

# MECHANICAL ENGINEERING

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The opportunities and challenges in the field of mechanical engineering are many and diverse. The broad variety of career possibilities includes research and development, design analysis and synthesis, manufacturing and production engineering, testing, sales engineering, maintenance and administration. The challenge of a mechanical engineer may lie in the perfection of a device that will be duplicated a million-fold or in the control optimization of a single complex system of unique design. To prepare undergraduate students for these opportunities, the Wayne State University Mechanical Engineering curriculum is designed to give a basic core education in the humanities, mathematics, natural sciences, basic applied sciences, engineering fundamentals, and to provide advanced electives in many applied fields.

Fields of departmental expertise include such important areas as biomechanics, energy conversion, combustion engines, emissions controls, structural analysis, automatic controls, robotics, thermodynamics, continuum mechanics, fluid dynamics, vibrations, heat transfer, mechanisms, acoustics and noise control, design, machine tool design, manufacturing, laser diagnostics, and mechanics of composite materials. Research and teaching is carried out in all of these areas.

ABIANEH, OMID SAMIMI: Ph.D. and M.S., University of Alabama-Huntsville; Assistant Professor

ARAVA, LEELA: Ph.D., Indian Institute of Technology Madras, India; M.S., B.S., Sri Venkateswara University, India ; Assistant Professor

AYORINDE, EMMANUEL: Ph.D., M.S., B.S., University of Nottingham; Associate Professor

BERDICHEVSKY, VICTOR L.: Ph.D., M.S.c, Moscow State University; Professor

BRYZIK, WALTER: Ph.D., M.S., B.S., University of Detroit; Professor Emeritus

CHALHOUB, NABIL: Ph.D., University of Michigan; M.S., B.S., Wayne State University; Professor and Chair

DINDA, GURU PRASAD: Ph.D., Saarland University; M.Tech., Indian Institute of Technology; B.E., National Institute of Technology; Assistant Professor

EAGLE, W. ETHAN: Ph.D., University of Michigan; M.S. and B.S., University of Maryland; Assistant Professor

GIBSON, RONALD: Ph.D., University of Minnesota; M.S., University of Tennessee; B.S., University of Florida; Professor Emeritus

HENEIN, NAEIM A.: Ph.D., University of Michigan; M.S., Alexandria University; B.S., Cairo University; Distinguished Professor

IBRAHIM, RAOUF A.: Ph.D., University of Edinburgh; M.S., B.S., University of Cairo; Professor Emeritus

JANSONS, MARCIS: Ph.D., B.S., Rutgers University; M.S., New Jersey Institute of Technology; Associate Professor

KLINE, K.A.: Ph.D., B.S., University of Minnesota; Professor Emeritus

KU, JERRY C.: Ph.D., M.S., State University of New York at Buffalo; B.S., Tatung Institute of Technology; Associate Professor

LAI, MING-CHIA: Ph.D., M.S., Pennsylvania State University; Professor

NEWAZ, GOLAM M.: Ph.D., M.S., University of Illinois at Urbana-Champaign; B.S., Texas A & M University; Professor

OZBEKI, Mohammad Ali E.: Ph.D., Penn State University; M.B.A., University of Detroit Mercy; M.S., University of Michigan; Lecturer

PYLYPCHUK, VALERY: Dr. Sci., Moscow Institute for Problems in Mechanics, Russian Academy of Sciences; Lecturer

SINGH, TRILOCHAN: Ph.D., M.S., University of California; B.S., Punjabi University; Professor Emeritus

TAN, CHIN-AN: Ph.D., B.S., University of California - Berkeley; M.S., California Institute of Technology; Professor

TARAZA, DINU: Ph.D., B.S., Polytechnic Institute of Bucharest; Professor Emeritus

WU, SEAN-FENG: Ph.D., M.S.M.E., Georgia Institute of Technology; Distinguished Professor

WU, XIN: Ph.D., M.S., University of Michigan; Associate Professor

- Mechanical Engineering (B.S.) (<http://bulletins.wayne.edu/undergraduate/college-engineering/mechanical-engineering/mechanical-engineering-bs>)

## ME 2200 Thermodynamics Cr. 3

Transformation of heat energy to other energy forms. Basic concepts and laws of thermodynamics. Thermodynamic properties and processes for simple substances. Applications to power and refrigeration cycles. No credit after ME 2210. Offered Fall, Winter.

