AE - Aerospace Engineering

All graduate courses must be approved in advance of enrollment by a student's graduate advisor.

Courses numbered 500 to 799 = *undergraduate/graduate*. (Individual courses may be limited to undergraduate students only.) Courses numbered 800 to 999 = *graduate*.

AE 502. Aerospace Propulsion I (3).
Surveys aerospace propulsion methods. Production of thrust and consumption of fuel. Rocket performance analysis; liquid chemical and solid propellant rocket engines. Jet engine cycle analysis; turbojet, ramjet, turbofan and turboprop engines. Analyzes piston engines and propellers. Prerequisite(s): AE 227, 373, ME 398. Pre- or corequisite(s): AE 424.

AE 512. Experimental Methods in Aerospace (3).
Studies experimental methods and test planning, error analysis and propagation, model design, instrumentation and flow visualization. Uses electromechanical testing machines, subsonic and supersonic wind tunnels. Prerequisite(s): AE 333, 424. Pre- or corequisite(s): AE 524. Corequisite(s): AE 512L.

AE 514. Flight Dynamics and Control (3).
Static stability and control of conventional aircraft and implications in aircraft design, six degrees of freedom, time dependent equations of motion and their linearized solutions. Consideration of stability versus maneuverability and the dynamic modes of motion of the aircraft. Prerequisite(s): AE 415. Pre- or corequisite(s): AE 424.

AE 524. Aerodynamics II (3).
Continues the discussion of potential flow from AE 424. Introduces energy equation, fundamental concepts of high speed flow, normal and oblique shock waves, Prandtl-Meyer flow, nozzles and diffusers, linearized high speed potential flow, airfoils and wings in subsonic and supersonic flow, Navier-Stokes equation, boundary layer flow, momentum integral approximation and various laminar and turbulent flow solutions, introduction to convective heat transfer. Prerequisite(s): AE 424 and ME 398.

AE 525. Flight Structures I (3).
Introduces the theory of elasticity, advanced mechanics of materials, and stress analysis of flight vehicle components. APEN 334 will not meet the prerequisite for this course. Prerequisite(s): AE 333 (no grade lower than one that generates 2.000 or more credit points per credit hour will be accepted for this course). Pre- or corequisite(s): MATH 555. Corequisite(s): AE 525L.

AE 527. Numerical Methods in Engineering (3).
Error analysis. Includes polynomial approximations and power series, iterative solutions of equations, matrices and systems of linear equations, numerical differentiation and integration, approximate solution of differential equations by finite differences. Prerequisite(s): AE 227. Pre- or corequisite(s): MATH 555.

AE 528. Aerospace Design I (4).
Methodology of flight vehicle design; mission objectives, regulations and standards; use of hand and computer methods for configuration development and component sizing, ethics, and liability in design. This course has a lab component. For undergraduate credit only. Prerequisite(s): AE 424, AE 502, AE 514 and AE 525. Pre- or corequisite(s): PHIL 385 and either ECON 201 or ECON 202 or IME 255.

AE 607. Flight Control Systems (3).
Classical design methods for stability and control augmentation and guidance systems specifically for aerospace vehicles, including block diagrams, root locus and frequency response. Sensors used in aerospace systems. Flying qualities and performance specifications for closed loop systems. Includes a review of the aircraft and spacecraft dynamic model derivation. Prerequisite(s): AE 514.

AE 625. Flight Structures II (3).
Strength analysis and design of flight vehicle components. Introduces energy methods and variational principles. Applies finite element method, including commercial finite element software, to the analysis of flight vehicle structures. Prerequisite(s): AE 525. Corequisite(s): AE 625L.

AE 628. Aerospace Design II (4).
Preliminary design of flight vehicles, design iteration, sensitivity studies, optimization, economic considerations and introduction to project management. This course has a lab component. For undergraduate credit only. Prerequisite(s): AE 528, PHIL 385 and either ECON 201 or ECON 202 or IME 255.

AE 660. Selected Topics (1-3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 660A, 660B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): instructor's consent.

AE 690. Independent Study (1-3).
Arranged individual independent study in specialized areas of aerospace engineering under the supervision of a faculty member. Repeatable for credit. Prerequisite(s): consent of supervising faculty member.

