workspace, Jacobians, and singularities.

AEE 521. Flight Vehicle Dynamics. 3 Hours

Dynamics of flight vehicles that emphasize the fundamental theory of flight and its application to aerospace systems. Static and dynamic stability including the characteristic longitudinal and lateral perturbation motions about the equilibrium state. Prerequisite(s): AEE 501.

AEE 522. Geometric Methods in Kinematics. 3 Hours

Trajectories and velocities of moving bodies are designed and analyzed via the principles of classical differential and algebraic geometry. Fundamentals include centrodes, instantaneous invariants, resultants and center point design curves. Curves, surfaces, metrics, manifolds and geodesics in spaces of more than three dimensions are analyzed to study multi-parameter systems.

AEE 523. Engineering Design Optimization. 3 Hours

An introduction to the theory and algorithms of nonlinear optimization with an emphasis on applied engineering problems. Fundamentals include Newton's method, line searches, trust regions, convergence rates, and linear programming. Advanced topics include penalty, barrier and interior-point methods.

AEE 524. Electrochemical Power. 3 Hours

The course will cover fundamental as well as engineering aspects of fuel cell technology. Specifically, the course will cover basic principles of electrochemistry, electrical conductivity (electronic and ionic) of solids, and development/design of major fuel cells (alkaline, polymer electrolyte, phosphoric acid, molten carbonate, and solid oxide). A major part of the course will focus on solid oxide fuel cells (SOFC), as it is emerging to be dominant among various fuel cell technologies. The SOFC can readily and safely use many common hydrocarbon fuels such as natural gas, diesel, gasoline, alcohol, and coal gas. Prerequisite(s): MEE 301, MEE 312 or permission of instructor.

AEE 526. Aerospace Fuels Science. 3 Hours

Basic elements of hydrocarbon fuel production including petroleum based fuels and alternative fuels. Fuel properties, specifications, handling, and logistics. Introduction to chemical kinetics and the chemistry associated with liquid phase thermal-oxidative degradation of fuels. Introduction to the computational modeling of fuel thermal stability and fuel systems. Prerequisite(s): Permission of instructor.

AEE 527. Automatic Control Theory. 3 Hours

Stability and performance of automatic control systems. Classical methods of analysis including transfer functions, time-domain solutions, root locus and frequency response methods. Modern control theory techniques including state variable analysis, transformation to companion forms, controllability, pole placement, observability and observer systems. Prerequisite(s): ELE 432, MEE 435, or equivalent.

AEE 538. Introduction to Aeroelasticity. 3 Hours

The study of the effect of aerodynamic forces on a flexible aircraft. Flexibility coefficients and natural modes of vibration. Quasi-steady aerodynamics. Static aeroelastic problems; wing divergence and dynamic aeroelasticity; wing flutter. An introduction to structural stability augmentation with controls. Prerequisite(s): AEE 501.

AEE 539. Structural Design Optimization. 3 Hours

The study of structural design using gradient and non-gradient based optimization techniques. Fundamentals of the non-linear mathematical programming problem, conditions of optimality, constrained and unconstrained optimization algorithms, sensitivity analysis, sequential quadradic programming, genetic algorithms, structural sizing, shape and topology optimization. Prerequisites: (MEE 409 or equivalent) or permission of instructor.

AEE 540. Flight Dynamics. 3 Hours

Laplace Transforms are used to investigate one DOF harmonic oscillations. One to six DOF differential equations of motion, including inertia, geometric, thrust, and aerodynamic terms are developed in the time domain. Euler angle rotations determine the orientation of the body. Small Disturbance Theory is used to linearize the equations, and the complex eigenproblem is solved to determine stability and mode shapes of aircraft motion. Pitch plane and lateral dynamics are analysed in both the time and frequency domains. Prerequisite(s): MTH 219, EGM 202.

AEE 541. Experimental Mechanics of Composite Materials. 3 Hours Introduction to the mechanical response of fiber-reinforced composite materials with emphasis on the development of experimental methodology. Analytical topics include stress-strain behavior of an isotropic materials, laminate mechanics, and strength analysis.

Theoretical models are applied to the analysis of experimental techniques used to characterize composite materials. Lectures are supplemented by laboratory sessions in which characterization tests are performed on contemporary composites. Prerequisite(s): EGM 303 or EGM 330.

AEE 543. Analytical Mechanics of Composite Materials. 3 Hours

Analytical models are developed to predict the mechanical and thermal behavior of fiber-reinforced composite materials as a function of constituent material properties. Both continuous and discontinuous fiber-reinforced systems are considered. Specific topics include basic mechanics of an isotropic materials, micromechanics, lamination theory, free-edge effects, and failure criteria. Prerequisite(s): EGM 303 or EGM 330.

AEE 545. Computational Methods for Design. 3 Hours

Modeling of mechanical systems and structures, analysis by analytical and numerical methods, development of mechanical design criteria and principles of optimum design. Selected topics in mechanical design and analysis, use of the digital computer as an aid in the design of mechanical elements. Prerequisite(s): Computer programming.

AEE 546. Finite Element Analysis I. 3 Hours

Fundamental development of the Finite Element Methods (FEM) and solution to field and comprehensive structural problems. Variational principles and weak-forms; finite element discretization; shape functions; finite elements for field problems; bar, beam, plate, and shell elements; isoparametric finite elements, stiffness, nodal force, and mass matrices; matrix assembly procedures; computer coding techniques; modeling decisions; program output interpretation. Course emphasis on a thorough understanding of FEM theory and modeling techniques. Prerequisite(s): AEE 503 or MEE 533.