**Prerequisites:** MAT 2020 with a minimum grade of C- and PHY 2175 with a minimum grade of C- and May be taken concurrently. BE 1300 with a minimum grade of C- and May be taken concurrently. BE 1310 with a minimum grade of C- and BE 1500 with a minimum grade of C-

## ME 2410 Statics Cr. 3

Basic concepts and principles of statics with applications to Newton's Laws of Motion to engineering problems. Forces, moments, equilibrium, couples, free body diagrams, trusses, frames, fluid statics, friction, area and mass moment of inertia. Offered Every Term.

**Prerequisites:** MAT 2020 with a minimum grade of C- and PHY 2175 with a minimum grade of C- and BE 1500 with a minimum grade of C-

**Equivalent:** CE 2410

## ME 2420 Elementary Mechanics of Materials Cr. 3

Elastic relationships between external forces acting on deformable bodies and the associated stresses and deformations; structural members subjected to axial load, torsion, and bending; column buckling; combined stresses; repeated loads; unsymmetrical bending. Offered Every Term.

**Prerequisites:** ME 2410 with a minimum grade of C- or CE 2410 with a minimum grade of C-

**Equivalent:** CE 2420

## ME 2500 Numerical Methods Using MATLAB Cr. 2

Developing numerical solutions for engineering problems using MATLAB. Evaluation of alternative approaches to the numerical solutions in terms of accuracy and efficiency. Offered Fall, Spring/Summer.

**Prerequisites:** BE 1500 with a minimum grade of C- and MAT 2030 with a minimum grade of C- and May be taken concurrently. MAT 2150 with a minimum grade of C-

**ME 3300 Fluid Mechanics: Theory and Laboratory Cr. 4**

Introduction to the nature and physical properties of fluids, statics, equation of motion, incompressible inviscid flow, dimensional analysis, incompressible one-dimensional compressible channel flow. Experiments to supplement lectures. Offered Fall, Winter.

**Prerequisites:** ME 2410 with a minimum grade of C- and BE 2550 with a minimum grade of C- or ME 2500 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**ME 3400 Dynamics Cr. 3**

Basic concepts and principles of dynamics with application of Newton's Laws of Motion to engineering problems. Kinematics and kinetics of particles and rigid and variable-mass bodies. Equations of motion, impulse-momentum, impact and work-energy principles. Offered Fall, Winter.

**Prerequisites:** ME 2410 with a minimum grade of C- and ME 2500 with a minimum grade of C- and MAT 2150 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**ME 3450 Manufacturing Processes I Cr. 3**

A study of the field of manufacturing processes from a mechanical engineering design standpoint. Topics include: processing of metals, polymers and ceramics, and computer-aided manufacturing. Offered Fall, Winter.

**Prerequisites:** BE 1500 with a minimum grade of C- and ME 2420 with a minimum grade of C- and BE 1300 with a minimum grade of C- and BE 1310 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**Course Material Fees:** \$25

**Equivalent:** IE 3450

**ME 4150 Design of Machine Elements Cr. 4**

Static body stresses, strain and deflection, failure theories, introduction to impact loading and fatigue. Design of common mechanical elements: threaded fasteners, rivets, welding and bonding, springs, lubrication and sliding bearings, rolling element bearings. Offered Every Term.

