MECHANICAL ENGINEERING

The mechanical engineering program in the department of mechanical and aerospace engineering offers comprehensive graduate education in a number of areas. The principal areas include: dynamics and controls; manufacturing; materials and structures; mechanical design; and thermal and fluid systems. A wide variety of interdisciplinary programs meeting specific objectives are available. The mechanical engineering program offers the master of science, doctor of philosophy, and direct doctor of philosophy degrees. The department also offers several graduate certificate programs in both aerospace engineering and mechanical engineering.

The mechanical and aerospace engineering department has many well-equipped laboratories located on the main campus, and a subsonic-flow laboratory in an off-campus facility. Some of the specially equipped laboratories on campus include: aerospace flow laboratory; advanced machining laboratory, augmented reality laboratory, composite materials manufacturing and characterization laboratory, computational radiative transfer laboratory, convection heat transfer laboratory, electromechanical transducer development laboratory, environmental control group laboratory, fluid dynamics and combustion laboratories, internal combustion engine and spray laboratories, laboratory for industrial automation and flexible manufacturing, laser-based manufacturing laboratory, rapid prototyping laboratory, radiative heat transfer laboratory, robotics laboratory, structural health monitoring laboratory and welding laboratory.

Some examples of research areas a candidate could specialize in are: acoustics; biomechanics; combustion and I. C. engines; computational fluid dynamics; computer-aided design; design methodology; dynamics and controls; heating, ventilation and air-conditioning (environmental control); heat transfer; laser-aided manufacturing; manufacturing and machining processes; materials and structures; mechanisms and robotics; mechatronics; micro-electromechanical systems (MEMS); thermal-fluid and energy systems; tribology; virtual reality and rapid prototyping.

The master of science thesis program consists of a minimum of 30 credit hours, including the following requirements: at least 21 credit hours of lecture courses, at least 6 credit hours of MECH ENG 6099, at least 9 credit hours of lecture courses in the MAE department (of which at least 3 credit hours must be at the 6000-level), at least 3 credit hours of mathematics, statistics, or computer science (AERO ENG 5830/MECH ENG 5830 Applied Compt Methods may be used to satisfy this requirement), and at least 6 credit hours of 6000-level lecture courses. A master of science non-thesis program consists of a minimum of 30 credit hours, including the following requirements: at least 24 credit hours in the MAE department and at least 9 credit hours of 6000-level lecture courses (of which at least 6 credit hours must be in the MAE department). Note that no course below the 5000-level may be applied to the degree requirements.

A student pursuing the doctor of philosophy degree normally follows a program of 72 semester hours beyond the B.S. degree or 42 semester hours beyond the M.S. degree. For those with M.S. degree, the 42 hours will consist of 18 hours of course work and 24 hours of thesis research. The Ph.D. course work must satisfy the departmental core course requirements for the M.S. degree. For the 18 hours of course work, a minimum of 12 hours must be completed within the department and at least three credit hours of mathematics/statistics. At least nine credit hours of course work must be at the 6000-level in the major field of study. In addition to these course requirements, a candidate must prepare a dissertation based on analytical and/or experimental research in a major area. This research must be equivalent to a minimum of 24 hours beyond the M.S. degree. There are no foreign language requirements for the master of science, doctor of engineering and doctor of philosophy degrees in mechanical engineering. However, a reading knowledge of one foreign language, German, French or Russian, may be required for the doctor of philosophy degree if the candidate's advisory committee feels that it is necessary.

A candidate for the degree of doctor of philosophy must pass a qualifying examination. The qualifying examination consists of taking a minimum of nine credit hours of approved graduate course work at the 5000- and 6000-level, including six hours in the major field, of which three hours must be at the 6000-level, and three hours of mathematics/statistics. To pass the qualifying examination, a student must have obtained a grade of B or better for all the courses with a GPA of at least 3.25.

A student holding a B.S. degree and pursuing the direct doctor of philosophy degree must complete at least 72 total credit hours, including the following requirements: at least 36 credit hours of lecture courses, at least 36 credit hours of MECH ENG 6099, at least 21 credit hours of course work in the MAE department, at least 6 credit hours of mathematics, statistics, or computer science (AERO ENG 5830/MECH ENG 5830 Applied Computational Methods may be used to satisfy three credit hours of this requirement), and at least 15 credit hours of 6000-level courses (of which at least 9 credit hours must be in the MAE department). In addition to these course requirements, a candidate must prepare a dissertation based on analytical, numerical, and/or experimental research. Note that no course below the 5000-level may be applied to the degree requirements.

A candidate for the degree of doctor of philosophy must pass a qualifying examination. The candidate is considered to have passed the qualifying examination if the candidate has taken at least four courses and has a GPA ≥ 3.5 at the end of the candidate's fourth semester. At least two courses must be in the MAE department, one of which must be at the 6000-level.

A candidate for the degree of doctor of engineering must complete the equivalent of three years (six semesters) of full-time work beyond the bachelor's degree for a total of at least 90 semester hours. The six semesters must include a minimum of two semesters in residence at Missouri S&T with a graduate registration of at least 12 hours per semester. At least two semesters above the M.S. must be in residence at Missouri S&T with a registration of at least six hours per semester. The course work must be directed toward two major engineering areas plus one area from the physical sciences, mathematics, or another field of engineering. In addition, a non-technical group of courses of 9 to 12 hours is required. The formal course work is expected to consist of at least 65 hours (the average is 72 hours). In addition to the formal course work, the candidate is expected to complete an internship with an industrial organization. This internship will consist of a minimum of one year of planned and approved high-level engineering experience. At the end of the internship period, the candidate will prepare a dissertation which will earn from 18 to 25 hours credit and will be included in the total of 90 hours for the degree of doctor of engineering.

A candidate for the degree of doctor of philosophy must pass a qualifying examination. The candidate is considered to have passed the qualifying examination if the candidate has taken at least four courses and has a GPA ≥ 3.5 at the end of the candidate's fourth semester. At least two courses must be in the MAE department, one of which must be at the 6000-level. The candidate must also pass a comprehensive examination and a final examination, which consists of the dissertation defense. These examinations are conducted according to the rules of the graduate faculty and the department. The graduate faculty has residency requirements which must be satisfied by all doctoral students.

