Mechanical and Aerospace Engineering

The Department of Mechanical and Aerospace Engineering (MAE) offers baccalaureate, masters and doctoral degree programs in Mechanical Engineering and Aerospace Engineering, and Certificate Programs in Automotive Engineering, Electronic Packaging, and Unmanned Vehicle Systems. The Mechanical and Aerospace Engineering programs have been accredited since 1967 and 1968, respectively, by the Engineering Accreditation Commission of ABET, http://www.abet.org. Major focus areas within the Department include Design, Manufacturing and Multidisciplinary Optimization; Dynamic Systems and Controls; Fluid Mechanics, Aerodynamics and Propulsion; Structural Mechanics and Structural Optimization; and Thermal Sciences and Energy Systems.

Undergraduate (http://catalog.uta.edu/engineering/mechanical/undergraduate/)

- Bachelor of Science in Aerospace Engineering
- Bachelor of Science in Mechanical Engineering
- Double Major in Mechanical and Aerospace Engineering
- Minor in Aerospace Engineering
- Minor in Mechanical Engineering
- Undergraduate Certificate in Automotive Engineering
- Undergraduate Certificate in Unmanned Vehicle Systems

Graduate (http://catalog.uta.edu/engineering/mechanical/graduate/)

- Aerospace Engineering, M.Engr.
- Aerospace Engineering, M.S.
- Mechanical Engineering, M.Engr.
- Mechanical Engineering, M.S.
- Aerospace Engineering, B.S. to Ph.D.
- Aerospace Engineering, Ph.D.
- Mechanical Engineering, B.S. to Ph.D.
- Mechanical Engineering, Ph.D.
- Graduate Certificate in Automotive Engineering
- Graduate Certificate in Electronic Packaging
- Graduate Certificate in Manufacturing
- Graduate Certificate in Unmanned Vehicle Systems
- Graduate Certificate in Vertical Lift/Rotorcraft

COURSES

AE 5100. PREPARATORY COURSE FOR AEROSPACE ENGINEERING. 1 Hour.
The course may be offered with multiple sections, wherein each section is paired with a corresponding UG course being offered that semester. The purpose of this course is to strengthen academic preparation of students who were found inadequately prepared for a graduate degree in Aerospace Engineering. Students can concurrently enroll in multiple sections and may need to enroll in this course multiple times until their academic preparation is deemed complete. In order to pass this class, the student has to earn at least a B grade in aggregate based on all the assignments and exams. The student will earn an R grade if the class aggregate is a C/D and will need to repeat the course until the student passes the class. The student will Fail the class if the aggregate is an F. The course may be repeated as often as required.

AE 5101. GRADUATE SEMINAR. 1 Hour.
The purpose is to acquaint graduate students with ongoing research at UTA, and outside in academia and industry. Seminars are given by graduate students of the department based on their ongoing research. Seminars are also given by external speakers from academia, industry and government.

AE 5191. ADVANCED STUDIES IN AEROSPACE ENGINEERING. 1 Hour.
Individual research or design project performed for fulfilling the requirements of the Master of Engineering degree option. Prior approval of the AE Graduate Advisor is required for enrollment. A written and/or oral report is required.

AE 5197. RESEARCH IN AEROSPACE ENGINEERING. 1 Hour.
Research in masters programs.

AE 5200. PREPARATORY COURSE FOR AEROSPACE ENGINEERING. 2 Hours.
The course may be offered with multiple sections, wherein each section is paired with a corresponding UG course being offered that semester. The purpose of this course is to strengthen academic preparation of students who were found inadequately prepared for a graduate degree in Aerospace Engineering. Students can concurrently enroll in multiple sections and may need to enroll in this course multiple times until their academic preparation is deemed complete. In order to pass this class, the student has to earn at least a B grade in aggregate based on all the assignments and exams. The student will earn an R grade if the class aggregate is a C/D and will need to repeat the course until the student passes the class. The student will Fail the class if the aggregate is an F. The course may be repeated as often as required.

AE 5291. ADVANCED STUDIES IN AEROSPACE ENGINEERING. 2 Hours.
Individual research or design project performed for fulfilling the requirements of the Master of Engineering degree option. Prior approval of the AE Graduate Advisor is required for enrollment. A written and/or oral report is required.

AE 5297. RESEARCH IN AEROSPACE ENGINEERING. 2 Hours.
Research in masters programs.

AE 5300. PREPARATORY COURSE FOR AEROSPACE ENGINEERING. 3 Hours.
The course may be offered with multiple sections, wherein each section is paired with a corresponding UG course being offered that semester. The purpose of this course is to strengthen academic preparation of students who were found inadequately prepared for a graduate degree in Aerospace Engineering. Students can concurrently enroll in multiple sections and may need to enroll in this course multiple times until their academic preparation is deemed complete. In order to pass this class, the student has to earn at least a B grade in aggregate based on all the assignments and exams. The student will earn an R grade if the class aggregate is a C/D and will need to repeat the course until the student passes the class. The student will Fail the class if the aggregate is an F. The course may be repeated as often as required.

AE 5301. ADVANCED TOPICS IN AEROSPACE ENGINEERING. 3 Hours.
To provide formal instruction in special topics pertinent to Aerospace Engineering from semester to semester depending on the availability of faculty. May be repeated for credit as provided topics change.

AE 5302. ADVANCED FLIGHT MECHANICS. 3 Hours.
Rigid body motion. Kinematics and dynamics of aerospace vehicles. Linear and nonlinear control of aircraft and spacecraft. Advanced aircraft and spacecraft modeling and control issues. Prerequisite: MAE 3405 and MAE 4310.

AE 5303. CLASSICAL METHODS OF CONTROL SYSTEMS ANALYSIS AND SYNTHESIS. 3 Hours.
Equip the student with familiarity of significant tools of the control engineer. Topics covered include controllers and their effect on system performance and stability, block diagram algebra, stability and analysis, system performance definition, root locus, frequency techniques, and state variable methods. Digital simulation tools for design and simulation of control systems. Demonstration of controller design and performance in the laboratory. Also offered as ME 5303.

AE 5305. DYNAMIC SYSTEMS MODELING. 3 Hours.
To equip the student with the capability of determining the necessary equations for distributed and lumped parameter modeling of mixed physical system types including mechanical, fluid, electrical, and thermal components. Models are formulated for computer simulation and analysis for systems with deterministic and stochastic inputs. Topics of random vibration and system identification are included. Offered as AE 5305 and ME 5305. Credit will be granted only once.

AE 5310. FINITE ELEMENT METHODS. 3 Hours.
Finite element method in the study of the static response of complex structures and of continua applications to field problems; analytical methods emphasized and digital computer application undertaken. Offered as AE 5310 and ME 5310. Credit will be granted only once.

AE 5311. STRUCTURAL DYNAMICS. 3 Hours.
Natural frequencies; forced response of complex structural systems studied through the use of the finite element method; computational aspects of these problems discussed, and digital computer applications undertaken. Offered as AE 5311 and ME 5311. Credit will be granted only once.

AE 5312. CONTINUUM MECHANICS. 3 Hours.
Study of the underlying physical and mathematical principles relating to the behavior of continuous media; interrelationships between fluid and solid mechanics. Offered as AE 5312 and ME 5312. Credit will be granted only once.

AE 5313. FLUID DYNAMICS. 3 Hours.
Basic conservation laws, flow kinematics, special forms of the governing equations, two-dimensional potential flows, surface waves and some exact solutions of viscous incompressible flows. Offered as AE 5313 and ME 5313. Credit will be granted only once.

AE 5315. FUNDAMENTALS OF COMPOSITES. 3 Hours.
This fundamental course will introduce students to mechanics of composites at various scales, including analysis, characterization, and manufacturing methods. Emphasis is on constitutive relations; mechanical and hygrothermal behavior; stress analysis; and simple applications. Offered as AE 5315 and ME 5315. Credit will be granted only once.

AE 5320. DESIGN OPTIMIZATION. 3 Hours.
The purpose of this course is to present modern concepts of optimal design of structures. Basic ideas from optimization theory are developed with simple design examples. Analytical and numerical methods are developed and their applications discussed. Use of numerical simulation methods in the design process is described. Concepts of structural design sensitivity analysis and approximation methods will be discussed. The emphasis is made on the application of modern optimization techniques linked to the numerical methods of structural analysis, particularly, the finite element method. Prerequisite: AE 5310 or ME 5310.

AE 5322. AEROELASTICITY. 3 Hours.
A fundamental course addressing phenomena related to the time-independent interactions between structural flexibility and aerodynamic loads as relevant to flying vehicles. Emphasis is placed upon the development and use of simple analytical and/or interactive computational models that capture the essential aspects of the static aeroelastic phenomena investigated and provide insight into the response, including i) aeroelastic divergence; ii) aeroelastic change in control effectiveness; iii) aeroelastic distribution of lift; and iv) aeroelastic change in longitudinal static stability.

AE 5323. ENGINEERING RESEARCH METHODS. 3 Hours.
This hands-on course will teach the tools that are essential for conducting graduate research, with an aim to prepare the students for project-based graduate research. The course will be focused on the integration of engineering concepts to complete course projects that imitate mini research projects. Prerequisite: Undergraduate education in engineering or science.

AE 5325. COMBUSTION. 3 Hours.
Fundamental treatment of problems involving simultaneous occurrence of chemical reaction and transfer of heat, mass and momentum. Topics include kinetically controlled combustion phenomena; diffusion flames in liquid fuel combustion; combustion of solids; combustion of gaseous fuel jets; flames in premixed gasses. Offered as AE 5325 and ME 5325. Credit will be granted only once.

AE 5326. AIR-BREATHING PROPULSION. 3 Hours.
Development of thrust and efficiency equations, thermodynamic cycle analysis, cycle design methods of aerospace propulsion systems, component performance analysis methods, component matching and dynamic interactions, and vehicle/propulsion-system integration.

AE 5327. COMPUTATIONAL AERODYNAMICS I. 3 Hours.
Solution of engineering problems by finite-difference methods, emphasis on aerodynamic problems characterized by single linear and non-linear equations, introduction to and application of major algorithms used in solving aerodynamics problems by computational methods.

AE 5328. COMPUTATIONAL AERODYNAMICS II. 3 Hours.
Review of the fundamental equations of aerodynamics, development of methods for solving Euler, boundary-layer, Navier-Stokes, and parabolized Navier-Stokes equations, application to practical aerodynamic analysis and design problems.

AE 5329. ADDITIVE MANUFACTURING. 3 Hours.
The range of technologies and processes, both physical and digital, used to translate virtual solid model data into physical models using additive layering methods. Emphasis is given to application of these technologies to manufacture end use components and assemblies but rapid prototyping is also discussed. Metal, polymer, ceramic, and composite material applications of additive manufacturing are included. Discussion includes advantages and limitations of additive methods with respect to subtractive methods and to each other. Principles of design for additive manufacturing are covered along with discussion of applications. Students complete a project to design and build an engineering component or assembly for additive manufacturing. Offered as AE 5329 and ME 5329. Credit will be granted only once. Prerequisite: Graduate standing.