**Prerequisites:** ME 3450 with a minimum grade of C- and BE 2100 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**Course Material Fees:** \$40

**ME 4210 Heat Transfer: Theory and Laboratory Cr. 4**

Fundamental concepts and basic modes of heat transfer. General equation of heat conduction, steady state heat conduction on one and more dimensions. Transient heat conduction. Heat transfer by radiation, Kirchoff's law and the black body. Radiation between diffuse surfaces. Radiation from gases, vapors and flames. Introduction to heat convection; concept of heat transfer coefficient and Nusselt number. Lab experiments to supplement lectures. Offered Fall, Winter.

**Prerequisite:** ME 3300 with a minimum grade of C- and ENG 3050 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**Course Material Fees:** \$25

**ME 4300 Thermal Fluid Systems Design Cr. 4**

Design of thermal-fluid systems to meet system performance requirements, computer-aided design, system simulation, design optimization including investment economics. Offered Fall, Winter.

**Prerequisite:** ME 4210 with a minimum grade of C- and ENG 3060 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the College of Engineering; enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**Course Material Fees:** \$40

**ME 4410 Vibrations: Theory and Laboratory Cr. 4**

Fundamentals of dynamic principles, energy relation and Rayleigh's principle. Undamped and damped free vibration of one degree of freedom systems. Forced vibrations with harmonic excitation. Vibration isolation, critical speed of shafting. Experiments to supplement theory. Offered Fall, Winter.

**Prerequisite:** ME 3400 with a minimum grade of C- and ENG 3050 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**Course Material Fees:** \$25

**ME 4420 Dynamic Modeling and Control of Engineering System Cr. 4**

Mathematical modeling of linear, lumped, time-invariant systems, open and closed loop systems, single-input-single-output system design using root locus method. Offered Fall, Winter.

**Prerequisite:** ME 3400 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**ME 4500 Mechanical Engineering Design II Cr. 4**

**Satisfies General Education Requirement:** Writing Intensive Competency  
Involve teamwork on semester-long open-ended design project. Develop design concepts based on various design theories, analyze alternative solutions and identify "best design solution" within given constraints. Students perform patent literature search, design, fabricate, develop and test prototypes. Perform product verification and validation. Require submission of formal progress reports, a final written report and a public presentation. Course satisfies Writing Intensive course requirement. Offered Fall, Winter.

**Prerequisites:** ME 4150 with a minimum grade of C- or ME 4250 with a minimum grade of C- and ENG 3060 with a minimum grade of C- and BE 2250 with a minimum grade of C- or ME 2500 with a minimum grade of C- and May be taken concurrently: ME 4410 with a minimum grade of C-  
**Restriction(s):** Enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**Course Material Fees:** \$50

**ME 5000 Engineering Analysis I Cr. 4**

Applications of ordinary differential equations. The method of Frobenius, Bessel functions, Legendre polynomials. Orthogonality of characteristic functions. Fourier series and Fourier integrals. Characteristics and solutions of partial differential equations. Method of separation or variations. Applications to initial and boundary value problems in engineering. Offered Fall.

**Course Material Fees:** \$5

**ME 5040 Finite Element Methods I Cr. 4**

Introduce finite element methods and review solid mechanics concepts and formalisms, variational methods and potential energy principles. Emphasize the basic understanding of the finite element method including its physical and mathematical principles, numerical procedures and their implementation. Define displacement-based formulations of spring, bar, beam, plane strain and plane stress elements along with isoparametric element formulation, assembly of elements and solution of global stiffness equations. Offered Fall, Winter.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5100 Quantitative Physiology Cr. 4**

Basic principles of human physiology presented from the engineering perspective. Bodily functions, their regulation and control discussed in quantitative terms and illustrated by mathematical models where feasible. Offered Fall, Winter.