The mechanical and aerospace engineering department offers five graduate certificate programs. The certificate program consists of a four-course sequence from existing graduate-level courses. The graduate certificate program is available to all individuals holding a B.S. degree in an appropriate engineering discipline who have a minimum of two years of professional experience or are currently accepted into a graduate degree program in the mechanical and aerospace engineering department. While the students admitted to the certificate program will have non-matriculated status, if they complete the four-course sequence with a grade of B or better in each of the courses taken, they will be admitted to the M.S. program if they so choose. The certificate credits taken by students admitted to the M.S. program will count toward their master's degrees. Currently, most classes offered in the graduate certificate are offered over the internet.

Composite Materials and Structures

Students enrolled in this graduate certificate program will take three required courses and one elective course offered by the mechanical and aerospace engineering graduate degree programs. Alternative courses may be substituted with the departmental approval dependent on the availability of the courses listed below:

Required courses:	
MECH ENG 5236/ AERO ENG 5236	Fracture Mechanics
MECH ENG 5282/ AERO ENG 5282	Introduction to Composite Materials & Structures
MECH ENG 6284/ AERO ENG 6284	Analysis of Laminated Composite Structures
Choose one of the following:	
MECH ENG 5212/ AERO ENG 5212	Introduction to Finite Element Analysis
MECH ENG 6222/ AERO ENG 6222	Theory of Elasticity
MECH ENG 6230	Theory and Design of Plate and Shell Structures

Control Systems

Students pursuing a graduate certificate in control systems will select two courses from Group I and two courses from Group II.

Group I	
Select two of the following:	
AERO ENG 5361	Flight Dynamics-Stability And Control
MECH ENG 5481/ AERO ENG 5481	Mechanical And Aerospace Control Systems
MECH ENG 5001/ AERO ENG 5001	Special Topics
MECH ENG 6479/ AERO ENG 6479	Analysis And Synthesis Of Mechanical And Aerospace Systems
Group II	
Select two of the following:	
AERO ENG 5361	Flight Dynamics-Stability And Control
ELEC ENG 5300	Digital Control
ELEC ENG 6300	Linear Control Systems
ELEC ENG 6310	Optimal Control And Estimation

Energy Conversion and Transport

A total of four courses from the list below are required for successful completion of the certificate. At least two of these courses must be from core MECH ENG or AERO ENG graduate courses (5000-level) and at least one must be an advanced course (6000-level).

Choose at least two of the following courses:	
MECH ENG 4001/ AERO ENG 4001/ NUC ENG 4001/ PHYSICS 3001	Special Topics
MECH ENG 4001/ AERO ENG 4001	Special Topics
MECH ENG 5131/ AERO ENG 5131	Intermediate Thermofluid Mechanics
MECH ENG 5139/ AERO ENG 5139	Computational Fluid Dynamics
MECH ENG 5525/ AERO ENG 5525	Intermediate Heat Transfer
MECH ENG 5527/ AERO ENG 5527	Combustion Processes
MECH ENG 5533	Internal Combustion Engines
AERO ENG 5535	Aerospace Propulsion Systems
MECH ENG 5541	Applied Energy Conversion
MECH ENG 5566	Solar Energy Technology
Choose at least one of the following courses:	
MECH ENG 6123/ AERO ENG 6123	Viscous Fluid Flow
MECH ENG 6131/ AERO ENG 6131	Gas Dynamics I
MECH ENG 6135/ AERO ENG 6135	Turbulent Flows - Theory, Measurements and Modeling
MECH ENG 6137/ AERO ENG 6137	Physical Gas Dynamics I
MECH ENG 6527/ AERO ENG 6527	Heat Transfer by Convection
Choose one of the following courses:	
MECH ENG 4001/ AERO ENG 4001/ NUC ENG 4001/ PHYSICS 3001	Special Topics
MECH ENG 4001/ AERO ENG 4001	Special Topics
MECH ENG 5527/ AERO ENG 5527	Combustion Processes
MECH ENG 5131/ AERO ENG 5131	Intermediate Thermofluid Mechanics
MECH ENG 5541	Applied Energy Conversion
MECH ENG 5139/ AERO ENG 5139	Computational Fluid Dynamics
MECH ENG 5566	Solar Energy Technology
AERO ENG 5535	Aerospace Propulsion Systems
MECH ENG 5525/ AERO ENG 5525	Intermediate Heat Transfer
MECH ENG 5533	Internal Combustion Engines
MECH ENG 6123/ AERO ENG 6123	Viscous Fluid Flow
MECH ENG 6527/ AERO ENG 6527	Heat Transfer by Convection
MECH ENG 6131/ AERO ENG 6131	Gas Dynamics I
MECH ENG 6135/ AERO ENG 6135	Turbulent Flows - Theory, Measurements and Modeling

MECH ENG 6137/ AERO ENG 6137	Physical Gas Dynamics I

Engineering Mechanics

Students enrolled in this graduate certificate program will have a choice from the following list of courses offered to graduate students in mechanical or aerospace engineering:

MECH ENG 5211	Introduction To Continuum Mechanics
MECH ENG 5212/ AERO ENG 5212	Introduction to Finite Element Analysis
MECH ENG 5220/ AERO ENG 5220	Advanced Mechanics of Materials
MECH ENG 5234/ AERO ENG 5234	Stability of Engineering Structures
MECH ENG 5236/ AERO ENG 5236	Fracture Mechanics
MECH ENG 5238/ AERO ENG 5238	Fatigue Analysis
MECH ENG 5282/ AERO ENG 5282	Introduction to Composite Materials & Structures
MECH ENG 6212/ AERO ENG 6212	Advanced Finite Element Analysis
MECH ENG 6222/ AERO ENG 6222	Theory of Elasticity
MECH ENG 6230	Theory and Design of Plate and Shell Structures
MECH ENG 6284/ AERO ENG 6284	Analysis of Laminated Composite Structures

Manufacturing Automation

Students pursuing a graduate certificate in manufacturing automation through the mechanical engineering program will complete the following:

Required course:	
MECH ENG 5655	Manufacturing Equipment Automation
Select three of the following:	
ELEC ENG 5340	Advanced PLC
ELEC ENG 5350	Plantwide Process Control
MECH ENG 5478/ AERO ENG 5478/ COMP ENG 5820/ ELEC ENG 5870	Mechatronics
MECH ENG 5481/ AERO ENG 5481	Mechanical And Aerospace Control Systems
MECH ENG 5653	Computer Numerical Control of Manufacturing Processes
MECH ENG 5763	Computer Aided Design: Theory and Practice
MECH ENG 6653	Advanced Cnc Of Manufacturing Processes & Engineering Metrology
MECH ENG 6655	Modeling And Control Of Manufacturing Processes

David Bayless, Professor and Chair
PHD University of Illinois-Urbana
Air pollution control, algae, algal bio-fuels, alternative fuel, bio-reactor, biodiesel, blue-green algae, coal, energy, gassification of coal and biomass, leadership development, mechanical engineering, power generation, shale and shale energy.

Richard Billo, Director of the Kummer Institute Center for Advanced Manufacturing, Distinguished Professor of Mechanical and Aerospace Engineering
PHD Arizona State University

Victor Birman, Emeritus Professor
PHD Technion, Haifa, Israel
Composite material structures, smart structures and materials, structural dynamics and vibration, buckling and dynamic stability.

Douglas A Bristow, Professor
PHD University of Illinois Urbana-Champaign
Dynamic modeling and control of micro- and nano-positioning systems, atomic force microscopes and additive manufacturing systems; volumetric error compensation; iterative learning control, multi-dimensional control, and signal processing.

Douglas Carroll, Professor
PHD University of Missouri-Rolla

K Chandrashekhara, Curators Distinguished Professor
PHD Virginia Polytechnic Institute
Composite materials, smart structures, structural dynamics, finite element analysis, composite manufacturing and experimental characterization.

L R Dharani, Curators Distinguished Professor
PHD Clemson University
Micromechanics of bi-material interfaces, composite materials, fracture mechanics, fatigue and failure analysis of welded structures, wear and friction in composites, fracture and failure of laminated glass.

Xiangyang Dong, Assistant Professor
PHD Purdue University
Mechanics/microstructural evolution of advanced manufacturing and; materials processing, multiscale modeling of materials by bridging first-principles calculations, molecular dynamics simulations,and finite element methods, materials design and manufacturing processes of composite and ceramics, relationships between the microstructure, properties, and processing of materials.

James A Drallmeier, Curators Distinguished Teaching Professor Emeritus
PHD University of Illinois Urbana-Champaign
Combustion, laser based diagnostics for sprays and combustion, optical measurement systems, fuel injection, and internal combustion engines.

Xiaosong Du, Assistant Professor
PHD Iowa State University
Machine learning, deep learning, rapid aerodynamic forward/inverse/robust design, single-/multi-fidelity predictive modeling, analysis and decision making under uncertainty.

Fateme Fayyazbakhsh, Assistant Research Professor
PHD Amirkabir University of Technology-Tehran Polytechnic
Smart biomaterials, biofabrication, wound healing, medical device commercialization.

Kelly O Homan, Associate Professor
PHD University of Illinois Urbana-Champaign
Fluid dynamics, heat transfer and thermodynamics of energy systems, heat and mass transfer in buoyant flows, second-law and energy analysis, numerical simulation of transport phenomena and experimental methods.

Umit O Koylu, Professor
PHD University of Michigan
Combustion, environmental technology, soot formation, turbulent flames, laser diagnostics, flame radiation, formation and emission of pollutants, synthesis of nanoparticles, micro-energy systems.

K Krishnamurthy, Professor
PHD Washington State University
Advanced manufacturing systems, intelligent control, micro-electromechanical systems, nanotechnology, robotics.

Ming C Leu, Keith & Pat Bailey Distinguished Professor
PHD University of California-Berkeley
Rapid prototyping, intelligent manufacturing, virtual reality, CAD/CAM, robotics, mechatronics, automatic control.

Zhi Liang, Associate Professor
PHD Missouri University of Science and Technology
Micro/nanoscale thermodynamics and heat transfer, dynamics of nanodroplets, nanobubbles, and nanoparticles, structure-property relationship for materials and interfaces, and computational modeling.

Fue-Wen Frank Liou, Michael and Joyce Bytnar Product Innovation and Creativity Professor, Director of Manufacturing Engineering Program
PHD University of Minnesota at Twin Cities
Computer-aided design and manufacturing, rapid prototyping, rapid manufacturing, virtual manufacturing, and micro-machining.

Ashok Midha, Professor, Director of the Product Innovation Creativity Center
PHD University of Minnesota at Twin Cities
Mechanical design, rigid-body and compliant mechanism design, high-performance machinery analysis and design, machine vibration and stability.

J Keith Nisbett, Associate Professor
PHD University of Texas-at Arlington
Kinematics, mechanical design, and synthesis of mechanisms.

Anthony Chukwujekwu Okafor, Professor
PHD Michigan Technological University
Manufacturing including intelligent machining, metal forming, machine tool dynamics, acoustic emission, sensors, multi-sensor fusion and signal processing, CNC, CAD/CAM, virtual manufacturing, machine tool metrology, neural network and expert system applications; smart structures including intelligent health monitoring, damage assessment of composite structures; non-destructive evaluation.

Jonghyun Park, Associate Professor
PHD University of Michigan-Ann Arbor
Advanced li-ion battery, beyond li-ion battery, energy storage systems, renewable energy systems, grid energy storage systems, nano-/macro-mechanics of materials, self-assembly of nanoparticles, nanostructures, multiphysics/multiscale experiment and simulations.

Yun Seong Song, Associate Professor
PHD Massachusetts Institute of Technology
Physical Human-Robot Interaction (pHRI), Physical Human-Human Interaction (pHHI), Human Movement Assistance, Rehabilitation Robotics, Wearable Devices, Energy-Harvesting from Human Movement, Design and Instrumentation of Medical Devices.