AE 5331. ANALYTIC METHODS IN ENGINEERING. 3 Hours.
Introduction to advanced analytic methods in engineering. Methods include multivariable calculus and field theory, Fourier series, Fourier and Laplace Transforms. Offered as AE 5331 and ME 5331. Credit will be granted only once. Prerequisite: Undergraduate degree in engineering, physics, or mathematics.

AE 5332. ENGINEERING ANALYSIS. 3 Hours.
Introduction to partial differential equations and complex variable theory with application to modeling of physical systems. Offered as AE 5332 and ME 5332. Credit will be granted only once.

AE 5333. THERMAL PHENOMENA IN MICROSYSTEMS. 3 Hours.
Introduction to experimental methods for microscale thermal transport, including experimental measurement techniques, design of experiments, data acquisition and analysis tools. Significant emphasis on carrying out mini-projects on related topics. Course learning outcomes are directly relevant for engineering jobs in semiconductors, energy conversion and other related industries. Offered as AE 5333 and ME 5333. Credit will be granted only once.

AE 5335. OPTIMAL CONTROL OF DYNAMIC SYS. 3 Hours.
Linear and nonlinear optimization methods; optimal control; continuous time Ricatti equation; bang-bang control; singular arcs; differential inclusions; collocation techniques; design of optimal dynamic system trajectories. Offered as AE 5335 and ME 5335. Credit will be granted only once.

AE 5336. OPTIMAL ESTIMATION OF DYNAMIC SYSTEMS. 3 Hours.
Kalman filter design and implementation. Optimal filtering for discrete-time and continuous-time dynamical systems with noise. Wiener filtering. State-space determination. Offered as EE 6327, AE 5336 and ME 5336. Credit will be granted only once. Prerequisite: Prior introductory systems or identification course is desirable.

AE 5337. INTRODUCTION TO ROBOTICS. 3 Hours.
An overview of industrial robots and their application to traditional and emerging applications. Coordinate systems and homogeneous transformations, kinematics of manipulators; motion characteristics and trajectories; dynamics and control of manipulators; actuation and design issues. Programming of industrial robotic manipulators in the laboratory. Offered as AE 5337 and ME 5337. Credit will be granted only once.

AE 5338. ANALYTICAL & COMPUTATIONAL DYNAMICS. 3 Hours.
The course focuses on developing the equations of motion for dynamic systems composed of multiple, connected and unconnected, rigid bodies using Kane's method and the Lagrangian approach. The resulting model is used to simulate and visualize the predicted motion. Topics include kinematics, Euler parameters, kinematic constraints, virtual work, the calculus of variations, energy, momentum, contact, impact, and checking functions. Offered as AE 5338 and ME 5338. Credit will be granted only once.

AE 5339. INTERMEDIATE MECHANICS OF MATERIALS. 3 Hours.
This fundamental mechanics course covers the concepts of deriving stress formulas from deformation and the stress-strain relationship, stress and failure analysis, 2D elasticity, energy methods, and elastic stability. Offered as AE 5339 and ME 5339. Credit will be granted only once.

AE 5341. CONTROL SYSTEM COMPONENTS. 3 Hours.
The components and hardware used in electronic, hydraulic, and pneumatic control systems; techniques of amplification, computation, compensation, actuation, and sensing; modeling of multiport systems as well as servo systems analysis. Pulse modulated systems. Offered as AE 5341 and ME 5341. Credit will be granted only once. Prerequisite: Undergraduate introductory control course in Mechanical Engineering or equivalent or ME 5303 or equivalent.

AE 5342. GAS DYNAMICS. 3 Hours.
Review of fundamental compressible flow theory, method of characteristics for perfect gases, the Rankine-Hugoniot conditions, linearized flow theory. Offered as AE 5342 and ME 5342. Credit will be granted only once. Prerequisite: MAE 3303 or equivalent.

AE 5345. NUMERICAL HEAT TRANSFER AND FLUID FLOW. 3 Hours.
Introduction to numerical solutions for problems in heat transfer and fluid flow by the finite-volume method. The focus will be on numerical aspects pertaining to incompressible fluids. It provides the background training towards the use of commercial software. Offered as AE 5345 and ME 5345. Credit will be granted only once.

AE 5347. ROCKET PROPULSION. 3 Hours.
Thrust and efficiency relations, trajectory analysis, introduction to design and performance analysis of chemical (liquid and solid), electrical and nuclear rocket systems, combined cycle propulsion systems, and pulse detonation rockets.

AE 5348. HYPERSONIC PROPULSION. 3 Hours.
Design and performance analysis of propulsion systems for sustained flight at hypersonic speeds, airframe/propulsion system integration, supersonic combustion, finite-rate chemistry effects, radiative cooling.

AE 5350. CLASSICAL AERODYNAMICS. 3 Hours.
To present a classical treatment of incompressible and compressible aerodynamics. Kinematics of fluid flow. Potential flow theory applied to non-lifting and lifting wings and bodies. Subsonic and supersonic wings and bodies. Familiarity with advanced engineering mathematics is recommended.

AE 5362. GUIDANCE, NAVIGATION, AND CONTROL OF AEROSPACE VEHICLES. 3 Hours.
Basics of flight dynamics and control. Autopilot structures for aerospace vehicles (aircraft, missiles, launch vehicles). Equilibrium glide trajectories for atmospheric flight. Discussion of the various guidance algorithms used in aircraft/missiles/launch vehicles. Basics of Kalman filtering, sensor and data fusion. Selection and trade-off between various navigation components such as the IMU, GPS and other navigation components. Integration of the guidance, navigation and control components in aerospace vehicles.

AE 5363. INTRODUCTION TO ROTORCRAFT ANALYSIS. 3 Hours.
History of rotorcraft. Behavior of the rotor blade in hover and forward flight. Rotor configurations, dynamic coupling with the fuselage, elastic and aeroelastic effects. Offered as AE 5363 and ME 5363. Credit will be granted only once.

AE 5364. INTRODUCTION TO AERODYNAMICS OF ROTORCRAFT. 3 Hours.
Practical aerodynamics of rotors and other components of rotorcraft. Introduction to performance, handling qualities, and general flight mechanics related to rotorcraft design, test, and certification requirements. Emphasis is on real rotorcraft mission capabilities as defined by the customer. Offered as AE 5364 and ME 5364. Credit will be granted only once.

AE 5365. INTRODUCTION TO HELICOPTER AND TILTROTOR SIMULATION. 3 Hours.
Dynamic and aerodynamic modeling of rotorcraft elements using vector mechanics, linear algebra, calculus and numerical methods. Special emphasis on rotors, aerodynamic interference, proper axis system representation, model assembly methods and trimming. Offered as AE 5365 and ME 5365. Credit will be granted only once.

AE 5367. HIGH-SPEED AIRCRAFT AND SPACE ACCESS VEHICLE DESIGN. 3 Hours.
An introductory course on high-speed aircraft and space access vehicle design. The course concentrates on reusable flight vehicles. Topics covered are historical case studies, design disciplines, design space visualization and proof of design convergence. Prerequisite: consent of the instructor.

AE 5368. FLIGHT VEHICLE SYNTHESIS AND SYSTEMS ENGINEERING. 3 Hours.
An introductory course on multi-disciplinary design decision-making applied to flight vehicle design. The course introduces decision-making techniques leading to efficient aerospace product design. The following main topics are covered: a) management domain, b) operational domain, c) engineering domain. Prerequisite: MAE 4350, MAE 4351 or equivalent.

AE 5372. PARAMETRIC SIZING OF HIGH-SPEED AIRCRAFT. 3 Hours.
An introductory course on high-speed aircraft design. Aimed to develop insight into basic concepts underlining the analysis and design of supersonic and hypersonic aircraft. Topics covered are historical case studies, design disciplines, and design methodologies. Prerequisite: MAE 4350, MAE 4351 or equivalent.

AE 5374. NONLINEAR SYSTEMS ANALYSIS AND CONTROLS. 3 Hours.
Nonlinear systems; phase plane analysis; Poincare-Bendixon theorems; nonlinear system stability; limit cycles and oscillations; center manifold theorem, Lyapunov methods in control; variable structure control; feedback linearization; backstepping techniques. Offered as AE 5374 and ME 5374. Credit will be granted only once.

AE 5378. INTRODUCTION TO UNMANNED VEHICLE SYSTEMS. 3 Hours.
Introduction to UVS (Unmanned Vehicle Systems) such as UAS (Unmanned Aircraft Systems), UGS (Unmanned Ground System) and UMS (Unmanned Maritime System), their history, missions, capabilities, types, configurations, subsystems, and the disciplines needed for UVS development and operation. UVS missions could include student competitions sponsored by various technical organizations. This course is team-taught by engineering faculty. Offered as AE 5378 and ME 5378. Credit will be granted only once.

AE 5379. UNMANNED VEHICLE SYSTEM DEVELOPMENT. 3 Hours.
Introduction to the technologies needed to create an UVS (Unmanned Vehicle System). Integration of these technologies (embodied as a set of sensors, actuators, computing and mobility platform sub-systems) into a functioning UVS through team work. UVS could be designed to compete in a student competition sponsored by various technical organizations or to support a specific mission or function defined by the instructors. This course is team-taught by engineering faculty. Offered as AE 5379 and ME 5379. Credit will be granted only once. Prerequisite: B or better in MAE 4378 or AE 5378 or ME 5378 and admission to the UVS certificate program.

AE 5380. DESIGN OF DIGITAL CONTROL SYSTEMS. 3 Hours.
Difference equations, Z- and w-transforms, discrete TF (Transfer Function). Discrete equivalence (DE) to continuous TF. Aliasing & Nyquist sampling theorem. Design by DE, root locus in z-plane & Youla parameterization. Discrete state-space model, minimality after sampling, pole placement, Moore-Kimura method, linear quadratic regulator, asymptotic observer. Computer simulation and/or lab implementation. Offered as EE 5324, AE 5380 and ME 5380. Credit will be granted only once. Prerequisite: MAE 4310 or equivalent.

AE 5381. BOUNDARY LAYERS. 3 Hours.
An introductory course on boundary layers. The coverage emphasizes the physical understanding and the mathematical foundations of boundary layers, including applications. Topics covered include laminar and turbulent incompressible and compressible layers, and an introduction to boundary layer transition. Offered as AE 5381 and ME 5381. Credit will be granted only once.

AE 5382. ADVANCED ASTRONAUTICS. 3 Hours.
Topics include orbital mechanics, orbital maneuvering, relative motion, orbit determination and estimation, three body problem, perturbations and numerical techniques.

AE 5383. HYPERSONIC FLOW. 3 Hours.
A study of the basic principles of hypersonic flows. Inviscid and viscous hypersonic flows. The course focuses on the effects of high temperature on the gas properties and associated effects on canonical gas dynamics processes. Applications in aerodynamic heating and atmospheric entry. Application of numerical methods.

AE 5385. HIGH TEMPERATURE GASDYNAMICS. 3 Hours.
Surveys kinetic theory, statistical mechanics, and chemical reaction rate theory. Application to the prediction of thermodynamic properties of gasses and the analysis of problems in high-temperature gasdynamics.