**Equivalent:** BME 5010, CHE 5100, ECE 5100

**ME 5110 Fundamental Fuel Cell Systems Cr. 4**

Introduce various types of fuel cells, materials properties of electrodes and polymeric membranes, and electrochemical mechanisms. Reforming of various types of hydrocarbon fuel to hydrogen, and reforming technology. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Equivalent:** AET 5110, CHE 5110, EVE 5130

**ME 5115 Fundamentals of Electric-drive Vehicle Engineering Cr. 4**

Cover engineering fundamentals and basic design of electric-drive vehicle powertrains by understanding and analyzing the relevant multi-physics and applying the associated equations and simple models. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Equivalent:** EVE 5110

**ME 5120 Fundamentals of Alternative Energy Technology Cr. 4**

Provide an overview/review of thermodynamics. Cover advanced thermodynamics topics of energy and chemical reacting systems. Introduce general areas of alternative energy technology, engineering analysis and design of solar angle/time/radiation, solar heating, solar photovoltaic, and wind power. Offered Winter.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Equivalent:** AET 5120

**ME 5160 Musculoskeletal Biomechanics Cr. 4**

Structure and properties of the major tissue components of the musculoskeletal system and evaluation of how tissues combine to provide support and motion to the body. Offered Fall.

**Prerequisite:** BME 5010 with a minimum grade of C or BMS 6550 with a minimum grade of C

**Equivalent:** BME 5210

**ME 5170 Design of Human Rehabilitation Systems Cr. 4**

Design, fabrication and testing of customized hardware to aid handicapped patients. Offered Fall.

**ME 5180 Introduction to Biomaterials Cr. 4**

Introduction to study of both biological materials (bone, muscle, etc.) and materials for medical applications. Topics include tissue properties and effects of pathology, biocompatibility, and design considerations. Offered Winter.

**Prerequisites:** BE 1300 with a minimum grade of C- and BME 5010 with a minimum grade of C- or BMS 6550 with a minimum grade of C

**Equivalent:** BME 5370

**ME 5210 Convective and Radiative Heat Transfer Cr. 4**

Introduce radiative processes, properties of solids, radiative heat transfer among surfaces in an enclosure and gas radiation. Derive energy equation for laminar flows. Apply semi-empirical correlations for forced and free convection of laminar and turbulent flows. Implement analytical methods for convective heat transfer and heat exchange analysis. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5215 Fundamentals of Battery Systems for Electric and Hybrid Vehicles Cr. 4**

Covers fundamental electrochemistry and engineering aspects for electric propulsion batteries including lead acid, nickel metal hydride, lithium ion and capacitor technologies. Offered Winter.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Equivalent:** AET 5310, CHE 5120, EVE 5120

**ME 5300 Intermediate Fluid Mechanics Cr. 4**

Introduce fluid kinematics entailing vector field, potential flows, vorticity along with the computation of particle trajectory in a given velocity field and near stagnation points. Define basics of fluid dynamics including stress tensor in fluids, Navier-Stokes equations, Euler's equations, properties of solutions of Euler's equations, Bernoulli's integral and role of viscosity. Extend the analysis to two-dimensional potential flows and vortex flows. Offered Winter.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5330 Advanced Thermal Fluid System Design Cr. 4**

Involve teamwork on semester-long open-ended design project of thermal fluid systems to meet performance requirements using sound design process and system engineering approach. Apply engineering principles and computational design software to analyze and optimize system or subsystem processes. Offered Fall, Winter.

**Prerequisites:** ENG 3060 with a minimum grade of C- and ME 4210 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the College of Engineering.

**Course Material Fees:** \$40

**ME 5400 Dynamics II Cr. 4**

Cover three-dimensional kinematics and kinetics of rigid bodies, Euler angles, angular momentum, D'Alembert Principle, equations of motion in general rotating coordinate frames. Derive Lagrange's equation of motion for particles and rigid bodies. Introduce Lagrange multipliers, holonomic and non-holonomic constraints, virtual work principle, and Hamilton's Principle. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Course Material Fees:** \$10