Daniel S Stutts, Associate Professor
PHD Purdue University
Dynamics, vibrations, modeling and development of piezo-actuators and transducers-mechatronics, mechanics of bone, design of orthopedic implants, structural dynamics, optimal design, acoustics.

Xiaodong Yang, Professor, Associate Chair of Graduate Affairs
PHD Columbia University
Optical materials and devices in nanophotonics and plasmonics; physics and applications of optical metamaterials; nanoscale optomechanics, optical nanoelectromechanical systems (NEMS); integrated optofluidic devices and optical sensors; photon management for solar/thermal energy harvesting; optical device micro-/nano-fabrication.

MECH ENG 5000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MECH ENG 5001 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title. (Co-listed with Aero Eng 5001).

MECH ENG 5131 Intermediate Thermofluid Mechanics (LEC 3.0)
Derivation of Navier-Stokes equations, analytical solutions of viscous flows; flow in pipes, flow networks; intermediate treatment of boundary layer theory; micro-fluidics and MEMS; introduction to numerical methods for solving fluid flows; and, preliminary treatise on turbulence. Prerequisite: Mech Eng 3131 or Aero Eng 3131. (Co-listed with Aero Eng 5131).

MECH ENG 5139 Computational Fluid Dynamics (LEC 3.0)
Introduction to the numerical solution of the Navier-Stokes equations, by finite difference methods, in both stream function-vorticity and primitive variable formulations. Course format emphasizes student development of complete computer programs utilizing a variety of solution methods. Prerequisites: Comp Sci 1570 or Comp Sci 1970 or Comp Sci 1971 or Comp Sci 1972; one course in fluid mechanics. (Co-listed with Aero Eng 5139).

MECH ENG 5211 Introduction To Continuum Mechanics (LEC 3.0)
Introductory cartesian tensor analysis to aid in the development of the theory of a continuum. Kinematics of deformation, stress tensor, equations of motion, equations of mass and energy balance. Examples from specific material theories in solid and fluid mechanics. Prerequisites: Civ Eng 2210, Math 3304.

MECH ENG 5212 Introduction to Finite Element Analysis (LEC 3.0)
Variational formulation of the governing equations. Finite element model, interpolation functions, numerical integration, assembly of elements and solution procedures. Applications to solid mechanics, fluid mechanics and heat transfer problems. Two-dimensional problems. Computer implementation and use of commercial finite element codes. Prerequisites: Math 3304; senior or graduate standing. (Co-listed with Aero Eng 5212).

MECH ENG 5229 Smart Materials And Sensors (LAB 1.0 and LEC 2.0)
Smart structures with fiber reinforced polymer (FRP) composites and advanced sensors. Multi-disciplinary topics include characterization, performance, and fabrication of composite structures; fiber optic, resistance, and piezoelectric systems for strain sensing; and applications of smart composite structures. Laboratory and team activities involve manufacturing, measurement systems, instrumented structures, and performance tests on a large-scale smart composite bridge. Prerequisites: Senior standing and Math 3304. (Co-listed with Aero Eng 5229, Elec Eng 5270 and Civ Eng 5118).

MECH ENG 5234 Stability of Engineering Structures (LEC 3.0)
Solution of stability problems with applications to columns, plates and shell structures. Torsional and lateral buckling of columns. Buckling under high temperatures. Effect of imperfections introduced by a technological process on stability. Design issues related to stability requirements. Prerequisites: Civ Eng 2210; Math 3304; and Mech Eng 2350 or Mech Eng 2360 or Aero Eng 2360. (Co-listed with Aero Eng 5234).

MECH ENG 5236 Fracture Mechanics (LEC 3.0)
Linear elastic and plastic mathematical models for stresses around cracks; concepts of stress intensity; strain energy release rates; correlation of models with experiment; determination of plane stress and plane strain parameters; application to design. Prerequisite: Civ Eng 2210. (Co-listed with Aero Eng 5236).

MECH ENG 5238 Fatigue Analysis (LEC 3.0)
The mechanism of fatigue, fatigue strength of metals, fracture mechanics, influence of stress conditions on fatigue strength, stress concentrations, surface treatment effects, corrosion fatigue and fretting corrosion, fatigue of joints, components and structures, design to prevent fatigue. Prerequisite: Civ Eng 2210. (Co-listed with Aero Eng 5238).

MECH ENG 5282 Introduction to Composite Materials & Structures (LEC 3.0)
Introduction to fiber-reinforced composite materials and structures with emphasis on analysis and design. Composite micromechanics, lamination theory and failure criteria. Design procedures for structures made of composite materials. An overview of fabrication and experimental characterization. Prerequisite: Civ Eng 2210. (Co-listed with Aero Eng 5282).

MECH ENG 5307 Vibrations I (LEC 3.0)
Equations of motion, free and forced vibration of single degree of freedom systems and multidegree of freedom systems. Natural frequencies, resonance, modes of vibration and energy dissipation are studies. The vibration of continuous systems is introduced. Prerequisites: Mech Eng 3411 and 3313, or Aero Eng 3613 and Math 3304. (Co-listed with Aero Eng 5307).

MECH ENG 5309 Engineering Acoustics I (LEC 3.0)
Introduction to acoustical theory and measurement with emphasis on mechanical and aerospace engineering applications. Plane and spherical wave propagation, resonators and filters, absorption, room acoustics, human response to noise, noise legislation, noise control. Use of common instrumentation in several projects. Prerequisites: Mech Eng 3411 and 3313, or Aero Eng 3613 and Math 3304. (Co-listed with Aero Eng 5309).

MECH ENG 5313 Intermediate Dynamics Of Mechanical And Aerospace Systems (LEC 3.0)
Principles of dynamics are applied to problems in the design of mechanical and aerospace systems; basic concepts in kinematics and dynamics; dynamics of systems of particles; dynamics of rigid bodies, three-dimensional effects in machine elements; dynamic stability, theory and applications; methods of analytical dynamics. Prerequisite: Mech Eng 3313 or Aero Eng 3613. (Co-listed with Aero Eng 5313).