AE 5386. WIND & OCEAN CURRENT ENERGY HARVESTING FUNDAMENTALS. 3 Hours.
A broad senior/graduate first course in wind/wave/ocean current energy harvesting systems, focused on fundamentals, and serving as the basis for subsequent MAE specialized follow-on graduate course offerings focused on structures (conventional and composite), aero/hydro-mechanical response and control, and tailoring and smart material actuation, respectively, as well as for non-MAE, specialized graduate courses.

AE 5391. ADVANCED STUDIES IN AEROSPACE ENGINEERING. 3 Hours.
Individual research or design project performed for fulfilling the requirements of the Master of Engineering degree option. Prior approval of the AE Graduate Advisor is required for enrollment. A written and/or oral report is required.

AE 5397. RESEARCH IN AEROSPACE ENGINEERING. 3 Hours.
Research in masters programs.

AE 5398. THESIS. 3 Hours.
Thesis.

AE 5400. PREPARATORY COURSE FOR AEROSPACE ENGINEERING. 4 Hours.
The course may be offered with multiple sections, wherein each section is paired with a corresponding UG course being offered that semester. The purpose of this course is to strengthen academic preparation of students who were found inadequately prepared for a graduate degree in Aerospace Engineering. Students can concurrently enroll in multiple sections and may need to enroll in this course multiple times until their academic preparation is deemed complete. In order to pass this class, the students has to earn at least a B grade in aggregate based all the assignments and exams. The student will earn an R grade if the class aggregate is a C/D and will need to repeat the course until the student passes the class. The student will Fail the class if the aggregate is an F. The course may be repeated as often as required.

AE 5698. THESIS. 6 Hours.
Thesis.

AE 6196. AEROSPACE ENGINEERING INTERNSHIP. 1 Hour.
For students participating in internship programs. Requires prior approval of Graduate Advisor.

AE 6197. RESEARCH IN AEROSPACE ENGINEERING. 1 Hour.
Research in doctoral programs.

AE 6297. RESEARCH IN AEROSPACE ENGINEERING. 2 Hours.
Research in doctoral programs.

AE 6299. DISSERTATION. 2 Hours.
Dissertation Prerequisite: Admission to candidacy for the Doctoral of Philosophy degree.

AE 6304. ADVANCED MECHANICS OF MATERIALS. 3 Hours.
This graduate level course will cover the calculation of stresses and strains in a body that experiences hyperelastic, viscoelastic and plastic deformation. Offered as AE 6304 and ME 6304. Credit will be granted only once. Prerequisite: AE 5339, ME 5339, or instructor consent.

AE 6310. ADVANCED FINITE ELEMENT METHODS. 3 Hours.
Modeling of large systems, composite and incompressible materials, substructuring, mesh generation, solids applications, nonlinear problems. Offered as AE 6310 and ME 6310. Credit will be granted only once. Prerequisite: AE 5310, ME 5310, or instructor consent.

AE 6311. ADVANCED STRUCTURAL DYNAMICS. 3 Hours.
Normal mode method for undamped and proportionally damped systems, component mode synthesis, generally damped systems, complex modes, effect of design modification on system response. Offered as AE 6311 and ME 6311. Credit will be granted only once. Prerequisite: AE 5311, ME 5311, or instructor consent.

AE 6314. FRACTURE MECHANICS. 3 Hours.
Linear elastic fracture mechanics, energy of fracture, mixed mode crack propagation, fatigue crack growth, numerical methods for stress intensity factor determination, damage tolerance and durability design. Offered as AE 6314 and ME 6314. Credit will be granted only once. Prerequisite: AE 5339, ME 5339, or instructor consent.

AE 6315. ADVANCED COMPOSITES. 3 Hours.
This course introduces students to advanced mechanics of composites at various scales, including analysis and characterization methods. Emphasis is on advanced methods for material characterization; nonlinear constitutive relations; structural and microstructural analysis; and advanced materials and structures applications. Offered as AE 6315 and ME 6315. Credit will be granted only once. Prerequisite: AE 5315, ME 5315, or instructor consent.

AE 6337. ADVANCED ROBOTICS. 3 Hours.
Advanced robotic design concepts considering structural statics, dynamics and control strategies for both rigid and flexible manipulators will be studied using optimization techniques and analytical approaches and introduction to micro- and mobile robotic devices. Study of emerging applications of robotics will be explored. Digital simulation of robotic devices and programming and demonstration of robotic devices in the laboratory. Prerequisites: AE 5337 or ME 5337 or equivalent.

AE 6397. RESEARCH IN AEROSPACE ENGINEERING. 3 Hours.
Research in doctoral programs.

AE 6399. DISSERTATION. 3 Hours.
Dissertation Prerequisite: admission to candidacy for the Doctor of Philosophy degree.

AE 6697. RESEARCH IN AEROSPACE ENGINEERING. 6 Hours.
Research in doctoral programs.

AE 6699. DISSERTATION. 6 Hours.
Dissertation. Prerequisite: Admission to candidacy for the Doctor of Philosophy degree.

AE 6999. DISSERTATION. 9 Hours.
Dissertation. Prerequisite: Admission to candidacy for the Doctor of Philosophy degree.

AE 7399. DOCTORAL DEGREE COMPLETION. 3 Hours.
This course may be taken during the semester in which a student expects to complete all requirements for the doctoral degree and graduate. Enrolling in this course meets minimum enrollment requirements for graduation, for holding fellowships awarded by The Office of Graduate Studies and for full-time GTA or GRA positions. Students should verify that enrollment in this course meets other applicable enrollment requirements. To remain eligible in their final semester of study for grants, loans or other forms of financial aid administered by the Financial Aid Office must enroll in a minimum of 5 hours as required by the Office of Financial Aid. Other funding sources may also require more than 3-hours of enrollment. Additional hours may also be required to meet to requirements set by immigration law or by the policies of the student's degree program. Students should contact the Financial Aid Office, other sources of funding, Office of International Education and/or their graduate advisor to verify enrollment requirements before registering for this course. This course may only be taken once and may not be repeated. Students who do not complete all graduation requirements while enrolled in this course must enroll in a minimum of 6 dissertation hours (6699 or 6999) in their graduation term. Graded P/F/R.

COURSES

MAE 1104. INTRODUCTION TO ENGINEERING. 1 Hour.
Introduction to basic engineering concepts. Students will become familiar with engineering and its many sub-fields, ethical responsibilities, creativity, and design.

MAE 1105. INTRODUCTION TO MECHANICAL AND AEROSPACE ENGINEERING. 1 Hour.
Introduction to basic engineering concepts. Opportunities are provided to develop skills in oral and written communication and department specific material. Case studies are presented and analyzed. Prerequisite: C or better in ENGR 1250 (or concurrent enrollment), or C or better in ENGR 1300 or MAE 1104.

MAE 1106. INTRODUCTION TO AEROSPACE ENGINEERING. 1 Hour.
An introduction to human flight and to the field of aerospace engineering through a combined theoretical and hands-on approach. Topics covered include history of flight and aerospace engineering and introductions to aerostatics and aerodynamics, aerospace structures, stability and control, and propulsion. Some College of Engineering requirements are satisfied by the content of this course. Prerequisite: C or better in MATH 1426 (or concurrent enrollment) or MATH 1426 qualifying score in Math Placement Test; or student group.

MAE 1107. INTRODUCTION TO MECHANICAL ENGINEERING. 1 Hour.
Introduction to basic engineering concepts. Opportunities are provided to develop skills in oral and written communication, in engineering design teamwork, as well as in department-specific material. Some College of Engineering requirements are satisfied by the content of this course. Prerequisite: C or better in MATH 1426 (or concurrent enrollment) or MATH 1426 qualifying score in Math Placement Test; or student group.

MAE 1140. PROBLEMS IN MECHANICAL AND AEROSPACE ENGINEERING. 1 Hour.
This course introduces students to units, 2D and 3D coordinate geometry, vector algebra and scientific problem solving, in preparation for higher level courses. Prerequisite: C or better in MATH 1426 (or concurrent enrollment); or student group.

MAE 1312. ENGINEERING STATICS. 3 Hours. (TCCN = ENGR 2301)
A study of forces and force systems, resultants and components of force systems, forces due to friction, conditions of equilibrium, forces acting on members of trusses and frame structures, centroids and moments of inertia. Vector and index notation introduced. Prerequisite: C or better in each of the following, MAE 1140 (or ENGR 1250 or REE 1301), MATH 1426 (or HONR-SC 1426), and PHYS 1443; or student group.

MAE 1351. INTRODUCTION TO ENGINEERING DESIGN. 3 Hours.
Foundational course in product design and manufacturing using computer-based methodologies. 3D parametric solid modeling of parts and assemblies. Technical sketching, and ASME Y14 engineering drawing standards. Industrial practices for product design and fabrication. Introduction to 3D product analysis tools. Prerequisite: C or better in MATH 1426 (or concurrent enrollment) or HONR-SC 1426 (or concurrent enrollment) or MATH 1426 qualifying score in Math Placement Test; or student group.

MAE 2000. UNDERGRADUATE RESEARCH. 0 Hours.
Sophomore level undergraduate research. Prerequisite: Departmental good standing and permission of instructor. May be taken a maximum of 3 times.

MAE 2010. AUTOMOTIVE ENGINEERING PRACTICUM I. 0 Hours.
Practical design experience as full team member of automotive design competition team. Prerequisite: Permission of Director of the Arnold E. Petsche Center for Automotive Engineering.

MAE 2312. SOLID MECHANICS. 3 Hours.
The relationship between stresses and strains in elastic bodies and the tension, compression, shear, bending, torsion, and combined loadings which produce them. Deflections and elastic curves, shear and bending moment diagrams for beams, and column theory. Prerequisite: C or better in each of the following, MAE 1140 (or ENGR 1250 or REE 1301) and MAE 1312; or student group.

MAE 2315. FLUID DYNAMICS. 3 Hours.
Introduction to Fluid Dynamics and low speed aerodynamics; fluid properties; dimensional analysis; conservation equations in integral and differential form; potential flow theory and viscous flow. Prerequisites: C or better in each of the following, MAE 1106, MAE 2323 (or concurrent enrollment), MAE 3309 (or concurrent enrollment) or MAE 3310 (or concurrent enrollment), and MAE 3360 (or concurrent enrollment); or student group.

MAE 2323. DYNAMICS. 3 Hours. (TCCN = ENGR 2302)
The relation between forces acting on particles, systems of particles and rigid bodies, and the changes in motion produced. Review of kinematics and vector analysis, Newton's Laws, energy methods, methods of momentum, inertia tensor and Euler's equations of motion. Prerequisite: C or better in each of the following, MAE 1140 (or ENGR 1250 or REE 1301), MAE 1312 and MATH 2425 (or HONR-SC 2425); or student group.

MAE 2360. NUMERICAL ANALYSIS & PROGRAMMING. 3 Hours.
Utilization of digital computers in mechanical and aerospace engineering. Computational algorithms and their representation in FORTRAN, C, and Matlab. Introduction to linear algebra and numerical methods. Prerequisite: C or better in MATH 1426; or student group.