AE 703. Rotor Aerodynamics (3).
Aerodynamics of rotors, including propellers, wind turbines and helicopters; momentum, blade element and potential flow analysis methods; helicopter dynamics, control and performance. Prerequisite(s): AE 424.

AE 707. Modern Flight Control System Design I (3).
Modern multi-loop design methods for stability and control augmentation and guidance systems, specifically for aerospace vehicles. State variable model. Optimal state feedback gains and Riccati's equation, tracking systems, sensors and actuator, discretization of continuous dynamic systems, optimal design for digital controls, and effect of nonlinearities and trim conditions on design considerations. Prerequisite(s): AE 514 or 714, and AE 607 or ECE 684 or ME 659.

AE 711. Intermediate Aerodynamics (3).
Studies potential flow equations of motion, singularity solutions, principles of superposition, conformal mapping, thin airfoil theory, finite wing theory, three-dimensional singularities, swept wing theory, delta wing theory, and introduces panel methods. Prerequisite(s): AE 424 or equivalent.

AE 712. Advanced Aerodynamics Laboratory (3).
Advanced topics in wind tunnel testing, such as analysis and sensitivity, modeling techniques, flexure design and calibration, control surface loads and moments, laser velocimetry, hot film anemometry, dynamic signal processing, flow measurement probes, flow visualization using smoke tunnels and water tunnel. Prerequisite(s): AE 512.

AE 714. Advanced Flight Dynamics I (3).
Detailed derivation of the linear and nonlinear equations of motion for aircraft. Aerodynamic and thrust force and moment models. Steady state flight and dynamic stability and control of aircraft. Aircraft, FAR and MIL specs. Prerequisite(s): AE 514.

AE 715. Intermediate Space Dynamics (3).
Advanced topics in orbital mechanics-vector mechanics perspective of the two-body problem; fast transfers; interplanetary missions including

gravity assist maneuver and intercept problem; atmospheric entry. Prerequisite(s): AE 415 or instructor's consent.

AE 716. Compressible Fluid Flow (3).
Analyzes compressible fluid flow for one- and two-dimensional cases, unsteady wave motion, velocity potential equation, method of characteristics, linearized velocity potential equation, aerodynamic coefficients, approximate pressure calculation for hypersonic flows, Newtonian pressure, and chemically reacting flows. Prerequisite(s): AE 524.

AE 718. Nano-Satellite Engineering (3).
Provides a fundamental understanding of the design of a nano-satellite and mission design catering to given mission requirements. Covers nano-satellite mission analysis, attitude control, electrical power systems, propulsion subsystem, thermal system, telemetry, data handling/processing and systems engineering tests. Includes hands-on experimentation using nano-satellite educational kits. This course has a lab component. Prerequisite(s): AE 415 or AE 715 or a similar course in orbital mechanics . Pre- or corequisite(s): AE 607 or a similar control course.

AE 719. Introduction to Computational Fluid Dynamics (3).
Classification of partial differential equations, numerical solution of parabolic, elliptic and hyperbolic differential equations, stability analysis, boundary conditions, scalar representation of the Navier-Stokes equations, incompressible Navier-Stokes equations. Prerequisite(s): AE 424 or ME 521.

AE 721. Aircraft Icing (3).
Topics include the icing environment, icing envelopes, ice accretion physics, fundamental equations for icing analysis, types of ice accretions, effects of ice accretions on aircraft aerodynamic performance, ice protection and detection systems, icing test facilities, introduces simulation tools for aircraft icing analysis, icing incidents and accidents, and aspects of aircraft icing certification. Corequisite(s): AE 424 or equivalent.

AE 722. Finite Element Analysis of Structures I (3).
Advanced treatment of the theoretical concepts and principles necessary for the application of the finite element method in the solution of differential equations in engineering. Prerequisite(s): AE 525 or AE 733.

AE 731. Theory of Elasticity (3).
Develops the equations of the theory of elasticity and uses them to determine stress and displacement fields in linear elastic isotropic bodies; uses Airy stress functions to obtain solutions. Prerequisite(s): AE 525 or AE 733.