MECH ENG 5420 Signal Processing for Instrumentation and Control (LEC 3.0)
The course presents fundamental techniques for analysis and processing of experimental data and real-time signals. Continuous- and discrete-time development of signal spectra, Fourier Transform, convolution, filter design, and system identification. The emphasis is on practical problems that arise in instrumentation and control applications. Prerequisites: Math 3304; Mech Eng 3411 or permission of instructor for non-Mech Eng majors.

MECH ENG 5449 Robotic Manipulators and Mechanisms (LAB 1.0 and LEC 2.0)
Overview of industrial applications, manipulator systems and geometry. Manipulator kinematics; hand location, velocity and acceleration. Basic formulation of manipulator dynamics and control. Introduction to machine vision. Projects include robot programming, vision-aided inspection and guidance, and system integration. Prerequisites: Mech Eng 3313; Comp Sci 1970 or Comp Sci 1971 or Comp Sci 1972 or Comp Sci 1570. (Co-listed with Aero Eng 5449).

MECH ENG 5478 Mechatronics (LAB 1.0 and LEC 2.0)
This course will introduce students to the basics of mechatronics (i.e., the integration of mechanical, electrical, computer, and control systems). Students will learn the fundamentals of sensors and actuators for mechanical systems, computer interfacing, microcontrollers, real-time software, and control. Prerequisite: Mech Eng 4479 or equivalent. (Co-listed with Aero Eng 5478, Elec Eng 5870 and Comp Eng 5820).

MECH ENG 5479 Machine Learning for Manufacturing Automation (LEC 3.0)
Principles of machine learning, machine learning techniques (support vector machines, regression analysis, recurrent and convolution neural networks, autoencoders, deep reinforcement learning), applications (anomaly detection, computer vision, robotics). Prerequisites: Mech Eng 4479 or Mech Eng 5313 or Aero Eng 3361 or Aero Eng 5313; and Comp Sci 1972. (Co-listed with Aero Eng 5479).

MECH ENG 5481 Mechanical And Aerospace Control Systems (LEC 3.0)
Synthesis of mechanical and aerospace systems to perform specific control functions. Response and stability are studied. Singular value analysis for stability margins is introduced. Prerequisite: Mech Eng 4479 or Aero Eng 3361. (Co-listed with Aero Eng 5481).

MECH ENG 5519 Advanced Thermodynamics (LEC 3.0)
After a short review of classical thermodynamics, the elements of chemical reactions, chemical equilibrium, statistical thermodynamics, and the basic concepts of kinetic theory are presented. Prerequisite: Mech Eng 2519. (Co-listed with Aero Eng 5519).

MECH ENG 5525 Intermediate Heat Transfer (LEC 3.0)
Analytical study of conduction; theory of thermal radiation and applications; energy and momentum equations in convective heat transfer and review of empirical relations. Current topics are included. Prerequisite: Mech Eng 3525. (Co-listed with Aero Eng 5525).

MECH ENG 5527 Combustion Processes (LEC 3.0)
Application of chemical, thermodynamic, and gas dynamic principles to the combustion of solid, liquid, and gaseous fuels. Includes stoichiometry, thermochemistry, reaction mechanism, reaction velocity, temperature levels, and combustion waves. Prerequisite: Mech Eng 3521. (Co-listed with Aero Eng 5527).

MECH ENG 5533 Internal Combustion Engines (LEC 3.0)
A course dealing primarily with spark ignition and compression ignition engines. Topics include: thermodynamics, air and fuel metering, emissions and their control, performance, fuels, and matching engine and load. Significant lecture material drawn from current publications. Prerequisite: Mech Eng 3521.

MECH ENG 5537 Fuel Cell Principles (LEC 3.0)
Fuel cell fundamentals including thermodynamics, reaction kinetics, mass transport, characterization, and modeling are discussed. Different types of fuel cells such as proton exchange membrane and solid oxide are covered together with subsystem design and system integration as well as environmental impacts. Prerequisites: MECH ENG 3521.

MECH ENG 5539 Modeling Across Scales in Computational Mechanics (LEC 3.0)
Basic principles of computational mechanics, focusing on modeling and simulation on various length scales. The goal is to mathematically represent mechanical and material behavior, and to effectively solve those equations. Fundamental principles of continuum and sub-continuum (atomic) models will be learned through lectures and hands-on Matlab coding. Prerequisites: Civ Eng 2210, Mech Eng 2519, or consent of instructor for majors that do not require either of these courses; or graduate standing. (Co-listed with Aero Eng 5539).

MECH ENG 5541 Applied Energy Conversion (LEC 3.0)
The study of the principles of energy conversion. Specific applications include fuel cells and other direct energy conversion devices used in plug-in hybrid electric vehicles. Prerequisite: Mech Eng 3521.

MECH ENG 5543 Energy Efficiency of Vehicles (LEC 3.0)
Course topics include the energy consumption, energy efficiency, pollution and carbon emissions of vehicles. Energy efficiency models are developed to illustrate how to optimize the energy efficiency of vehicles. Detailed models are developed for gasoline, diesel, electric and hybrid-electric cars and trucks. Prerequisites: Math 2222, Physics 2135.

MECH ENG 5544 Non-Intrusive Measurement Methods (LEC 3.0)
Fundamentals of non-contact measurement methods for engineers. Basic engineering optics with a focus on radiation measurement methods including the effects of various sources and detectors. Prerequisites: Phys 2135; Mech 3525 or consent of instructor for non-Mech Eng majors.

MECH ENG 5566 Solar Energy Technology (LEC 3.0)
Introduction to the nature of solar radiation and associated thermal energy transfers. Methods of collecting and storing solar energy. Analysis and design of systems for utilizing solar energy, including heating and cooling. Prerequisite: Mech Eng 3525, or consent of instructor for non-Mech Eng majors.

MECH ENG 5567 Heat Pump And Refrigeration Systems (LEC 3.0)
The various methods used in the thermal design and analysis of both refrigeration and heat pumps systems are investigated. Various methods of producing heating and cooling are examined including vapor compression, absorption, air cycle, steam jet, and thermoelectric systems. Prerequisites: Mech Eng 3521, 3525.