MAE 2381. EXPERIMENTAL METHODS AND MEASUREMENTS. 3 Hours.
Introduction to data analysis, incorporating statistics and probability, design and planning of engineering experiments for error prediction and control. Measurement and instrumentation, basic instruments, their calibration and use. Prerequisite: C or better in each of the following, MAE 1351 and MATH 2425 (or HONR-SC 2425) and PHYS 1443 (or HONR-SC 1443); or student group.

MAE 2391. SPECIAL PROBLEMS IN MECHANICAL AND AEROSPACE ENGINEERING. 3 Hours.
Special problems in mechanical and aerospace engineering for preprofessional students in mechanical or aerospace engineering. Prerequisite: Instructor permission.

MAE 3000. UNDERGRADUATE RESEARCH. 0 Hours.
Junior level undergraduate research. Prerequisite: Departmental good academic standing and permission of instructor. May be taken a maximum of 3 times.

MAE 3181. MATERIALS AND STRUCTURES LAB. 1 Hour.
Experiments to study materials behavior and deformation of structural elements. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 2381 and C or better in MAE 3315 (or concurrent enrollment) or MAE 3242 (or concurrent enrollment); or student group.

MAE 3182. AERODYNAMICS AND FLUIDS LAB. 1 Hour.
Wind tunnel experiments to study flow phenomena of aerodynamics interest, including scale testing of airfoils, wings, and aircraft. Prerequisite: C or better in each of the following, MAE 2381, MAE 3302 (or concurrent enrollment), and MAE 3303 (or concurrent enrollment); or student group.

MAE 3183. MEASUREMENTS LABORATORY II. 1 Hour.
Fundamental measurement techniques and experimental data analysis in mechanical engineering in the fields of thermal, fluid, structures, design, and dynamic systems. Introduction to sensor calibration, digital data acquisition, uncertainty analysis, and report writing. Prerequisite: Must be in the professional ME program and C or better in each of the following, MAE 2381, MAE 3314, and MAE 3319; or student group.

MAE 3185. INTRODUCTION TO MECHATRONICS. 1 Hour.
Project based introduction to the application of software and hardware required to build functioning electromechanical systems. Integrates the theory of electrical circuits, electromechanics, electronics, mechanics, and mechanical devices, along with computer and microprocessor programming and the software-hardware interface, for practical applications. Prerequisite: Professional AE or ME program and C or better in each of MAE 2360, MAE 2381, MAE 3360 and EE 2320; or student group.

MAE 3242. MECHANICAL DESIGN I. 2 Hours.
The overall nature of design as a process is presented along with various models, methods, techniques, and tools for the various phases of the process provide the student with an excellent understanding of how to design. Students learn to design mechanical components based on stress/deflection and the associated failure theories. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2312, MAE 2323, and MAE 3324; or student group.

MAE 3302. INCOMPRESSIBLE AERODYNAMICS. 3 Hours.
Introduction to and application of the methods used to determine the low speed aerodynamic forces on aerodynamic components such as wings and airfoils. Topics include potential flow theory for lifting flows; airfoil and finite wing theory; panel and vortex-lattice methods. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2315, MAE 2323, MAE 3309 (or MAE 3310), and MAE 3360; or student group.

MAE 3303. COMPRESSIBLE FLOW. 3 Hours.
Fundamental thermodynamic concepts of compressible flow, isentropic flow, normal and oblique shock waves; expansion waves; quasi-one dimensional flows within nozzles and diffusers, linearized compressible flow theory, the method of characteristics and supersonic nozzle design. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following MAE 2315, MAE 2323, MAE 3309 (or MAE 3310), and MAE 3360; or student group.

MAE 3304. ASTRONAUTICS I. 3 Hours.
Introduction to astronautics, the solar system, and the two-body problem. Orbit shaping and orbit transfers. Patched conic approximations for interplanetary transfers. Introduction to the three-body problem and relative motion. Rigid spacecraft equation of motion. Active and passive attitude stabilization techniques for spacecraft. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following: MAE 2323, MAE 2360, and MAE 3360; or student group.

MAE 3306. FLIGHT PERFORMANCE, STABILITY & CONTROL. 3 Hours.
Review of aerodynamics. Introduction to aircraft performance and the assessment of aircraft static stability and control characteristics. Performance topics covered include cruise, climb, gliding flight, turns, range and endurance. Static stability and control topics covered include longitudinal, lateral and directional stability and control power calculations. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following: MAE 3302 and MAE 3303.

MAE 3309. THERMAL ENGINEERING. 3 Hours.
Basic concepts and definitions, properties of pure substances, work and heat, first law of thermodynamics, second law of thermodynamics, entropy, and introduction to conductive, convective, and radiative transfer. Prerequisite: Must be in an EE or MAE department degree program and C or better in each of the following, CHEM 1465 or both CHEM 1441 and CHEM 1442; MATH 2425 (or HONR-SC 2425) and PHYS 1444; or student group.

MAE 3310. THERMODYNAMICS I. 3 Hours.
Basic concepts and definitions, properties of pure substances, work and heat, first law of thermodynamics, second law of thermodynamics, entropy, thermodynamics of gases, vapors, and liquids in various nonflow and flow processes, and irreversibility and availability. Prerequisite: Must be in an MAE department degree plan and C or better in each of the following, CHEM 1465 or both CHEM 1441 and CHEM 1442; MATH 2425 (or HONR-SC 2425), and PHYS 1444; or student group.

MAE 3311. THERMODYNAMICS II. 3 Hours.
Availability, power, refrigeration and heat pump cycles (both gas and vapor), property relations and equations of state, ideal gas mixtures, mixtures of gases and vapors, psychrometrics, adiabatic flame temperature, thermochemical equilibrium, and compressible flow. Emphasis is on applying these topics to thermal systems design. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3313 (or concurrent enrollment) and MAE 3310; or student group.

MAE 3313. FLUID MECHANICS. 3 Hours.
Fundamental concepts of fluid mechanics leading to the development of both the integral and differential forms of the basic conservation equations. Application of the integral conservation equations to engineering problems in fluid dynamics including buoyancy and other hydrostatics problems. Dimensional analysis and similitude are also discussed. Prerequisite: Must be in the professional ME program and C or better in each of the following, MAE 2323, MAE 2360, MAE 3360, and MAE 3310 (or concurrent enrollment); or student group.

MAE 3314. HEAT TRANSFER. 3 Hours.
Topics cover the fundamental laws of heat and mass transfer, including steady and unsteady conduction, forced and free convection, and radiation as well as heat transfer in phase change. Applications of heat transfer to thermal systems design are included. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3313 or C or better in MAE 3302.

MAE 3315. AEROSPACE STRUCTURAL STATICS. 3 Hours.
Overview of aircraft basic structural elements and materials; introduction to elasticity; equations of equilibrium; constitutive equations of isotropic solids; bending and torsion analysis of thin-walled beams; flexure shear of thin-walled beams with stringer reinforcement; introduction to fatigue and fracture analysis; failure criteria; energy method to find strain energy release rate; elastic column buckling. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 2312; or student group.

MAE 3316. AEROSPACE STRUCTURAL DYNAMICS. 3 Hours.
Harmonic and periodic motion including both damped and undamped free and forced vibration. Single-and multi-degree-of-freedom discrete systems. Vibration of continuous systems. Introduction of finite element method for structural dynamics. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2312, MAE 2323, MAE 3360, and MATH 3330; or student group.

MAE 3318. KINEMATICS AND DYNAMICS OF MACHINES. 3 Hours.
The motion and interaction of linkage and mechanisms. Fundamental concepts of kinematics and dynamics applied to the determination of degree of freedom mechanisms and forces acting on joints of mechanisms. Specific mechanisms and applications such as multi-body mechanisms, linkage synthesis, cam design, and balancing. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 2323, or student group.

MAE 3319. DYNAMIC SYSTEMS MODELING AND SIMULATION. 3 Hours.
Introduction to modeling and prediction of behavior of engineering systems. Analytic and numerical simulation, state-space differential equations, and Laplace transform methods. Effects of physical characteristics of system elements on system design and dynamic performance. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3314 (or concurrent enrollment), EE 2320, and MATH 3330; or student group.

MAE 3324. STRUCTURE & MECHANICAL BEHAVIOR OF MATERIALS. 3 Hours.
Crystal structure and defects in materials. Diffusion, phase diagrams and phase transformations in metallic systems. The inter relationships between processing, structure, and properties of engineering materials with emphasis on the mechanical behavior of metals, polymers, and composite materials. Prerequisites: Must be in an MAE department degree program and C or better in each of the following, CHEM 1465 (or CHEM 1441 and CHEM 1442), MAE 2312 (or concurrent enrollment), and PHYS 1444; or student group.

MAE 3344. INTRODUCTION TO MANUFACTURING ENGINEERING. 3 Hours.
Introduction to casting, forming, machining, and joining processes for metals and nonmetals. Prerequisite: Must be in the professional ME program and C or better in each of the following, MAE 2312 and MAE 3324; or student group.

MAE 3360. ENGINEERING ANALYSIS. 3 Hours.
Mathematical analysis with emphasis on solution techniques and engineering applications. Topics include: ordinary differential equations (ODE), Laplace Transform, numerical solutions of ODE, boundary value problems, Fourier series, Sturm-Liouville problem and vector calculus. Prerequisite: Must be in an MAE department degree program and C or better in each of the following, MATH 2326 and MAE 2360 (or concurrent enrollment); or student group.

MAE 3405. FLIGHT DYNAMICS. 4 Hours.
Derivation of equation of motion (EOM) of a flight vehicle. Trimmed flight condition analysis based on the nonlinear EOM. Linearization of EOM for a given trimmed flight condition. State-space and transfer-function representations of the linear EOM. Aircraft stability and dynamic performance analysis based on the linear EOM. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3406 (or concurrent enrollment) or MAE 3306 (or concurrent enrollment) and MATH 3330; or student group.

MAE 3406. FLIGHT PERFORMANCE & STABILITY. 4 Hours.
Classical Aerodynamics including potential flow theory for lifting flows; airfoil and finite wing theory; panel and vortex-lattice methods. Lift and drag buildup for aircraft. Aircraft performance analysis including cruise, climbing, gliding and turning flight, range and endurance. Aircraft longitudinal, lateral and roll stability and control. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3303 (or concurrent enrollment).

MAE 4000. UNDERGRADUATE RESEARCH. 0 Hours.
Senior level undergraduate research. Prerequisite: Departmental good academic standing and permission of instructor. May be taken a maximum of 3 times.

MAE 4010. AUTOMOTIVE ENGINEERING PRACTICUM II. 0 Hours.
Practical design experience as full team member of automotive design competition team. Prerequisite: Permission of Director of the Arnold E. Petsche Center for Automotive Engineering.

MAE 4151. AEROSPACE VEHICLE DESIGN II. 1 Hour.
Analysis and design of an aerospace system such as a complete flight vehicle, a propulsion system, a structural system, or a control system; market analysis, operating studies, mission specification, civil and military certification requirements; design process, methods and tools; configuration concept selection, harmonization of individual design disciplines (aerodynamics, performance, flight mechanics, structures, cost, systems, etc.). Prerequisite: Must be in the professional ME or AE program and C or better in MAE 4350.