AEE 547. Finite Element Analysis II. 3 Hours

Advanced topics: heat transfer; transient dynamics; nonlinear analysis; substructuring and static condensation; effects of inexact numerical integration and element incompatibility; patch test; frontal solution techniques; selected topics from the recent literature. Prerequisite(s): AEE 546.

AEE 550. Exergy Analysis for Aerospace Applications. 3 Hours

Apply the concept of exergy to the integration of rate mechanisms (i.e., heat transfer and fluid dynamics) into thermodynamic system modeling and analyses; design challenges through open-ended problems with explicit considerations of system-level impacts, engineering trade-offs, and system optimization. Analysis, modeling & design of engineering systems involving applications of thermodynamics, heat transfer, and fluid flow. Perform exergy and thermodynamic analyses and optimization of selected systems. Prerequisites: (MEE 511 or equivalent) or permission of instructor.

AEE 551. Noise & Vibration Control. 3 Hours

Concepts of noise and vibration control applied to mechanical systems. Methodologies covered will include passive treatments using resistive elements (sound absorbers, vibration damping) and reactive elements (tailoring of material stiffness and mass); active control of sound and vibration; and numerical analysis. Prerequisite(s): MEE 319 or MEE 439.

AEE 553. Compressible Flow. 3 Hours

Fundamental equations of compressible flow. Introduction to flow in two and three dimensions. Two-dimensional supersonic flow, small perturbation theory, method of characteristics, oblique shock theory. Introduction to unsteady one-dimensional motion and shock tube theory. Method of surface singularities. Prerequisite(s): AEE 504 or equivalent.

AEE 554. Transonic Aerodynamics. 3 Hours

Fundamentals of transonic flows; transonic characteristics and flow modeling, transonic similarity, properties of shock waves, shockboundary layer interactions, three-dimensional effects, transonic solution techniques. Prerequisites: (AEE 501 or equivalent) or permission of instructor.

AEE 555. Turbulence. 3 Hours

Origin, evolution, and dynamics of fully turbulent flows. Description of statistical theory, spectral dynamics, and the energy cascade. Characteristics of wall-bounded and free turbulent shear flows. Reynolds stress models. Prerequisite(s): AEE 504 or equivalent.

AEE 556. Hypersonic Aerodynamics. 3 Hours

Hypersonic prediction techniques, similarity rules, Newtonian impact theory, high-temperature equilibrium properties of gases; wake characteristics; heat transfer, chemical kinetics and reacting gas flows, simulation and testing techniques. Prerequisite(s): AEE 504 or permission of instructor.

AEE 557. Viscous Flow. 3 Hours

Development of the Prandtl boundary layer approximation in two and three dimensions for both compressible and incompressible flows. Exact and approximate solutions for laminar flows. Unsteady boundary layers. Linear stability theory and transition to turbulence. Empirical and semiempirical methods for turbulent boundary layers. Prerequisites: (MEE 504 or equivalent) or permission of instructor.

AEE 558. Computational Fluid Dynamics. 3 Hours

Introduction to the numerical computation of continuum fluid flows in engineering applications. Finite--difference and finite--volume numerical formulations as well as iterative and temporal solution procedures. Introduction to the use of commercial CFD codes to analyze flow problems of practical engineering interest including verification and validation (V&V). Prerequisite(s): MEE 504 or permission of instructor.

AEE 560. Propulsion Systems. 3 Hours

Introduction and history, types of propulsion systems, thermodynamics review and simple cycle analysis, thermodynamics of high speed gas flow, aircraft gas turbine engine, parametric cycle analysis of various types of gas turbine engines, component and engine performance analysis (inter-turbine burners), advanced cycles with regeneration, reheating, and inter-cooling, variable and inverse cycle engines, hybrid propulsion systems (turbo-ramjets, rocket-ram-scramjets, etc.), advanced propulsion systems, pulse detonation engine theory and concepts, thermal management of high-speed flight, energy management and vehicle synthesis. Prerequisite(s): (MEE 413 or MEE 513) or permission of instructor.

AEE 565. Fundamentals of Fuels & Combustion. 3 Hours

Heat of combustion and flame temperature calculations; rate of chemical reaction and Arrhenius relationship; theory of thermal explosions and concept of ignition delay and critical mass; phenomena associated with hydrocarbon-air combustion; specific applications of combustion.

AEE 570. Fracture Mechanics. 3 Hours

Application of the principles of fracture mechanics to problems associated with fatigue and fracture in engineering structures. The course will cover the development of models that apply to a range of materials, geometries and loading conditions. Prerequisite(s): AEE 506 or permission of instructor.

AEE 590. Problems in Aerospace Engineering. 1-3 Hours

Special topics in Aerospace.

AEE 595. Aerospace Engineering Project. 0-6 Hours

Student participation in an aerospace research, design, or development project under the direction of a project advisor. The student must show satisfactory progress as determined by the project advisor and must present a written report at the conclusion of the project.

AEE 599. Aerospace Engineering Thesis. 1-3 Hours

Thesis in Aerospace Engineering.

AEE 690. Selected Readings in Aerospace Engineering. 1-3 Hours

Directed readings in aerospace engineering to be arranged and approved by the student's advisory committee and the program director. May be repeated.

AEE 698. DE Dissertation. 1-15 Hours

An original investigation as applied to aerospace engineering practice. Results must be of sufficient importance to merit publication.

AEE 699. PHD Dissertation. 1-3 Hours

Research in aerospace engineering. Results must be of sufficient importance to merit publication.