MECH ENG 5570 Plasma Physics I (LEC 3.0)
Single particle orbits in electric and magnetic fields, moments of Boltzmann equation and introduction to fluid theory. Diffusion of plasma in electric and magnetic fields. Analysis of laboratory plasmas and magnetic confinement devices. Introduction to plasma kinetic theory. Prerequisite: Aero Eng 3131 or Mech Eng 3131 or Physics 3211 or Nuc Eng 3221 or Elec Eng 3600. (Co-listed with Aero Eng 5570, Nuc Eng 4370, Physics 4543).

MECH ENG 5571 Environmental Controls (LEC 3.0)
Theory and applications of principles of heating, ventilating, and air conditioning equipment and systems; design problems. Physiological and psychological factors relating to environmental control. Prerequisites: Mech Eng 3521 and accompanied or preceded by Mech Eng 3525; or Mech Eng 2527 and Civ Eng 3330.

MECH ENG 5575 Mechanical Systems For Environmental Control (LEC 3.0)
Analysis of refrigeration, heating, and air-distribution systems. Synthesis of environmental control systems. Prerequisites: Mech Eng 3521 and 3525; or Mech Eng 2527 and Civ Eng 3330.

MECH ENG 5606 Material Processing By High-Pressure Water Jet (LEC 3.0)
Methods of generating high pressure water jets; standard equipment, existing techniques, and basic calculations. Application of water jets to materials cutting and mineral processing. Safety rules. The course will be supported by laboratory demonstrations. Prerequisite: Mech Eng 3131 or undergraduate fluids course. (Co-listed with Min Eng 5413).

MECH ENG 5653 Computer Numerical Control of Manufacturing Processes (LAB 1.0 and LEC 2.0)
Fundamental theory and application of computer numerical controlled machine tools from the viewpoint of design principles, machine structural elements, control systems, and programming. Projects include manual and computer assisted part programming and machining. Prerequisites: Preceded or accompanied by Mech Eng 3653.

MECH ENG 5655 Manufacturing Equipment Automation (LAB 1.0 and LEC 2.0)
Manufacturing automation at the equipment level. Topics include sensors, actuators, and computer interfacing for manufacturing equipment, dynamic modeling and control of manufacturing equipment, interpolation, coordinated motion control, kinematic and geometric error modeling, and runout. Prerequisites: Preceded or accompanied by Mech Eng 4479 or equivalent.

MECH ENG 5656 Design For Manufacture (LEC 3.0)
Course covers the approach of concurrent product and process design. Topics includes: principle of DFM, New product design process, process capabilities and limitations, Taguchi method, tolerancing and system design, design for assembly and AI techniques for DFM. Prerequisites: Mech Eng 3708, Mech Eng 3653.

MECH ENG 5702 Synthesis Of Mechanisms (LEC 3.0)
Synthesis of planar mechanisms for function generation, path generation, and motion generation. Emphasis is on analytical methods for synthesis. Prerequisite: Mech Eng 3313.

MECH ENG 5704 Compliant Mechanism Design (LEC 3.0)
Introduction to compliant mechanisms; review of rigid-body mechanism analysis and synthesis methods; synthesis of planar mechanisms with force/energy constraints using graphical and analytical methods; pseudo-rigid-body models; force-deflection relationships; compliant mechanism synthesis methods; and special topics, e.g. bistable mechanisms, constant-force mechanisms, parallel mechanisms, and chain algorithm in design. Emphasis will be on applying the assimilated knowledge through a project on compliant mechanisms design. Prerequisites: Mech Eng 3313, Civ Eng 2210.

MECH ENG 5708 Rapid Product Design And Optimization (LEC 3.0)
Product Life cycle design; Finding design solutions using optimization technique; Rapid product realization using rapid prototyping and virtual prototyping techniques. Prerequisite: Mech Eng 3708.

MECH ENG 5709 Machine Design II (LEC 3.0)
A continuation of the study of machine elements; bearings, spur, bevel, worm, and helical gearing, and indeterminate machine elements; impact and shrink stresses. Prerequisite: Mech Eng 3708.

MECH ENG 5715 Concurrent Engineering (LEC 3.0)
Students will be introduced to the concurrent engineering approach to product development. They will learn to set up quantitative requirements and then use a quantitative rating process to identify the critical requirements relating to the desired product. The interaction between design, manufacturing, assembly, cost, and supportability will be covered. The students will form teams and practice the concurrent engineering process for simple products. Prerequisites: Mech Eng 3313 or Aero Eng 3131, and Civ Eng 2210. (Co-listed with Aero Eng 5715).

MECH ENG 5757 Integrated Product And Process Design (LEC 3.0)
Emphasize design policies of concurrent engineering and teamwork, and documenting of design process knowledge. Integration of product realization activities covering important aspects of a product life cycle such as "customer" needs analysis, concept generation, concept selection, product modeling, process development, and end of product life options. Prerequisites: Junior or above standing. (Co-listed with ENG MGT 5515).

MECH ENG 5760 Probabilistic Engineering Design (LEC 3.0)
The course deals with uncertainties in engineering analysis and design at three levels - uncertainty modeling, uncertainty analysis, and design under uncertainty. It covers physics-based reliability analysis and reliability-based design, robustness assessment and robust design, their integration with design simulations, and their engineering applications. Prerequisite: Mech Eng 3708 or Aero Eng 3361. (Co-listed with Aero Eng 5760).

MECH ENG 5761 Engineering Design Methodology (LEC 3.0)
This course examines structured engineering design theory and methodologies for conceptual design and redesign of products. Topical coverage includes customer needs gathering, functional modeling, engineering specifications creation (OFD), concept generation, selection and design embodiment. Team work/hands-on projects emphasized. Prerequisite: At least Senior standing in engineering.

MECH ENG 5763 Computer Aided Design: Theory and Practice (LAB 1.0 and LEC 2.0)
Lectures cover the fundamentals of computer-aided design with emphasis on geometric modeling of curves, surfaces and solids, CAD/CAM data exchange, and computer graphics. In the lab session, students practice with commercial CAD/CAM systems including NX and SolidWorks to gain practical experience. Prerequisites: Comp Sci 1570 or Comp Sci 1970 or Comp Sci 1971 or Comp Sci 1972; Mech Eng 2761; Math 2222; at least Junior standing.