MAE 4188. DESIGN PROJECT LABORATORY II. 1 Hour.
The design project from MAE 4287 continued. The design is finalized, a physical model (prototype) is manufactured and tested. Redesign and retest is accomplished as desired. The final design is documented by written report and oral presentation. Exit survey forms and exit essays must be submitted to complete the requirements of this course. Prerequisite: Must be in the professional ME program and C or better in MAE 4287.

MAE 4191. SPECIAL PROBLEMS IN MECHANICAL AND AEROSPACE ENGINEERING. 1 Hour.
Special problems in mechanical and aerospace engineering for students of professional program standing. Prerequisite: Must be in the professional ME or AE program.

MAE 4287. DESIGN PROJECT I. 2 Hours.
Team engineering approach to a design project that integrates engineering knowledge from several courses. Problem definition and creative synthesis of prospective design solutions. Engineering proposals, feasibility studies, trade-off studies, systems models and analysis, decision making, and engineering reports and presentations. Professionalism, ethics, and societal impact issues. Prerequisite: Must be in the professional ME program and C or better in MAE 4344 (or concurrent enrollment) and must be within two calendar semesters of graduation (possibly including an 11-week summer session). MAE 4287 and MAE 4188 must be taken in consecutive semesters.

MAE 4291. SPECIAL PROBLEMS IN MECHANICAL AND AEROSPACE ENGINEERING. 2 Hours.
Special problems in mechanical and aerospace engineering for students of professional program standing. Prerequisite: Must be in the professional ME or AE program.

MAE 4301. SPECIAL TOPICS IN MECHANICAL AND AEROSPACE ENGINEERING. 3 Hours.
Topics will vary from semester to semester depending on student interest and the availability of faculty. May be repeated, provided topics are different. Prior approval by the student's advisor required. Prerequisite: Must be in the professional ME or AE program and others that vary by topic.

MAE 4302. INTRODUCTION TO BEARING DESIGN AND LUBRICATION. 3 Hours.
The course introduces 1) selection principles and design guidelines for various rolling element bearings, 2) theory of liquid and gas lubrication, 3) various novel fluid film bearings used in modern high speed turbomachinery and energy systems, and 4) fundamental principles of rotordynamics. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3313.

MAE 4304. ASTRONAUTICS II. 3 Hours.
The restricted three-body problem, the n-body problem, and approximations. Interplanetary transfers. Design considerations for both manned and unmanned interplanetary vehicles. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3304.

MAE 4305. FUNDAMENTALS OF ELECTRONIC PACKAGING. 3 Hours.
An introductory treatment of electronic packaging, from single chip to multichip, including materials, electrical design, thermal design, mechanical design, package modeling and simulation, processing considerations, reliability, and testing. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3314 or MAE 3309; or student group.

MAE 4306. COMPUTATIONAL TECHNIQUES FOR ELECTRONIC PACKAGING. 3 Hours.
Characterization of the thermo/mechanical reliability of microelectronics devices using commercial computational heat transfer codes (Icepack, Flotherm, and ANSYS). Industry related problems ranging from first level packages through system level packages analyzed. Formulate and model contemporary problems using commercial CFD codes. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3314 or MAE 3309; or student group.

MAE 4307. FINITE ELEMENT METHODS. 3 Hours.
Static response of complex structures and continua; application to field problems; mesh generation; error estimation and adaptive refinement. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3242.

MAE 4310. INTRODUCTION TO AUTOMATIC CONTROL. 3 Hours.
Block diagram algebra, transfer functions, and stability criteria. The use of transient response, frequency response, and root locus techniques in the performance analysis, evaluation, and design of dynamic systems. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, (MAE 3314 and MAE 3319) or (MAE 3405 and EE 2320); or student group.

MAE 4312. CONTROL SYSTEMS COMPONENTS. 3 Hours.
The components used in mechanical, electronic, and fluid power control systems are studied. Modeling and performance analysis are used to help in the understanding of system behavior. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 4310.

MAE 4314. MECHANICAL VIBRATIONS. 3 Hours.
Harmonic and periodic motion including both damped and undamped free and forced vibration. Single and multi-degree-of-freedom discrete systems. Vibration of continuous systems. Introduction of finite element method for structural dynamics. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2312, MAE 2323, MAE 3360, and MATH 3330; or student group.

MAE 4315. INTRODUCTION TO COMPOSITES. 3 Hours.
Composite classification, laminate coding, fiber and weight fractions of composite lamina; lamina constitutive equations; structural characteristics of [A], [B], [D] matrices; lamination theory; thermal and moisture induced load and moment; lamina stress analysis and failure prediction; issues in composite structural design. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 2312 (or CE 2313); or student group.

MAE 4320. HYDRAULIC AND PNEUMATIC SYSTEMS. 3 Hours.
The fundamentals of fluid mechanics as applied to hydraulic and pneumatic hardware. Mathematical models of pumps, motors, pistons, accumulators, valves, and transmission lines. Design and analysis procedures for implementing total fluid power systems with high operating efficiencies and adequate dynamic response characteristics. Theory is supported by laboratory demonstrations. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3313, MAE 4310, and MAE 3310; or student group.

MAE 4321. AEROSPACE PROPULSION. 3 Hours.
Introduction to rocket and air-breathing propulsion systems. Development of thrust and efficiency relations, mission requirements, rocket and gas turbine engine cycle analysis, off-design performance, component design and performance analysis, advanced propulsion system concepts. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3303 or C or better in each of MAE 3313 and MAE 3311.

MAE 4322. ROCKET PROPULSION. 3 Hours.
Examines chemical, nuclear, and electrical propulsion concepts. Development of design and performance analysis methods. Flight performance of rocket powered vehicles. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3303 (or MAE 3311).

MAE 4323. ENERGY CONVERSION. 3 Hours.
Thermodynamics as applied to thermo-mechanical systems such as power cycles, engines, turbines, refrigeration, and air-conditioning systems. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3311 and MAE 3314.

MAE 4324. POWER PLANT ENGINEERING. 3 Hours.
Fundamental thermodynamics and heat transfer principles behind design and optimization of power generation systems with significant emphasis on component and system design. This class will cover a number of power plant types, including coal/gas fired, hydroelectric, nuclear, and solar. Concepts learnt in this class prepare students for an engineering career in power plants, oil, gas and related industries. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3310 (or MAE 3309); or student group.

MAE 4325. COMBUSTION. 3 Hours.
Fundamental treatment of problems involving simultaneous occurrence of chemical reaction and transfer of heat, mass and momentum. Topics include kinetically controlled combustion phenomena; diffusion flames in liquid fuel combustion; combustion of solids; combustion of gaseous fuel jets; flames in premixed gasses. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3311 or MAE 3303.

MAE 4326. COMPUTATIONAL AERODYNAMICS I. 3 Hours.
Solution of engineering problems by finite-difference methods, emphasis on aerodynamic problems characterized by single linear and non-linear equations, introduction to and application of major algorithms used in solving aerodynamics problems by computational methods. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3314 or MAE 3303.

MAE 4327. HEATING, VENTILATION, AND AIR CONDITIONING. 3 Hours.
Application of engineering sciences to design of heating, venting, and air conditioning (HVAC) systems. Humidification and dehumidification, psychrometric charts, heat load, cooling load, degree-days, comfort zones, and air distribution systems. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3311 and MAE 3314.

MAE 4328. METAL ADDITIVE MANUFACTURING. 3 Hours.
This course will provide students with essential knowledge and technical skills for metal additive manufacturing (AM), providing a solid foundation for a future career in the field. Primary areas of focus include: metal AM processes and their capabilities, process fundamentals, part design and analysis, build preparation and machine set-up, fabrication and post-processing, inspection and monitoring, microstructure analysis and mechanical testing, and process optimization. Prerequisite: Must be in the professional ME or AE program.

MAE 4329. ADDITIVE MANUFACTURING. 3 Hours.
The range of technologies and processes, both physical and digital, used to translate virtual solid model data into physical models using additive layering methods. Emphasis is given to application of these technologies to manufacture end use components and assemblies but rapid prototyping is also discussed. Metal, polymer, ceramic, and composite material applications of additive manufacturing (AM) are included. Discussion includes advantages and limitations of additive methods with respect to subtractive methods and to each other. Principles of design for AM are covered along with discussion of applications. Students complete a project to design and build an engineering component or assembly for additive manufacture. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 1351 and MAE 3324; or student group.

MAE 4331. DESIGN FOR MANUFACTURING. 3 Hours.
The interaction between design and manufacturing stressed in terms of the design process, customer-focused quality, design specifications versus process capability and tolerances, and redesign for producibility. Topics include material and manufacturing process selection, tolerancing, quality function deployment (QFD), design for assembly (DFA), quality control techniques, reliability, and robust design. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3242 and MAE 3344.

MAE 4335. ANALYTICAL & COMPUTATIONAL DYNAMICS. 3 Hours.
The course focuses on developing the equations of motion for dynamic systems composed of multiple, connected and unconnected, rigid bodies using Kane's method and the Lagrangian approach. The resulting model is used to simulate and visualize the predicted motion. Topics include: kinematics, Euler parameters, kinematic constraints, virtual work, the calculus of variations, energy, momentum, contact, impact, and checking functions. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3318.

MAE 4336. ADVANCED MECHANICAL BEHAVIOR OF MATERIALS. 3 Hours.
Concept of stress and strain; elementary dislocation theory. Deformation of single crystals; strengthening mechanisms including solid solution strengthening, and precipitation hardening. Fracture mechanics; microscopic aspects of fracture, fatigue, and creep of materials; design and processing of materials for improved mechanical properties. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2312 and MAE 3324; or student group.

MAE 4338. FAILURE ANALYSIS. 3 Hours.
Theory and practice of techniques for determining modes of failure and fracture of engineering materials. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2312 and MAE 3324; or student group.

MAE 4339. FRACTURE MECHANICS. 3 Hours.
Theory and applications of fracture mechanics. Stress analysis of cracks, crack-tip plasticity, fatigue crack growth, and stress corrosion cracking. Applicability to materials selection, structural design, failure analysis, and structural reliability. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3242.

MAE 4342. MECHANICAL DESIGN II. 3 Hours.
Analysis for the design and manufacture of basic mechanical elements, and their role in the design of machines. A brief review of relevant topics including stress/deflection, failure theories, and contact stress is initially conducted. It is then extended to the design of fundamental mechanical components including shafts, gears, springs, bearings, fasteners, and clutches/brakes. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3242 and MAE 3318 (or concurrent enrollment).

MAE 4344. COMPUTER-AIDED ENGINEERING. 3 Hours.
A study of the principles of computer-aided engineering in mechanical and aerospace engineering. Applications in mechanical, structural, and thermal systems. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 3242, MAE 3314 (or concurrent enrollment), and MAE 3318.

MAE 4345. INTRODUCTION TO ROBOTICS. 3 Hours.
Overview of industrial robots. Study of principles of kinematics, dynamics, and control as applied to industrial robotic systems; robotic sensors and actuators; path planning; guidelines to robot arm design and selection; introduction to mechatronics; laboratory exercise in designing, building, and controlling a 3D-printed robotic manipulator. Prerequisite: Must be in the professional ME or AE program.