AE 733. Advanced Mechanics of Materials (3).
Extension of AE 333. Includes transformation of stress and strain in three dimensions, torsion of members with noncircular cross sections, curved beams, beams with unsymmetrical cross sections, energy methods, stress concentrations, and theories of failure and fracture mechanics. Prerequisite(s): AE 333.

AE 737. Mechanics of Damage Tolerance (3).
Introduces fatigue analysis and mechanics of damage tolerance emphasizing stress analysis oriented fracture mechanics. Includes stress intensity, fracture toughness, residual strength, fatigue crack growth rate, fatigue crack propagation, and damage tolerance concepts. Prerequisite(s): AE 525 or AE 733.

AE 742. Applied Aeronautical Propulsion (3).
In-depth overview of jet propulsion. Effect of operating variables on turbojet and modified engine cycles. Introduces real world issues and engine testing. Prerequisite(s): AE 502 or instructor's consent.

AE 743. Applied Jet Propulsion Subsystems (3).
In-depth study of jet engine components. Introduces engine component manufacturing, maintenance and repair issues. Prerequisite(s): AE 502 or instructor's consent.

AE 744. Structural Acoustics (3).
Introduces the basic concepts of engineering acoustical analysis to study sound wave propagation, sound radiation from simple sources, absorption and transmission of acoustic waves through partitions and its implications for aircraft liners, duct acoustics, aircraft noise sources, and control techniques. Prerequisite(s): MATH 555 and AE 333 or equivalent; or instructor's consent.

AE 753. Mechanics of Laminated Composites (3).
Descriptive classification of advanced composite materials and their constituents; mechanics of lamina and laminates, testing for material properties, lamina and laminate failure criteria, laminate strain allowables, structural analysis (beams and axially loaded members), design guidelines, introduction to manufacturing methods, repair and nondestructive testing. Prerequisite(s): AE 525, or AE 733, or equivalent.

AE 759. Neural Networks for System Modeling and Control (3).
Introduces specific neural network architectures used for dynamic system modeling and intelligent control. Includes theory of feed-forward, recurrent, and Hopfield networks; applications in robotics, aircraft and vehicle guidance, chemical processes and optimal control. Prerequisite(s): AE 607 or ME 659 or ECE 684 or instructor's consent.

AE 760. Selected Topics (1-3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 760A, 760B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): instructor's consent.

AE 760AA. Micromechanics and Multi-Scale Modeling (3).
Many materials and structures consist of multiple phases. Micromechanics models can be used to homogenize a structure at some appropriate scale for more practical modeling. Course covers the classical mean-field homogenization models. Explores several state-of-the-art numerical techniques used in micromechanics modeling, such as the method of cells, variational methods and Fourier transforms in addition to finite element techniques for periodicity.

AE 760AG. Structural Dynamics and Acoustics (3).
Studies the dynamic response of continuous structural systems subjected to external dynamic forcing functions. Introduces the basic concepts of engineering acoustical analysis to study sound propagation in a medium, acoustic radiation from simple sources, and absorption and transmission of acoustic waves through partitions. Prerequisite(s): AE 777, MATH 555 or equivalent.

AE 760AL. Nonthesis Option Applied Learning Activity (0).
Applied learning activity for the nonthesis/nonproject option student in the MS degree in aerospace engineering. Prerequisite(s): instructor's consent.

AE 762. Airframe Analysis and Design (3).
Covers the analysis and design methods for semi-monocoque airframe structures under combined bending, twisting, transverse shear and pressurization loads. Emphasis is on details such as taper, cut-outs, joints, shear lag, buckling, etc. Prerequisite(s): AE 525 or AE 733 or instructor's consent.

AE 765. Special Topics: Composite Manufacturing (0.5).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 765A, 765B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll

in the lettered courses with specific topics in the titles rather than in this root course.

AE 765A. Special Topics - Composite Manufacturing: Technology Safety Awareness I (0.5).
Provides composite materials technologies basic knowledge, an overview of different forms of composites manufacturing, various factory workflows, and the associated regulatory guidance documents. For graduate students only. Repeatable for credit.