MECH ENG 5830 Applied Computational Methods (LEC 3.0)
Detailed study of computational methods for efficient solution of selected fluids, structures, thermodynamics, and controls problems in aerospace and mechanical engineering. Besides basic numerical techniques, topics covered include gradient-based optimization and uncertainty quantification. Prerequisite: Comp Sci 1570 or Comp Sci 1970 or Comp Sci 1971 or Comp Sci 1972; Math 3304. (Co-listed with Aero Eng 5830).

MECH ENG 6000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of the instructor required.

MECH ENG 6001 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MECH ENG 6010 Seminar (LEC 0.0-1.0)
Discussion of current topics. (Co-listed with Aero Eng 6010).

MECH ENG 6040 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/ comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

MECH ENG 6050 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

MECH ENG 6099 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

MECH ENG 6123 Viscous Fluid Flow (LEC 3.0)
Fundamentals of viscous fluids for incompressible and compressible flows governed by Navier-Stokes equations; exact, approximate, and numerical solutions for steady and unsteady laminar flows; boundary layer theory for incompressible and compressible flows; stability and transition. Prerequisite: Mech Eng 5131 or Aero Eng 5131 or Mech Eng 5139 or Aero Eng 5139 or equivalent. (Co-listed with Aero Eng 6123).

MECH ENG 6131 Gas Dynamics I (LEC 3.0)
A critical analysis of the phenomena governing the flow of a compressible fluid; introduction to flow in two and three dimensions; Prandil-Meyer expansions; small perturbations in subsonic and supersonic flows; method of characteristics. Prerequisite: Mech Eng or Aero Eng 5131. (Co-listed with Aero Eng 6131).

MECH ENG 6135 Turbulent Flows - Theory, Measurements and Modeling (LEC 3.0)
Navier-Stokes equations; statistical description and mean-flow equations; behavior of free shear and wall bounded flows; the energy cascade; turbulence spectra and Kolmogorov hypothesis; measurement techniques: PIV, hot-wires, LDV; turbulence modeling for transport processes and closure schemes for RANS equations; evaluation of model constants, introduction to LES, DNS and hybrid-RANS. Prerequisite: Mech Eng 5131 or Aero Eng 5131 or Mech Eng 5139 or Aero Eng 5139 or equivalent. (Co-listed with Aero Eng 6135).

MECH ENG 6137 Physical Gas Dynamics I (LEC 3.0)
Features of high temperature gas flows including the development of the necessary background from kinetic theory, statistical mechanics, chemical thermodynamics and chemical kinetics. Equilibrium and non-equilibrium gas properties and gas flows are included. Prerequisite: Mech Eng or Aero Eng 5131. (Co-listed with Aero Eng 6137).

MECH ENG 6212 Advanced Finite Element Analysis (LEC 3.0)
Higher order, isoparametric and mixed finite elements. Eigenvalue and time-dependent problems. Solution procedures for dynamic analysis. Implicit and explicit methods. Applications to viscous incompressible fluid and plate bending problems. Three-dimensional problems. Nonlinear finite element analysis. Practical applications using commercial software. Prerequisite: Mech Eng 5212 or Aero Eng 5212. (Co-listed with Aero Eng 6212).

MECH ENG 6222 Theory of Elasticity (LEC 3.0)
Formulation and study of boundary-value problems in 2-D linear elastostatics: Equilibrium and compatibility. Stress function formulations in Cartesian and polar coordinates. Curved beam, wedge and plane contact problems. Dislocations and cracks. Thermoelasticity. Prerequisites: CIV ENG 2210. (Co-listed with Aero Eng 6222).

MECH ENG 6230 Theory and Design of Plate and Shell Structures (LEC 3.0)
Theoretical backgrounds of plate and cylindrical shell structures. Extensive coverage of design issues with the emphasis on practical problems in diverse areas of engineering. Strength, buckling and dynamics of plates manufactured from metals and composites. Review of thermoelastic applications. Prerequisite: Civ Eng 2210, Math 3304.

MECH ENG 6236 Advanced Fracture Mechanics (LEC 3.0)
Mathematical theories of equilibrium cracks and brittle fracture, mathematical analysis of elastic-plastic fracture mechanics, COD, R-curve and J-integral analysis. Prerequisite: Aero Eng 5236 or Mech Eng 5236.

MECH ENG 6284 Analysis of Laminated Composite Structures (LEC 3.0)
An overview of isotropic beams, plates, and shells. Bending, vibration, and buckling of laminated composite beams and plates: exact and approximate solutions. Development of composite shell theory and simplified solutions. Analysis of composite structures including transverse shear deformation and thermal effects. Prerequisite: Mech Eng 5282 or Aero Eng 5282. (Co-listed with Aero Eng 6284).

MECH ENG 6307 Advanced Vibrations (LEC 3.0)
Advanced treatment of discrete and continuous vibratory systems. Extensive use is made of matrix methods and operator notation. Special topics include: transmission matrices, relative coordinates, time dependent boundary conditions, approximate techniques for linear systems, nonlinear systems, and random excitations. Prerequisite: Mech Eng or Aero Eng 5307. (Co-listed with Aero Eng 6307).

MECH ENG 6410 Optimal Control and Estimation (LEC 3.0)
Review of linear quadratic regulators, LQR extensions; constrained optimization (Pontragin's minimum principle); review of probability theory and random processes; optimal prediction and filters; frequency domain properties of LQR and Kalman filters; linear quadratic Gaussian (LQG) control; model uncertainties, frequency shaping, LQG/LTR design methodology. Prerequisites: Elec Eng 6300 or Mech Eng 5481 or Aero Eng 5481. (Co-listed with Aero Eng 6410 and Elec Eng 6310).

MECH ENG 6420 Nonlinear Control Systems (LEC 3.0)
Numerical solution methods, describing function analysis, direct and indirect methods of Liapunov stability, applications to the Lure problem - Popov circle criterion. Applications to system design and feedback linearizations. Prerequisite: Elec Eng 6300. (Co-listed with ELEC ENG 6320).