MAE 4347. HEAT EXCHANGER DESIGN. 3 Hours.
Design procedure system evaluation; design parameters in heat exchangers. The course considers various heat exchanger configurations and includes student design projects. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3314.

MAE 4348. COOLING OF ELECTRONIC PACKAGES. 3 Hours.
The calculation of heat loads and temperature fields using different cooling techniques. Includes parameter evaluation and design studies. Prerequisite: Must be in the professional ME or AE program and C or better in, MAE 3314 (or MAE 3309); or student group.

MAE 4350. AEROSPACE VEHICLE DESIGN I. 3 Hours.
Analysis and design of an aerospace system such as a complete flight vehicle, a propulsion system, a structural system, or a control system; market analysis, operating studies, mission specification, civil and military certification requirements; design process, methods and tools; configuration concept selection, integration of design disciplines (aerodynamics, performance, flight mechanics, structures, cost, systems, etc.). Prerequisite: Must be in the professional ME or AE program and C or better in each of the following: MAE 3306 or MAE 3406 and MAE 3405.

MAE 4351. AEROSPACE VEHICLE DESIGN II. 3 Hours.
Analysis, design, and synthesis of an aerospace system such as a complete flight vehicle, a propulsion system, a structural system, or a control system; market analysis, operating studies, mission specification, civil and military certification requirements; design process, methods and tools; configuration concept selection, integration of individual design disciplines (aerodynamics, performance, flight mechanics, structures, cost, systems, etc.). Also included will be economic, environmental, sustainability, manufacturability, safety, social and political considerations. Formal written and oral reports are required. Exit survey forms and exit essays must be submitted to complete the requirements of this course. Prerequisite: Must be in the professional AE program and C or better in MAE 4350.

MAE 4352. SPACE VEHICLE AND MISSION DESIGN. 3 Hours.
Space vehicle design; influence of space environment, astrodynamics, and atmospheric reentry. Space vehicle sub system design; propulsion, attitude determination and control, structural design, thermal control, power and telecommunications. Investigation into mission design concepts and considerations. Prerequisite: Must be in the professional ME or AE program and C or better in each of the following, MAE 2323 and MATH 2326; or student group.

MAE 4357. AUTOMOTIVE ENGINEERING. 3 Hours.
Introduction to automotive engine types and performance, drive train modeling and vehicle loading characteristics, fueling requirements, fuel injection systems, tire characteristics and modeling, suspension characteristics and handling, braking systems and requirements. Course taught through lecture, student presentations and student design projects. Prerequisite: Must be in the professional ME, AE or EE program and C or better in each of the following, MAE 3360 (or MATH 3319) and MAE 2312 (or EE 3446); or student group.

MAE 4358. RACECAR ENGINEERING. 3 Hours.
This course is intended for Formula SAE team members and other interested students to develop new systems or analyze concepts for the Formula SAE or Formula Electric racecar and related equipment. The students will form teams and perform research and development on projects related to automotive or racecar engineering. Prerequisites: Must be in the professional ME, AE or EE program and C or better in each of the following, MAE 3360 (or Math 3319) and MAE 2312 (or EE 3446); or student group.

MAE 4362. INTRODUCTION TO MICRO AND NANOFLUIDICS. 3 Hours.
As going down to micro scales, the basic hypothesis in the macro scale fluid mechanics may not be applicable in such scales. The objectives of this course are: to identify dominant forces and their effects in micro scale fluid systems that are different from those in the macro scales; to understand the fundamentals of micro fluidic phenomena; to discuss various microfluidic applications in research and commercial levels; and to explore new possible microfluidic applications in the emerging fields. Topics include overview of microfluidics, scaling laws, violation limit of the Navier-Stokes equations, surface force, surface tension, electrowetting, electrokinetics, dielectrophoresis, and soft lithography. Prerequisite: Must be in the professional ME or AE program and C or better in MAE 3313 and MAE 3310; or student group.

MAE 4363. INTRODUCTION TO ROTORCRAFT ANALYSIS. 3 Hours.
History of rotorcraft. Behavior of the rotor blade in hover and forward flight. Rotor configurations, dynamic coupling with the fuselage, elastic and aeroelastic effects.

MAE 4378. INTRODUCTION TO UNMANNED VEHICLE SYSTEMS. 3 Hours.
Introduction to UVS (Unmanned Vehicle Systems) such as UAS (Unmanned Aircraft Systems), UGS (Unmanned Ground System) and UMS (Unmanned Maritime System), their history, missions, capabilities, types, configurations, subsystems, and the disciplines needed for UVS development and operation. UVS missions could include student competitions sponsored by various technical organizations. This course is team-taught by engineering faculty. Prerequisite: Admission to a professional engineering or science program.

MAE 4379. UNMANNED VEHICLE SYSTEM DEVELOPMENT. 3 Hours.
Introduction to the technologies needed to create an UVS (Unmanned Vehicle System). Integration of these technologies (embodied as a set of sensors, actuators, computing and mobility platform sub-systems) into a functioning UVS through team work. UVS could be designed to compete in a student competition sponsored by various technical organizations or to support a specific mission or function defined by the instructors. This course is team-taught by engineering faculty. Prerequisite: B or better in MAE 4378 and admission to the UVS certificate program.

MAE 4382. RESEARCH TRENDS IN RENEWABLE ENERGY TECHNOLOGIES. 3 Hours.
This course is offered to graduate and senior level undergraduate students with engineering and science background to introduce them to micro/nano research and development for energy conversion and storage. This course will include: Scaling laws, MEMS fabrication, Nanomaterial synthesis, Electrochemical energy storage/conversion (Batteries, Fuel Cells & Supercapacitors), Solar energy (photovoltaics and solar thermal energy), Energy harvesting and Solar water splitting and electrocatalysis. Prerequisite: Must be in the professional ME or AE program.

MAE 4386. WIND & OCEAN CURRENT ENERGY HARVESTING FUNDAMENTALS. 3 Hours.
A broad senior/graduate first course in wind/wave/ocean current energy harvesting systems, focused on fundamentals, and serving as the basis for subsequent MAE specialized follow-on graduate course offerings focused on structures (conventional and composite), aero/hydro-mechanical response and control, and tailoring and smart material actuation, respectively, as well as for non-MAE, specialized graduate courses. Prerequisite: Must be in the professional ME or AE program and C or better in EE 2320 and C or better in either MAE 3313 or MAE 2315, or student group.

MAE 4391. SPECIAL PROBLEMS IN MECHANICAL AND AEROSPACE ENGINEERING. 3 Hours.
Special problems in mechanical and aerospace engineering for students of professional program standing. Prerequisite: Must be in the professional ME or AE program.

COURSES

ME 5010. AUTOMOTIVE ENGINEERING PRACTICUM. 0 Hours.
Practical design experience as full member of automotive design competition team. Prerequisite: Permission of Director for the Arnold E. Petsche Center for Automotive Engineering.

ME 5101. GRADUATE SEMINAR. 1 Hour.
The purpose is to acquaint graduate students with ongoing research at UTA, and outside in academia and industry. Seminars are given by graduate students of the department based on their ongoing research. Seminars are also given by external speakers from academia, industry and government.

ME 5191. PROJECT STUDIES IN MECHANICAL ENGINEERING. 1 Hour.
May be repeated for credit as topics change. Project work performed under a non-thesis degree will normally be accomplished under this course number, with prior approval of the Committee on Graduate Studies. May be graded pass/fail.

ME 5197. RESEARCH IN MECHANICAL ENGINEERING. 1 Hour.
Research in master's programs.

ME 5291. PROJECT STUDIES IN MECHANICAL ENGINEERING. 2 Hours.
May be repeated for credit as topics change. Work performed as a thesis substitute will normally be accomplished under this course number, with prior approval of the Committee on Graduate Studies. Maybe graded P/F.

ME 5297. RESEARCH IN MECHANICAL ENGINEERING. 2 Hours.
Research in master's programs.

ME 5302. INTRODUCTION TO BEARING DESIGN AND LUBRICATION. 3 Hours.
The course introduces 1) selection principles and design guidelines for various rolling element bearings, 2) theory of liquid and gas lubrication, 3) various novel fluid film bearings used in modern high speed turbomachinery and energy systems, and 4) fundamental principles of rotordynamics.

ME 5303. CLASSICAL METHODS OF CONTROL SYSTEMS ANALYSIS AND SYNTHESIS. 3 Hours.
Equip the student with familiarity of significant tools of the control engineer. Topics covered include controllers and their effect on system performance and stability, block diagram algebra, stability and analysis, system performance definition, root locus, frequency techniques, and state variable methods. Digital simulation tools for design and simulation of control systems. Demonstration of controller design and performance in the laboratory. Also offered as AE 5303. Credit will be granted only once.

ME 5305. DYNAMIC SYSTEMS MODELING. 3 Hours.
To equip the student with the capability of determining the necessary equations for distributed and lumped parameter modeling of mixed physical system types including mechanical, fluid, electrical, and thermal components. Models are formulated for computer simulation and analysis for systems with deterministic and stochastic inputs. Topics of random vibration and system identification are included. Offered as AE 5305 and ME 5305. Credit will be granted only once.

ME 5306. FLUID POWER CONTROL. 3 Hours.
Mathematical models for hydraulic and pneumatic control components and systems including hydraulic pumps, motors, and spool valves. The application of electrohydraulic and hydromechanical servomechanisms for position and velocity control are treated. Theory supported by laboratory demonstrations and experiments.

ME 5310. FINITE ELEMENT METHODS. 3 Hours.
Finite element method in the study of the static response of complex structures and of continua; applications to field problems; analytical methods emphasized, and digital computer application undertaken. Offered as AE 5310 and ME 5310. Credit will be granted only once.

ME 5311. STRUCTURAL DYNAMICS. 3 Hours.
Natural frequencies; forced response of complex structural systems studied through the use of the finite element method; computational aspects of these problems discussed, and digital computer applications undertaken. Offered as AE 5311 and ME 5311. Credit will be granted only once.

ME 5312. CONTINUUM MECHANICS. 3 Hours.
Study of the underlying physical and mathematical principles relating to the behavior of continuous media; interrelationships between fluid and solid mechanics. Offered as AE 5312 and ME 5312. Credit will be granted only once.

ME 5313. FLUID DYNAMICS. 3 Hours.
Basic conservation laws, flow kinematics, special forms of the governing equations, two-dimensional potential flows, surface waves and some exact solutions of viscous incompressible flows. Offered as AE 5313 and ME 5313. Credit will be granted only once.

ME 5315. FUNDAMENTALS OF COMPOSITES. 3 Hours.
This fundamental course will introduce students to mechanics of composites at various scales, including analysis, characterization, and manufacturing methods. Emphasis is on constitutive relations; mechanical and hygrothermal behavior; stress analysis; and simple applications. Offered as AE 5315 and ME 5315. Credit will be granted only once.

ME 5316. THERMAL CONDUCTION. 3 Hours.
Fundamental laws, initial and boundary conditions, basic equations for isotropic and anisotropic media, related physical problems and steady and transient temperature distributions in solid structures.

ME 5317. CONVECTION HEAT TRANSFER. 3 Hours.
Equations of motion of viscous fluids are reviewed and the energy equations are introduced. Exact and approximate solutions are made for forced convective problems with non-isothermal and unsteady boundaries. Free convection and combined free- and forced-convection problems are solved.