**ME 5410 Vibrations II Cr. 4**

Review the vibration response of two-degree-of-freedom systems including frequency response function. Extend the analysis to multi-degree-of-freedom systems including eigenvalues (natural frequencies) and orthogonality of eigenvectors (normal modes). Introduce numerical and experimental modal analysis techniques. Formulate the boundary-value problem for the vibration of continuous structural elements such as rods, strings, and beams. Offered Winter.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5425 Analysis of Vibration Movements and Instrumentation Cr. 4**

Basic tools and instrumentation, such as spectral analyzers to measure and analyze vibration time histories of excitation and response signals (stationary or non-stationary) in the time and frequency domains. Fast Fourier transform, frequency time analyses. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Course Material Fees:** \$20

**ME 5440 Industrial Noise Control Cr. 4**

Basic and advanced measurement techniques to acquire various acoustic quantities in a non-ideal environment including measurements of pressure, power and intensity of sound levels, reverberation time, absorption, coefficients of materials, room acoustics, and modal analysis. Cover noise reduction and control strategies for engineering applications. Offered Fall.

**Restriction(s):** Enrollment limited to students in the College of Engineering.

**ME 5453 Automotive Manufacturing Systems and Processes Cr. 4**

Introduce principles and methodologies of automotive assembly systems and processes. Cover operation management, quality management, principle of system development, planning and analysis of assembly systems and supportive functions, assembly processes, automatic and manual operations, management of tooling development and honing processes of sheet metal parts. Offered Spring/Summer.

**Prerequisite:** ME 3450 with a minimum grade of C- or ME 4250 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5460 Fundamentals in Acoustics and Noise Control Cr. 4**

Introduce principles of sound generation, propagation and interaction with solid boundary surfaces, as well as engineering noise control applications. Gain hands-on experience on simulating sound radiation and interactions with solid boundaries, and estimating sound transmission through partitions. Offered Every Other Fall.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5465 Lasers for Medical Applications Cr. 3**

Summarizes the wealth of recent research on the principles, technologies and application of lasers in diagnostics, therapy and surgery. Includes an overview of optics, optical components used in a typical laser, key principles of lasers and radiation interactions with tissue. The respective types of the laser (solid state, gas, dye, and semiconductor) are reviewed to provide an understanding of the wide diversity, and therefore, the large possible choice of these devices for a specific diagnosis, treatment, or surgery. Offered Winter.

**Equivalent:** BME 5460, PHY 5460

**ME 5500 Advanced Engineering Design Cr. 4**

**Satisfies General Education Requirement:** Writing Intensive Competency

Involve teamwork on semester-long open-ended design project. Develop design concepts based on various design theories, analyze alternative solutions and identify "best design solution" within given constraints. Students perform patent literature search, design, fabricate, develop and test prototypes. Perform product verification and validation. Require submission of formal progress reports, a final written report and a public presentation. Course satisfies Writing Intensive course requirement. Offered Fall, Winter.

**Prerequisites:** BE 2550 with a minimum grade of C-, ENG 3060 with a minimum grade of C-, and ME 4250 with a minimum grade of C-

**Course Material Fees:** \$50

**ME 5580 Computer-Aided Mechanical Design Cr. 4**

Introduce aspects of constraint-based solid modeling and parametric modeling using Unigraphics, Solid Edge, I-DEAS and Pro-E. Develop intelligent solid models with application to data management and sheet metal design. Introduce computer-aided simulation and manufacturing. Offered Spring/Summer.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5620 Fracture Mechanics in Engineering Design Cr. 4**

Introduce linear and nonlinear fracture mechanics principles and their applications to structural design. Formulate fracture parameters based on energy methods and stress-intensity factors for linear elastic fracture mechanics (LEFM), J-Integral and crack tip opening displacement (CTOD) for elastic plastic fracture mechanics (EPFM). Introduce design concepts based on failure assessment diagram and damage tolerance. Cover crack growth mechanisms, crack closure and crack retardation concepts. Offered Fall, Winter.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5700 Fundamentals of Mechanics Cr. 4**