MECH ENG 6430 Robust Control Systems (LEC 3.0)
Performance and robustness of multivariable systems, linear fractional transformations, LQG/LTR advanced loop shaping, Youla parameterization, H (subscript infinity) optimal control, mixed H (subscript 2) and H (subscript infinity) control, controller synthesis for multiple objective optimal control, linear matrix inequalities theory and case studies. Prerequisite: Elec Eng 6300 or Mech Eng 5481 or Aero Eng 5481. (Co-listed with Aero Eng 6430 and Elec Eng 6330).

MECH ENG 6447 Markov Decision Processes (LEC 3.0)
Introduction to Markov Decision Processes and Dynamic Programming. Application to Inventory Control and other optimization and control topics. Prerequisite: Graduate standing in background of probability or statistics. (Co-listed with Comp Eng 6310, Mech Eng 6447, Eng Mgt 6410, Sys Eng 6217 and Comp Sci 6202).

MECH ENG 6458 Adaptive Dynamic Programming (LEC 3.0)
Review of Neurocontrol and Optimization, Introduction to Approximate Dynamic Programming (ADP), Reinforcement Learning (RL), Combined Concepts of ADP and RL - Heuristic Dynamic Programming (HDP), Dual Heuristic Programming (DHP), Global Dual Heuristic Programming (GDHP), and Case Studies. Prerequisites: Elec Eng 5370 or Comp Eng 5310. (Co-listed with Comp Eng 6320, Elec Eng 6360, Aero Eng 6458 and Sys Eng 6215).

MECH ENG 6470 Adaptive Control (LEC 3.0)
Intro to adaptive control, Lypunov stability, positive real and strictly positive real, Kalman-Yukabovich lemma, system identification, direct/indirect adaptive control, adaptive observers, adaptive control design, nonlinear adaptive design tools-adaptive control with multiple models, adaptive neural network control, decentralized adaptive control design. Prerequisites: Elec Eng 6300. (Co-listed with ELEC ENG 6370).

MECH ENG 6479 Analysis And Synthesis Of Mechanical And Aerospace Systems (LEC 3.0)
A unified treatment of modern system theory for the Mechanical and Aerospace Engineering Controls Analyst, including analysis and synthesis of linear and nonlinear systems, compensation and optimization of continuous and discrete systems, and theory of adaptivity. Prerequisite: Mech Eng 5481 or Aero Eng 5481. (Co-listed with Aero Eng 6479).

MECH ENG 6481 Advanced Topics in Decision and Control (LEC 3.0)
This course will deal with latest topics in the areas of decision and control. Course may be repeated if topics vary. Prerequisite: Aero Eng 5481 or Mech Eng 5481 or equivalent. (Co-listed with Aero Eng 6481).

MECH ENG 6526 Micro-/Nano-Scale Thermophysics and Energy Transport (LEC 3.0)
Introduces advanced statistical thermodynamics, nonequilibrium thermodynamics, kinetic theory, and quantum theory to analyze thermophysics and energy transport for microscale and nanoscale systems. Covers the fundamental concepts of photons, electrons, and phonons in the forms of waves and particles. Includes applications to ultrafast laser processing. Prerequisite: Mech Eng 5525.

MECH ENG 6527 Heat Transfer by Convection (LEC 3.0)
An analytical study of convective heat transfer in laminar and turbulent flows; forced convection, natural convection, and mixed convection; combined heat and mass transfer; heat transfer with change of phase; instability of laminar flow; current topics in convection. Prerequisite: Mech Eng or Aero Eng 5525. (Co-listed with Aero Eng 6527).

MECH ENG 6585 Advanced Optical Materials and Structures (LEC 3.0)
Fundamental principles and advanced topics in optical materials and structures covering areas of photonics, plasmonics and metamaterials, and nanofabrication techniques. Prerequisite: Elec Eng 5200 or equivalent.

MECH ENG 6653 Advanced Cnc Of Manufacturing Processes & Engineering Metrology (LAB 1.0 and LEC 2.0)
Advanced treatment of Computer Numerical Control (CNC) part programming and machine tool metrology. Topics include mathematical modeling and characterization of machine tools and Coordinate Measuring Machines (CMMs); Measurement and analysis of dimensional accuracy, surface finish, precision, and uncertainty; Machine tool error modeling and compensation; Virtual Numerical Control (VNC) Machine Tool modeling, programming, simulation and process verification/optimization. Projects include advanced CNC programming and simulation. Prerequisite: Mech Eng 5653.

MECH ENG 6657 Laser Aided Manufacturing And Materials Processing (LEC 3.0)
Fundamental studies in laser aided manufacturing and materials processing including laser principles and optics, physics of laser-materials interaction, interface responses for rapid solidification, theories on non-equilibrium synthesis, modeling of transport phenomena, optical sensing techniques, current topics and considerations for lasers in manufacturing. Prerequisite: Mech Eng 5519. (Co-listed with Aero Eng 6657).

MECH ENG 6659 Advanced Topics in Design and Manufacturing (LEC 3.0)
Various topics in the area of design and manufacturing will be covered in this course: development of flexible manufacturing systems, CAD/CAM integration, rapid prototyping, etc. Prerequisites: Mech Eng 5655 or Mech Eng 5708 or equivalent.

MECH ENG 6663 Advanced Digital Design and Manufacturing (LEC 3.0)
This course covers freeform modeling, reverse engineering, numerical control path generation for material removal and addition, and virtual reality based digital design and manufacturing. Students learn theoretical and fundamental aspects of these topics from lectures and project exercises. Prerequisites: Mech Eng 5708 or Mech Eng 5757 or Mech Eng 5763 or equivalent.

MECH ENG 6704 Mechanics of Machinery (LEC 3.0)
Rigid-body kinematics, dynamics, and synthesis of mechanisms; cam-follower mechanisms; mathematical modeling of mechanisms containing elastic elements; transient and steady-state vibration response; parametric instability in elastic mechanisms; advanced topics in compliant mechanisms; high performance mechanisms will be emphasized. Prerequisites: Vector & matrix analysis; introductory planar kinematic & dynamic analysis of mechanisms; MECH ENG 5704 or equivalent.