ME 5318. RADIATIVE HEAT TRANSFER. 3 Hours.
General equations of radiative transfer derived and solved for special problems, and the elements of atomic, molecular, and continuum radiation are introduced.

ME 5319. ADVANCED FINITE ELEMENT METHODS. 3 Hours.
Continuation of ME 5310. Modeling of large systems, composite and incompressible materials, substructuring, mesh generation, solids applications, nonlinear problems. Prerequisite: ME 5310 or equivalent.

ME 5320. DESIGN OPTIMIZATION. 3 Hours.
The purpose of this course is to present modern concepts of optimal design of structures. Basic ideas from optimization theory are developed with simple design examples. Analytical and numerical methods are developed and their applications discussed. Use of numerical simulation methods in the design process is described. Concepts of structural design sensitivity analysis and approximation methods will be discussed. The emphasis is made on the application of modern optimization techniques linked to the numerical methods of structural analysis, particularly, the finite element method. Prerequisite: AE 5310 or ME 5310.

ME 5321. ADVANCED CLASSICAL THERMODYNAMICS. 3 Hours.
Fundamentals of thermodynamics reviewed. Different treatments of principles studied, compared and formal relationships developed and applied to chemical, magnetic, electric and elastic systems.

ME 5322. ADVANCED STRUCTURAL DYNAMICS. 3 Hours.
Normal mode method for undamped and proportionally damped systems, component mode synthesis, generally damped systems, complex modes, effect of design modification on system response. Prerequisite: ME 5311 or equivalent.

ME 5323. ENGINEERING RESEARCH METHODS. 3 Hours.
This hands-on course will teach the tools that are essential for conducting graduate research, with an aim to prepare the students for project-based graduate research. The course will be focused on the integration of engineering concepts to complete course projects that imitate mini research projects. Prerequisite: Undergraduate education in engineering or science.

ME 5324. POWER PLANT ENGINEERING. 3 Hours.
Fundamental thermodynamics and heat transfer principles behind design and optimization of power generation systems with significant emphasis on component and system design. This class will cover a number of power plant types, including coal/gas fired, hydroelectric, nuclear, and solar. Concepts learnt in this class prepare students for an engineering career in power plants, oil, gas and related industries.

ME 5325. COMBUSTION. 3 Hours.
Fundamental treatment of problems involving simultaneous occurrence of chemical reaction and transfer of heat, mass and momentum. Topics include kinetically controlled combustion phenomena; diffusion flames in liquid fuel combustion; combustion of solids; combustion of gaseous fuel jets; flames in premixed gasses. Offered as AE 5325 and ME 5325. Credit will be granted only once.

ME 5326. MANUFACTURING PROCESSES AND SYSTEMS. 3 Hours.
Survey and modeling of manufacturing, assembly, surface treatment, automation, and integration processes. Prerequisite: Graduate standing.

ME 5327. DESIGN FOR MANUFACTURING. 3 Hours.
The interaction between design and manufacturing stressed in terms of the design process, customer-focused quality, design specifications versus process capability and tolerances, and redesign for producibility. Topics include material and manufacturing process selection, tolerancing, quality function deployment (QFD), design for assembly (DFA), quality control techniques, reliability, and robust design. Prerequisite: ME 5326.

ME 5328. METAL ADDITIVE MANUFACTURING. 3 Hours.
This course will provide students with essential knowledge and technical skills for metal additive manufacturing (AM), providing a solid foundation for a future career in the field. Primary areas of focus include: metal AM processes and their capabilities, process fundamentals, part design and analysis, build preparation and machine set-up, fabrication and post-processing, inspection and monitoring, microstructure analysis and mechanical testing, and process optimization.

ME 5329. ADDITIVE MANUFACTURING. 3 Hours.
The range of technologies and processes, both physical and digital, used to translate virtual solid model data into physical models using additive layering methods. Emphasis is given to application of these technologies to manufacture end use components and assemblies but rapid prototyping is also discussed. Metal, polymer, ceramic, and composite material applications of additive manufacturing are included. Discussion includes advantages and limitations of additive methods with respect to subtractive methods and to each other. Principles of design for additive manufacturing are covered along with discussion of applications. Students complete a project to design and build an engineering component or assembly for additive manufacturing. Offered as AE 5329 and ME 5329. Credit will be granted only once. Prerequisite: Graduate standing.

ME 5331. ANALYTIC METHODS IN ENGINEERING. 3 Hours.
Introduction to advanced analytic methods in engineering. Methods include multivariable calculus and field theory, Fourier series, Fourier and Laplace Transforms. Offered as AE 5331 and ME 5331. Credit will be granted only once. Prerequisite: Undergraduate degree in engineering, physics, or mathematics.

ME 5332. ENGINEERING ANALYSIS. 3 Hours.
Introduction to partial differential equations and complex variable theory with application to modeling of physical systems. Offered as AE 5332 and ME 5332. Credit will be granted only once.

ME 5333. THERMAL PHENOMENA IN MICROSYSTEMS. 3 Hours.
Introduction to experimental methods for microscale thermal transport, including experimental measurement techniques, design of experiments, data acquisition and analysis tools. Significant emphasis on carrying out mini-projects on related topics. Course learning outcomes are directly relevant for engineering jobs in semiconductors, energy conversion and other related industries. Offered as AE 5333 and ME 5333. Credit will be granted only once.

ME 5335. OPTIMAL CONTROL OF DYNAMIC SYSTEMS. 3 Hours.
Linear and nonlinear optimization methods; optimal control; continuous time Ricatti equation; bang-bang control; singular arcs; differential inclusions; collocation techniques; design of optimal dynamic system trajectories. Offered as AE 5335 and ME 5335. Credit will be granted only once.

ME 5336. OPTIMAL ESTIMATION OF DYNAMIC SYSTEMS. 3 Hours.
Kalman filter design and implementation. Optimal filtering for discrete-time and continuous-time dynamical systems with noise. Wiener filtering. State-space determination. Offered as EE 6327, AE 5336 and ME 5336. Credit will be granted only once. Prerequisite: introductory systems or identification course is desirable. Also offered as AE 5336 and EE 6327. Credit will be granted only once.

ME 5337. INTRODUCTION TO ROBOTICS. 3 Hours.
An overview of industrial robots and applications to traditional and emerging applications. Coordinate systems and homogeneous transformations, kinematics of manipulators; motion characteristics and trajectories; dynamics and control of manipulators; actuation and design issues. Programming of industrial robotic manipulators in the laboratory. Offered as AE 5337 and ME 5337. Credit will be granted only once.

ME 5338. ANALYTICAL & COMPUTATIONAL DYNAMICS. 3 Hours.
The course focuses on developing the equations of motion for dynamic systems composed of multiple, connected and unconnected, rigid bodies using Kane's method and the Lagrangian approach. The resulting model is used to simulate and visualize the predicted motion. Topics include: kinematics, Euler parameters, kinematic constraints, virtual work, the calculus of variations, energy, momentum, contact, impact, and checking functions. Offered as AE 5338 and ME 5338. Credit will be granted only once.

ME 5339. INTERMEDIATE MECHANICS OF MATERIALS. 3 Hours.
This fundamental mechanics course covers the concepts of deriving stress formulas from deformation and the stress-strain relationship, stress and failure analysis, 2D elasticity, energy methods, and elastic stability. Offered as AE 5339 and ME 5339. Credit will be granted only once.

ME 5340. AUTOMOTIVE ENGINEERING. 3 Hours.
Introduction to automotive engine types and performance, drive train modeling and vehicle loading characteristics, fueling requirements, fuel injection systems, tire characteristics and modeling, suspension characteristics and handling, braking systems and requirements. Course taught through lecture, student presentations and student design projects.

ME 5341. CONTROL SYSTEM COMPONENTS. 3 Hours.
The components and hardware used in electronic, hydraulic, and pneumatic control systems; techniques of amplification, computation, compensation, actuation, and sensing; modeling of multiport systems as well as servo systems analysis. Pulse modulated systems. Offered as AE 5341 and ME 5341. Credit will be granted only once. Prerequisite:Undergraduate introductory control course in Mechanical Engineering or equivalent or ME 5303 or equivalent.

ME 5342. GAS DYNAMICS. 3 Hours.
Review of fundamental compressible flow theory, method of characteristics for perfect gases, the Rankine-Hugoniot conditions, linearized flow theory. Offered as AE 5342 and ME 5342. Credit will be granted only once. Prerequisite: MAE 3303 or equivalent.

ME 5344. VISCOUS FLOWS. 3 Hours.
Navier-Stokes equations and Prandtl's boundary layer approximations; laminar and turbulent boundary layers including internal and external flows.

ME 5345. NUMERICAL HEAT TRANSFER AND FLUID FLOW. 3 Hours.
Introduction to numerical solutions for problems in heat transfer and fluid flow by the finite-volume method. The focus will be on numerical aspects pertaining to incompressible fluids. It provides the background training towards the use of commercial software. Offered as AE 5345 and ME 5345. Credit will be granted only once.

ME 5347. HEAT EXCHANGER DESIGN. 3 Hours.
Design procedures, system evaluations and design parameters in heat exchangers. Heat exchanger configurations; student design projects.

ME 5352. FUNDAMENTALS IN ELECTRONIC PACKAGING. 3 Hours.
An introductory treatment of electronic packaging, from single chip to multichip, including materials, electrical design, thermal design, mechanical design, package modeling and simulation, processing considerations, reliability, and testing.

ME 5353. COMPUTATIONAL TECHNIQUES FOR ELECTRONIC PACKAGING. 3 Hours.
Characterization of the thermo/mechanical reliability of microelectronics devices using commercial computational heat transfer codes (Icepack, Flotherm, and ANSYS). Industry related problems ranging from first level packages through system level packages analyzed. Formulate and model contemporary problems using commercial CFD codes.

ME 5358. RACECAR ENGINEERING. 3 Hours.
This course intended for Formula SAE team members and other interested students to develop new systems or analyze concepts for the Formula SAE or Formula Electric racecar and related equipment. The students will form teams and perform research and development on projects related to automotive or racecar engineering.

ME 5359. APPLIED AUTOMOTIVE ENGINEERING. 3 Hours.
The purpose of this course is to gain practical experience in the design and fabrication of parts or systems for automotive applications. The student must write a proposal, give a public oral presentation, and prepare a formal final report. The student must have attained full team member status in a student design competition team. Prerequisites: permission of Director of the Arnold E. Petsche Center for Automotive Engineering.

ME 5362. INTRODUCTION TO MICRO AND NANOFLUIDICS. 3 Hours.
As going down to micro scales, the basic hypothesis in the macro scale fluid mechanics may not be applicable in such scales. The objectives of this course are: to identify dominant forces and their effects in micro scale fluid systems that are different from those in the macro scales; to understand the fundamentals of micro fluidic phenomena; to discuss various microfluidic applications in research and commercial levels; and to explore new possible microfluidic applications in the emerging fields. Topics include overview of microfluidics, scaling laws, violation limit of the Navier-Stokes equations, surface force, surface tension, electrowetting, electrokinetics, dielectrophoresis, and soft lithography. Prerequisite: MAE 2314 and MAE 3310 or equivalents.