AE 765B. Special Topics - Composite Manufacturing: Technology Safety Awareness II (0.5).
Educates students on the issues related to raw material manufacturing, its transport, incoming quality control and storage of composite materials. The preparation of tooling, cutting of composite preforms, layup and bagging of composite parts, and curing are discussed in detail. The use of procurement specifications and process control documents are emphasized. For graduate students only. Repeatable for credit. Prerequisite(s): AE 765A.

AE 765C. Special Topics - Composite Manufacturing: Technology Safety Awareness III (0.5).
Topics include technical aspects related to trimming and drilling of composites, defects in composites, adhesive bonding and assembly, nondestructive and destructive inspection. For graduate students only. Repeatable for credit. Prerequisite(s): AE 765B.

AE 765D. Special Topics - Composite Manufacturing: Technology Safety Awareness IV (0.5).
Topics include technical aspects related to painting and finishing composites, handling and storage, manufacturing defects and their root causes analyses, and scarf repair of composites. For graduate students only. Repeatable for credit. Prerequisite(s): AE 765C.

AE 765E. Special Topics - Composite Manufacturing: Technology Safety Awareness V (0.5).
Lab course providing students with hands-on experiences on prepreg cutting, manual layup and bagging of simple laminated composite parts, nondestructive inspection, and scarf repair. For graduate students only. Repeatable for credit. Prerequisite(s): AE 765D.

AE 765F. Composite Structural Engineering Technology-0 (0.5).
Provides students with background knowledge related to composite material applications, materials, processes, manufacturing, structural design, proof of structures, maintenance, aeroelastic issues, crashworthiness, fire safety and lightening protection. Course serves as a foundation course for the follow-on courses which elaborate on the aforementioned topics. Repeatable for credit. Prerequisite(s): instructor's consent.

AE 765G. Composite Structural Engineering Technology-1 (0.5).
Provides a historical overview of composites usage in aircraft structures; discusses the key technical characteristics of composite structures; composites safety and certification initiatives by FAA; issues affecting cost of incorporating composites; role of standards organizations; some evolving composite technologies; evolution and objectives of integrated product teams. Repeatable for credit. Pre- or corequisite(s): AE 765F.

AE 765I. Composite Structural Engineering Technology-2 (1).
The topics covered include control of composite materials and the processes used to fabricate airframe parts, material specifications, related FAA regulations and guidance materials, common processing defects and damage, protection of structures, manufacturing implementation, and maintenance considerations. Repeatable for credit. Prerequisite(s): AE 765G.

AE 765J. Composite Structural Engineering Technology-3 (1).
The topics covered in this course include structural design details, design considerations for manufacturing and maintenance, design requirements, criteria and objectives, lamination theory and design, composite analysis methods, composite material allowables, design values and knockdown factors, structural bonding, and structural bolted joints. Repeatable for credit. Prerequisite(s): AE 765I, AE 753.

AE 765K. Composite Structural Engineering Technology-4 (1).
Provides detailed information on the structural substantiation of composite airframes and their sub-components. The topics covered include FAA regulations and guidance for proof of structures, certification approaches and related considerations, addressing damage and defects, building block testing and analysis, and additional considerations for large scale testing. Repeatable for credit. Prerequisite(s): AE 765J, AE 753.

AE 765M. Composite Structural Engineering Technology-5 (0.5).
Provides detailed information on the manufacturing and maintenance interfaces for the composite airframes. The topics covered include quality control, certification conformity process, manufacturing defect disposition, inspection and maintenance, structural repair development and substantiation, teamwork, and repair techniques. Repeatable for credit. Prerequisite(s): AE 765K, AE 753.

AE 765N. Composite Structural Engineering Technology-6 (0.5).
Provides detailed information on the basic principles, regulations, guidance materials and compliance methodologies related to flutter, crashworthiness, fire safety and lightning protection. Repeatable for credit. Prerequisite(s): AE 765M, AE 753.

AE 765P. Composites Structural Integrity and Repair (0.75).
Exposes students to various aspects of composite manufacturing, inspections, repair and testing. Includes fabrication of monolithic and sandwich panels, joining composites with adhesive bonding, inspecting composites with various nondestructive techniques, machining and hole drilling repair of composite structures (monolithic and honeycomb), instrumentation of composite test articles, and various aspects of mechanical testing of composite structures. Designed as a supplemental course for composite theory classes, thus lab time is maximized so that the students get hands-on experience. Prerequisite(s): instructor's consent.