Introduce Lagrangian and Hamiltonian classical mechanics. Derive thermodynamics laws from mechanics. Cover continuum kinematics and basics of tensor analysis, continuum mechanics (basic laws; thermodynamics of continuum media; classical continuum models). Offered Winter.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Course Material Fees:** \$5

**ME 5720 Mechanics of Composite Materials Cr. 4**

Develop a comprehensive understanding of analytical models of micro-mechanical and macro-mechanical behavior of composite materials. Conduct stiffness, strength, hydrothermal, laminate, viscoelastic, dynamic behavior and fracture analyses. Introduce experimental characterization procedures for mechanical behavior evaluation. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5730 Tribology and Lubrication Technology Cr. 4**

Introduce friction, wear, and lubrication fundamentals including wear mechanisms, application of coatings, surface engineering fundamentals, measurement of surface topological features and surface wear. Offered Yearly.

**ME 5780 Products Liability Introduction for Engineers Cr. 1**

Application of engineering practice to minimize products liability exposure. Stages of a products liability lawsuit; how engineers may be involved at different stages of the process. Offered Yearly.

**Restriction(s):** Enrollment limited to students with a class of Applicant Masters, Candidate Masters or Senior; enrollment limited to students in the College of Engineering.

**Equivalent:** IE 5780

**ME 5800 Combustion Engines Cr. 4**

Cover thermodynamics and cycle analysis of spark and compression ignition engines. Introduce combustion processes in actual systems, engine performance characteristics and engine modeling. Offered Fall, Winter.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5810 Combustion and Emissions Cr. 4**

Define air quality and emissions standards. Cover fundamentals of emission formation in combustion systems, wall quenching and imperfect combustion, unburned hydrocarbons, carbon monoxide, aldehydes, nitrogen oxides, species stratification in the combustion chamber, and particulates. Discuss the effects of design parameters and engine operating variables on emission formation. Introduce chemical kinetics simulation. Offered Winter.

**Prerequisite:** ME 5800 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5820 Thermal Environmental Engineering Cr. 4**

Design and analyze heating, ventilating and air-conditioning systems. Introduce moist air properties calculations, heat transfer and transmission coefficients, heating load, cooling load, heating and cooling equipment, duct design, fans, air distribution, and refrigeration principles. Offered Spring/Summer.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**ME 5900 National Design Competition Projects Cr. 1-4**

Offered Every Term.

**Repeatable for 998.99 Credits**

**ME 5990 Directed Study Cr. 1-4**

Offered Every Term.

**Repeatable for 6 Credits**

**ME 5992 Research Experiences for Undergraduates Cr. 1-4**

Offered for undergraduate credit only. Offered Intermittently.

**Restriction(s):** Enrollment is limited to Undergraduate level students.

**Repeatable for 6 Credits**

**ME 5995 Special Topics in Mechanical Engineering I Cr. 1-4**

Topics to be announced in Schedule of Classes . Offered Intermittently.

**Restriction(s):** Enrollment limited to students in the College of Engineering.

**Repeatable for 8 Credits**

**ME 6180 Biomedical Instrumentation Cr. 4**

Engineering principles of physiological measurements, signal conditioning equipment, amplifiers, recorders and transducers. Recent advances in instrumentation. Offered Winter.

**Prerequisites:** BME 5020 with a minimum grade of C and ECE 3300 with a minimum grade of C or BME 5010 with a minimum grade of C or BMS 6550 with a minimum grade of C

**Equivalent:** BME 6480, ECE 6180

**ME 6550 Modeling and Control of Dynamic Systems Cr. 4**

Introduce state-space representation of dynamical systems, apply Lyapunov stability criteria, and examine controllability and observability of systems. Design linear state feedback controllers using pole-placement technique and formulate full- and reduced-order linear state observers such as Luenberger observer. Design linear model following controller and linear quadratic optimal controllers. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Course Material Fees:** \$5

**ME 6991 Internship in Industry Cr. 1-4**

Written report describing internship experience. Offered Every Term.

**Repeatable for 4 Credits**