ME 5363. INTRODUCTION TO ROTORCRAFT ANALYSIS. 3 Hours.
History of rotorcraft. Behavior of the rotor blade in hover and forward flight. Rotor configurations, dynamic coupling with the fuselage, elastic and aeroelastic effects. Offered as AE 5363 and ME 5363. Credit will be granted only once.

ME 5364. INTRODUCTION TO AERODYNAMICS OF ROTORCRAFT. 3 Hours.
Practical aerodynamics of rotors and other components of rotorcraft. Introduction to performance, handling qualities, and general flight mechanics related to rotorcraft design, test, and certification requirements. Emphasis is on rotorcraft mission capabilities as defined by the customer. Offered as AE 5364 and ME 5364. Credit will be granted only once.

ME 5365. INTRODUCTION TO HELICOPTER AND TILTROTOR SIMULATION. 3 Hours.
Dynamic and aerodynamic modeling of rotorcraft elements using vector mechanics, linear algebra, calculus and numerical methods. Special emphasis on rotors, aerodynamic interference, proper axis system representation, model assembly methods and trimming. Offered as AE 5365 and ME 5365. Credit will be granted only once.

ME 5366. FUEL CELLS AND APPLICATIONS. 3 Hours.
The course introduces: Principles and thermodynamics applied to fuel cell-based power generation systems; materials and manufacturing methods of two common fuel cells and their stacks; modeling, analysis, and design of fuel cells and various reformers; and design issue of balance of plants such as steam management systems.

ME 5374. NONLINEAR SYSTEMS ANALYSIS AND CONTROLS. 3 Hours.
Nonlinear systems; phase plane analysis; Poincare-Bendixon theorems; nonlinear system stability; limit cycles and oscillations; center manifold theorem, Lyapunov methods in control; variable structure control; feedback linearization; backstepping techniques. Offered as AE 5374 and ME 5374. Credit will be granted only once.

ME 5378. INTRODUCTION TO UNMANNED VEHICLE SYSTEMS. 3 Hours.
Introduction to UVS (Unmanned Vehicle Systems) such as UAS (Unmanned Aircraft Systems), UGS (Unmanned Ground System) and UMS (Unmanned Maritime System), their history, missions, capabilities, types, configurations, subsystems, and the disciplines needed for UVS development and operation. UVS missions could include student competitions sponsored by various technical organizations. This course is team-taught by engineering faculty. Offered as AE 5378 and ME 5378. Credit will be granted only once.

ME 5379. UNMANNED VEHICLE SYSTEM DEVELOPMENT. 3 Hours.
Introduction to the technologies needed to create an UVS (Unmanned Vehicle System). Integration of these technologies (embodied as a set of sensors, actuators, computing and mobility platform sub-systems) into a functioning UVS through team work. UVS could be designed to compete in a student competition sponsored by various technical organizations or to support a specific mission or function defined by the instructors. This course is team-taught by engineering faculty. Offered as AE 5379 and ME 5379. Credit will be granted only once. Prerequisite: B or better in MAE 4378 or AE 5378 or ME 5378 and admission to the UVS certificate program.

ME 5380. DESIGN OF DIGITAL CONTROL SYSTEMS. 3 Hours.
Difference equations, z- and w- transforms, discrete TF (Transfer Function). Discrete equivalence (DE) to continuous TF. Aliasing & Nyquist sampling theorem. Design by DE, root locus in z- plane & Youla parameterization. Discrete state- space model, minimality after sampling, pole placement, Moore-Kimura method, linear quadratic regulator, asymptotic observer. Computer simulation and/or laboratory implementation. Offered as EE 5324, AE 5380 and ME 5380. Credit will be granted only once. Prerequisite: undergraduate level controls course or equivalent. Also offered as AE 5380, EE 5324. Credit will be granted only once.

ME 5381. BOUNDARY LAYERS. 3 Hours.
An introductory course on boundary layers. The coverage emphasizes the physical understanding and the mathematical foundations of boundary layers, including applications. Topics covered include laminar and turbulent incompressible and compressible boundary layers, and an introduction to boundary layer transition. Offered as AE 5381 and ME 5381. Credit will be granted only once.

ME 5382. RESEARCH TRENDS IN RENEWABLE ENERGY TECHNOLOGIES. 3 Hours.
This course is offered to graduate and senior level undergraduate students with engineering and science background to introduce them to micro/nano research and development for energy conversion and storage. The course will cover topics such as Scaling laws, MEMS fabrication, Nanomaterial synthesis, Electrochemical energy storage/conversion (Batteries, Fuel Cells & Supercapacitors), Solar energy (photovoltaics and solar thermal energy), Energy harvesting and Solar water splitting and electrocatalysis.

ME 5386. WIND & OCEAN CURRENT ENERGY HARVESTING FUNDAMENTALS. 3 Hours.
A broad senior/graduate first course in wind/wave/ocean current energy harvesting systems, focused on fundamentals, and serving as the basis for subsequent MAE specialized follow-on graduate course offerings focused on structures (conventional and composite), aero/hydro-mechanical response and control, and tailoring and smart material actuation, respectively, as well as for non-MAE, specialized graduate courses. (also taught as AE 5386).

ME 5390. SPECIAL TOPICS IN MECHANICAL ENGINEERING. 3 Hours.
To provide formal instruction in special topics pertinent to Mechanical Engineering from semester to semester depending on the availability of faculty. May be repeated provided topics differ.

ME 5391. ADVANCED STUDIES IN MECHANICAL ENGINEERING. 3 Hours.
May be repeated for credit as topics change. Project work performed under a non-thesis degree will normally be accomplished under this course number, with prior approval of the Committee on Graduate Studies.

ME 5397. RESEARCH IN MECHANICAL ENGINEERING. 3 Hours.
Research in master's programs.

ME 5398. THESIS. 3 Hours.
Thesis.

ME 5698. THESIS. 6 Hours.
Thesis Prerequisite: GRAD ME thesis major.

ME 5998. THESIS. 9 Hours.
Thesis Prerequisite: GRAD ME thesis major.

ME 6196. MECHANICAL ENGINEERING INTERNSHIP. 1 Hour.
For students participating in internship programs. May be repeated for credit. Requires prior approval of ME Graduate Advisor.

ME 6197. RESEARCH IN MECHANICAL ENGINEERING. 1 Hour.
May be repeated for credit.

ME 6297. RESEARCH IN MECHANICAL ENGINEERING. 2 Hours.
May be repeated for credit.

ME 6299. DISSERTATION. 2 Hours.
Prerequisite: Admission to candidacy for the Doctoral of Philosophy degree.

ME 6304. ADVANCED MECHANICS OF MATERIALS. 3 Hours.
This graduate level course will cover the calculation of stresses and strains in a body that experiences hyperelastic, viscoelastic and plastic deformation. Offered as AE 6304 and ME 6304. Credit will be granted only once. Prerequisite: AE 5339, ME 5339, or instructor consent.

ME 6310. ADVANCED FINITE ELEMENT METHODS. 3 Hours.
Modeling of large systems, composite and incompressible materials, substructuring, mesh generation, solids applications, nonlinear problems. Offered as AE 6310 and ME 6310. Credit will be granted only once. Prerequisite: AE 5310, ME 5310, or instructor consent.

ME 6311. ADVANCED STRUCTURAL DYNAMICS. 3 Hours.
Normal mode method for undamped and proportionally damped systems, component mode synthesis, generally damped systems, complex modes, effect of design modification on system response. Offered as AE 6311 and ME 6311. Credit will be granted only once. Prerequisite: AE 5311, ME 5311, or instructor consent.

ME 6314. FRACTURE MECHANICS. 3 Hours.
Linear elastic fracture mechanics, energy of fracture, mixed mode crack propagation, fatigue crack growth, numerical methods for stress intensity factor determination, damage tolerance and durability design. Offered as AE 6314 and ME 6314. Credit will be granted only once. Prerequisite: AE 5339, ME 5339, or instructor consent.

ME 6315. ADVANCED COMPOSITES. 3 Hours.
This course introduces students to advanced mechanics of composites at various scales, including analysis and characterization methods. Emphasis is on advanced methods for material characterization; nonlinear constitutive relations; structural and microstructural analysis; and advanced materials and structures applications. Offered as AE 6315 and ME 6315. Credit will be granted only once. Prerequisite: AE 5315, ME 5315, or instructor consent.

ME 6316. COMPUTER AIDED DESIGN. 3 Hours.
Role of graphics; image representation, batch and interactive computing, methods of automated mathematical model generation in engineering design. Application in mechanical, structural, thermal, controls areas of mechanical engineering.

ME 6337. ADVANCED ROBOTICS. 3 Hours.
Advanced robotic design concepts considering structural statics, dynamics and control strategies for both rigid and flexible manipulators will be studied using optimization techniques and analytical approaches and introduction to micro- and mobile robotic devices. Study of emerging applications of robotics will be explored. Digital simulation of robotic devices and programming and demonstration of robotic devices in the laboratory. Prerequisites: AE 5337 or ME 5337 or equivalent.

ME 6344. HEAT TRANSFER IN TURBULENT FLOW. 3 Hours.
Introduction to heat transfer in turbulent boundary layers including internal and external flows, turbulence structure, the Reynolds analogy, van Driest hypothesis, high and low Prandtl number two equation model, effects of surface roughness on heat transfer. Also offered as AE 6344. Credit will be granted only once.

ME 6397. RESEARCH IN MECHANICAL ENGINEERING. 3 Hours.
May be repeated for credit.

ME 6399. DISSERTATION. 3 Hours.
May be repeated for credit.

ME 6697. RESEARCH IN MECHANICAL ENGINEERING. 6 Hours.
May be repeated for credit.

ME 6699. DISSERTATION. 6 Hours.
Prerequisite: Admission to candidacy for the Doctor of Philosophy degree.

ME 6997. RESEARCH IN MECHANICAL ENGINEERING. 9 Hours.
May be repeated for credit.

ME 6999. DISSERTATION. 9 Hours.
Admission to candidacy for the Doctor of Philosophy degree.

ME 7399. DOCTORAL DEGREE COMPLETION. 3 Hours.
This course may be taken during the semester in which a student expects to complete all requirements for the doctoral degree and graduate. Enrolling in this course meets minimum enrollment requirements for graduation, for holding fellowships awarded by The Office of Graduate Studies and for full-time GTA or GRA positions. Students should verify that enrollment in this course meets other applicable enrollment requirements. To remain eligible in their final semester of study for grants, loans or other forms of financial aid administered by the Financial Aid Office must enroll in a minimum of 5 hours as required by the Office of Financial Aid. Other funding sources may also require more than 3-hours of enrollment. Additional hours may also be required to meet to requirements set by immigration law or by the policies of the student's degree program. Students should contact the Financial Aid Office, other sources of funding, Office of International Education and/or their graduate advisor to verify enrollment requirements before registering for this course. This course may only be taken once and may not be repeated. Students who do not complete all graduation requirements while enrolled in this course must enroll in a minimum of 6 dissertation hours (6699 or 6999) in their graduation term. Graded P/F/R.