AE 765Q. Structural Integrity and Repair of Metallic Airframe Structures (0.75).
Provides students with hands-on experience in the structural testing and evaluation of stiffened metallic panels. Students learn the hole drilling methods and use a CNC machine to drill holes and assemble a stiffened picture frame shear specimen. The hands-on experience includes nondestructive inspection of damaged stiffened panels using eddy current, mag. particles, dye penetrant, pulse thermography and X-ray methods. Students install strain gages and crack gages on picture frame shear test article which is tested on a servo hydraulic testing machine. Students are exposed to the basic principles of testing, analysis of test data, and failure analysis using SEM and optical microscope. Prerequisite(s): instructor's consent.

AE 770. Badge: Aerospace Engineering Topics (0.5).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 770A, 770B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course.

AE 770BA. Badge: Composite Manufacturing Technology Safety Awareness I (0.5).
Students are provided with composite materials technologies basic knowledge, an overview of different forms of composites

manufacturing, various factory workflows, and the associated regulatory guidance documents. Graded Bg/NBg.

AE 770BB. Badge: Composite Manufacturing Technology Safety Awareness II (0.5).
Educates students on the issues related to raw material manufacturing, its transport, incoming quality control and storage of composite materials. The preparation of tooling, cutting of composite preforms, layup and bagging of composite parts, and curing are discussed in detail. The use of procurement specifications and process control documents are emphasized. Graded Bg/NBg. Prerequisite(s): AE 770BA.

AE 770BC. Badge: Composite Manufacturing Technology Safety Awareness III (0.5).
Topics include technical aspects related to trimming and drilling of composites, defects in composites, adhesive bonding and assembly, nondestructive and destructive inspection. Graded Bg/NBg. Prerequisite(s): AE 770BB.

AE 770BD. Badge: Composite Manufacturing Technology Safety Awareness IV (0.5).
Topics include technical aspects related to painting and finishing of composites, handling and storage, manufacturing defects and their root cause analysis, and scarf repair of composites. Graded Bg/NBg. Prerequisite(s): AE 770BC.

AE 770BE. Badge: Composite Manufacturing Technology Safety Awareness V (0.5).
Lab course provides students with hands-on experience on prepreg cutting, manual layup and bagging of simple laminated composite parts, nondestructive inspection and scarf repair. Graded Bg/NBg. Prerequisite(s): AE 770BD or instructor’s consent.

AE 770BG. Badge: Composite Structural Engineering Technology-0 (0.5).
Provides students with background knowledge related to composite material applications, materials, processes, manufacturing, structural design, proof of structures, maintenance, aeroelastic issues, crashworthiness, fire safety and lightening protection. Course serves as a foundation course for the follow-on courses which elaborate on the aforementioned topics. Graded Bg/NBg. Prerequisite(s): instructor’s consent.

AE 770BI. Badge: Composite Structural Engineering Technology-1 (0.5).
Historical overview of composites usage in aircraft structures; discusses the key technical characteristics of composite structures; composites safety and certification initiatives by FAA; issues affecting cost of incorporating composites; role of standards organizations; some evolving composite technologies; evolution and objectives of integrated product teams. Graded Bg/NBg. Pre- or corequisite(s): AE 770BG.

AE 770BJ. Badge: Composite Structural Engineering Technology-2 (1).
The topics covered in this course include control of composite materials and the processes used to fabricate airframe parts, material specifications, related FAA regulations and guidance materials, common processing defects and damage, protection of structures, manufacturing implementation, and maintenance considerations. Repeatable for credit. Graded Bg/NBg. Prerequisite(s): AE 770BI.

AE 770BK. Badge: Composite Structural Engineering Technology-3 (1).
The topics covered in this course include structural design details, design considerations for manufacturing and maintenance, design requirements, criteria and objectives, lamination theory and design, composite analysis methods, composite material allowables, design values and knockdown factors, structural bonding, and structural bolted joints. Repeatable for credit. Graded Bg/NBg. Prerequisite(s): AE 770BJ.

AE 770BM. Badge: Composite Structural Engineering Technology-4 (1).
Provides detailed information on the structural substantiation of composite airframes and their sub-components. The topics covered include FAA regulations and guidance for proof of structures, certification approaches and related considerations, addressing damage and defects, building block testing and analysis, and additional considerations for large scale testing. Repeatable for credit. Graded Bg/NBg. Prerequisite(s): AE 770BK.

AE 770BN. Badge: Composite Structural Engineering Technology-5 (0.5).
Provides detailed information on the manufacturing and maintenance interfaces for the composite airframes. The topics covered include quality control, certification conformity process, manufacturing defect disposition, inspection and maintenance, structural repair development and substantiation, teamwork, and repair techniques. Repeatable for credit. Graded Bg/NBg. Prerequisite(s): AE 770BM.

AE 770BO. Badge: Composite Structural Engineering Technology-6 (0.5).
Provides detailed information on the basic principles, regulations, guidance materials and compliance methodologies related to flutter, crashworthiness, fire safety and lightning protection. Graded Bg/NBg. Prerequisite(s): AE 770BN.

AE 773. Intermediate Dynamics (3).
Extension of AE 373. Studies the kinematics and kinetics of particles and rigid bodies for two- and three-dimensional motion. Includes an introduction to vibratory motion, dynamic stability of linear systems and Lagrange's equations. Prerequisite(s): AE 373.

AE 777. Vibration Analysis (3).
Studies free, forced, damped and undamped vibrations on multi-degree of freedom discrete mechanical systems. Introduces vibration analysis of continuous solids. Prerequisite(s): MATH 555, AE 333, 373.

AE 801. Structural Dynamics (3).
Studies the dynamic response of multiple degree of freedom systems and continuous systems subjected to external dynamic forcing functions. Classical, numerical and energy solutions, and introduces experimental techniques. Prerequisite(s): AE 525 or AE 733, and AE 777.

AE 807. Modern Flight Control Systems Design II (3).
Principles of optimal control, optimal spacecraft trajectories including high-thrust and low-thrust transfers, optimization of powered and unpowered atmospheric flights, numerical methods including both direct and indirect optimization schemes, trajectory optimization for multi-air and space vehicle systems. Prerequisite(s): AE 707 and at least one of AE 714 or AE 715.

AE 812. Aerodynamics of Viscous Fluids (3).
Viscous fluids flow theory and boundary layers. Prerequisite(s): AE 424 or ME 521.

AE 813. Intro to Aeroelasticity (3).
Studies phenomena involving interactions among aerodynamic, inertial and elastic forces. Explores the influence of these interactions on aircraft design. Includes such specific cases as divergence, control effectiveness, control reversal, flutter, buffeting, dynamic response to rapidly applied periodic forces, aeroelastic effects on load distribution, and static and dynamic stability. Prerequisite(s): AE 777 or MATH 757, or instructor's consent and programming proficiency.

AE 814. Advanced Flight Dynamics II (3).
Sensitivity analyses of flight parameters, control surface sizing, handling qualities, pilot in-the-loop analysis, trajectory optimization. Prerequisite(s): AE 714.

AE 818. Hypersonic Aerodynamics (3).
Covers classical hypersonic theory and approximations, Newtonian flow, aerodynamic forces and moments, flight corridors and trajectories, hot gas effects, various modes of energy, chemically reacting flows, heat transfer rates, and stagnation point heating. Prerequisite(s): AE 711, AE 716 or equivalent.

AE 822. Finite Element Analysis of Structures II (3).
Formulation of the finite element equations by variational methods; the use of isoparametric and higher order elements for analyzing two- and three-dimensional problems in solid mechanics; introduces solutions of nonlinear problems. Prerequisite(s): AE 722.

AE 829. Compressible Turbulence Modeling for Aerodynamic Applications (3).
Reviews the mathematics and physics of turbulence to create a solid background in the field mainly focusing on external boundary layers and shear flows related to the aerodynamics bodies in which compressibility effects are important. This course then continues with the concepts and analytical tools needed in using and developing turbulent models and turbulent simulation methods including Reynolds Average Navier-Stokes (RANS), Large Eddy Simulation (LES) and Direct Numerical Simulation (DNS). The focus is again on compressible flows and thus, for each method, the description of how the compressibility effects should be considered is described in detail. In the last part of the course, students are introduced to applying each of these models for numerical simulation of shock wave boundary layer interaction. The pros and cons of each method are examined in detail. Prerequisite(s): AE 524 and (MATH 757 or MATH 755); or instructor's consent.

AE 831. Continuum Mechanics (3).
Introductory treatment of the fundamental, unifying concepts of the mechanics of continua with applications to classical solid and fluid mechanics. Prerequisite(s): AE 731 or equivalent.

AE 832. Theory of Plates And Shells (3).
Analyzes the deformation of thin elastic plates, classical solutions for rectangular and circular plates, approximate solutions for plates of various shapes, introduces the analysis of thin shells. Prerequisite(s): MATH 757, AE 731.

AE 833. Theory of Elastic Stability (3).
Buckling of columns, frames, beams, plates and shells. Prerequisite(s): AE 731.

AE 837. Advanced Mechanics of Damage Tolerance (3).
Extension of AE 737. Includes the development of the mathematical foundations of linear elastic and plastic fracture mechanics, and computational fracture mechanics. Prerequisite(s): AE 731, 737, or equivalent.

AE 853. Advanced Mechanics of Laminated Composites (3).
Extension of AE 753. Includes anisotropic elasticity, micromechanics models for stiffness and strength, classical laminate and first order shear deformation theories, free-edge effects, failure theories, lateral deflections, analysis of notched laminates and sandwich structures. Prerequisite(s): AE 731, 753, MATH 758.

AE 860. Selected Topics (1-3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 860A, 860B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): instructor's consent.

AE 876. Thesis (1-6).
Student-driven research experience to address a specific research question. Potential topics should be formulated by the student and discussed with their advisor. Repeatable for credit.

AE 877. Experimental Vibration Analysis (3).
Covers all basic aspects of experimental vibration analysis including modal analysis theory, digital signal processing and experimental modal model development. Includes hands-on vibration testing labs and a basic overview of finite element modeling of dynamic systems and model correlation. Prerequisite(s): AE 777, AE 333 or equivalent, MATH 511 or equivalent, and MATH 555 or equivalent.

AE 878. MS Directed Project (1-3).
Project conducted under the supervision of an academic advisor for the directed project option. Requires a written report and an oral presentation on the project. Repeatable for credit. Prerequisite(s): academic advisor's consent.

AE 890. Independent Study (1-3).
Arranged individual independent study in specialized areas of aerospace engineering under the supervision of a faculty member. Repeatable for credit. Prerequisite(s): consent of supervising faculty member.

AE 911. Airfoil Design (3).
Historical development of airfoils, underlying theories and experiments, modern airfoil design philosophies and techniques, theories used in modern airfoil computation methods, application of computer programs for practical airfoil design problems including high lift and control devices. Prerequisite(s): AE 711, MATH 757.

AE 919. Advanced Computational Fluid Dynamics (3).
Studies structured grid generation schemes, transformation of the governing equations of fluid motion, numerical algorithms for the solution of Euler equations, parabolized Navier-Stokes equations, and Navier-Stokes equations. Explores the fundamentals of unstructured grids and finite volume schemes. Prerequisite(s): AE 719.

AE 936. Theory of Plasticity (3).
Includes criteria of yielding, plastic stress-strain relationships; stress and deformation in thick-walled shells, rotating discs and cylinders, bending and torsion of prismatic bars for ideally plastic and strain-hardening materials. Includes two-dimension and axially symmetric problems of finite deformation and variational and extremum principles. Prerequisite(s): AE 731.

AE 960. Advanced Selected Topics (1-3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 960A, 960B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): instructor's consent.

AE 976. PhD Dissertation (1-16).
Student-driven research experience to address a specific research question. Potential topics should be formulated by the student and discussed with their advisor. Repeatable for credit. Prerequisite(s): admission to doctoral aspirant status.

AE 990. Advanced Independent Studies (1-3).
Arranged individual independent study in specialized content areas under the supervision of a faculty member. Prerequisite(s): instructor's consent.