MECHANICAL ENGINEERING (ME)

ME 97: Special Topics

1-9 Credits/Maximum of 9

Formal courses given infrequently to explore, in depth, a comparatively narrow subject that may be topical or of special interest.

ME 101: Toy Fundamentals: First-Year Seminar

1 Credits

First-Year Seminar focusing on toy design and manufacture. M E 101S Toy Fundamentals (1)(FYS) Toy Fundamentals is a First-Year Seminar intending to be an introduction to engineering design and prototyping through a product type everyone has used: toys! This five-week class explores the history of toys, marketing, toy design for different ages, and includes toy dissection, design, prototyping and field testing. It will run in the first 5 weeks of the semester.

First-Year Seminar

ME 102: Smart Lego Robots & Design

1 Credits

First-Year Seminar focusing on the development of technology exploration kits for middle-school-aged children. M E 102S Toys for Technology Exploration: First-Year Seminar (1) This is a First-Year Seminar that focuses on an important sub-group of toys. "Learning-by-doing" is a recognized method for improving student's learning in grades K-12 (and in college!). As part of "Toys for Technology Exploration", existing hands-on kits used for science and math education for ages 10-14 will be reviewed. The new standards for science and technology education in Pennsylvania are used to guide new hands-on kit designs, and these designs will be prototyped and field-tested with public school students.Note: Class size, frequency of offering, and evaluation methods will vary by location and instructor. For these details check the specific course syllabus.

First-Year Seminar

ME 103: HYBRID ELECTRIC VEHICLES

1 Credits

Students in this first-year seminar will be exposed to the design, fabrication, and testing of advanced powertrain vehicles and other cutting-edge automotive technologies. This project-based, group-based course gives students the opportunity to become a member of one of the technical departments within the overall Penn State Advanced Vehicle student team and encourages students to interact with upper-class members of that department. In addition to technical skills, emphasis is placed on soft skills required of today's professional engineers including: presentation creation, public speaking, and technical writing.

First-Year Seminar

ME 105: Product Dissection A: Bicycles--First-Year Seminar

1 Credits

A First-Year Seminar in which students analyze and disassemble a multi-speed bicycle. M E 105S M E 105S Product Dissection A: Bicycles (1) (FYS)Students are led through the disassembly, testing, troubleshooting and re-assembly of 10- and 15-speed bicycles. Routine maintenance, common problems, and fundamental design principles are addressed. Also, manufacturing and design issues such as material selection, fabrication technology, and reliability will be discussed. Students may supply their own bicycle, or use one from our supply.

First-Year Seminar

ME 106: Product Dissection B: Household Appliances--First-Year Seminar

1 Credits

A First-Year Seminar in which students analyze and disassemble household appliances. M E 106S Product Dissection B: Household Appliances (1)(FYS) Students will disassemble, analyze and re-assemble a series of small household appliances such as telephones and electric drills. Lectures will discuss issues of design and manufacturing as well as consumer product testing. Students will conceive, design, and carry out a consumer product testing program.

First-Year Seminar

ME 107: Product Dissection C: The Enigmatic Engine--First-Year Seminar

1 Credits

A First-Year Seminar in which students analyze and disassemble a single-cylinder lawnmower engine. M E 107S M E 107S Product Dissection C: The Enigmatic Engine (1) (FYS)Students are led through the disassembly of a single cylinder lawn mower engine. Students work with faculty and student helpers to understand concepts of operation, manufacturing and assembly. Then the engines are reassembled and started. Guest speakers will lead discussions regarding the use of fossil fuels, design for manufacturing, and marketing.

First-Year Seminar

ME 109S: Explore Mechanical Engineering Research

1 Credits

Students will discuss the wide breadth of research topics in mechanical engineering and how to prepare for a research position. Throughout the course students will participate in tours of state-of-the-art research labs in the Mechanical and Nuclear Engineering department, interact with undergraduate students currently involved in conducting research in the Mechanical and Nuclear Engineering department, practice writing correspondence and making presentations.

First-Year Seminar

ME 190: Special Topics in Mechanical Engineering: First-Year Seminar

1 Credits

A First-Year Seminar focusing on issues related to Mechanical Engineering. M E 190S M E 190S Special Topics in Mechanical Engineering: First-Year Seminar (1) (FYS)In this First-Year Seminar, students will explore the Mechanical Engineering profession by means of treatment of a particular topic in M E. Students will be assigned

pertinent readings and the professor will lead discussions on the ethical, professional, and societal aspects of the topic area. The seminar will also feature group activities and encourage participation in the classroom setting.

First-Year Seminar

ME 201: Introduction to Thermal Science

3 Credits

Application of the basic concepts of thermodynamics, fluid dynamics, and heat transfer to the solution of engineering problems.

Prerequisite: CHEM 110

ME 240: Product Dissection

3 Credits

Dissection of products and processes; reverse engineering, examination of materials usage, manufacturing processes, design, invention, and consumer issues. M E 240 Product Dissection (3) This course examines the way in which products and machines work: their physical operation, the manner in which they are constructed, and the design and societal considerations that determine the difference between success and failure in the marketplace. The primary objectives in this course are to develop a basic aptitude for engineering and engineering design and to develop mental visualization skills by examination of design and manufacture of consumer and industrial products. Heavy emphasis is placed on hands-on laboratory experience and the development of team and communication skills.

Prerequisite: EDSGN100 , PHYS 211

ME 297: Special Topics

1-9 Credits/Maximum of 9

Formal courses given infrequently to explore, in depth, a comparatively narrow subject that may be topical or of special interest.

ME 299: Foreign Studies

1-12 Credits/Maximum of 12

Courses offered in foreign countries by individual or group instruction.

International Cultures (IL)

ME 300: Engineering Thermodynamics I

3 Credits

Basic thermodynamics concepts, properties of pure substances, first and second law analysis of systems and control volumes. M E 300 Engineering Thermodynamics I (3) This course is designed to develop an understanding of thermodynamic concepts and their application for the student by providing an integrative modeling and analysis approach to thermal-fluids systems. The course emphasizes the integration and application of fundamental principles of mass and energy conservation and fundamental ideal gas and non-ideal working fluids concepts to fundamental engineering systems. These systems include basic spark-ignition engines and turbojet engines as well as basic and extended Rankine and refrigeration cycles. Emphasis is on creating engineering models of these systems and indicating how the idealized versions of these systems can be extended to more realistic descriptions. Besides

these mass and energy conservation concepts the course introduces the basic concepts of heat transfer and mass flow, providing a foundation in these subjects to be further expanded in later courses. The course aims to develop knowledge and initiate skills for "thinking like an engineer.

Prerequisite: CHEM 110; Concurrent: MATH 141

ME 308: Fluid Flow and Heat Transfer Laboratory

1 Credits

Experimental work to enhance understanding of thermodynamics, fluid dynamics, and heat transfer.

Prerequisite: M E 320 . Prerequisite or concurrent: M E 410

ME 315: Heat Transfer Laboratory

1 Credits

This one-credit laboratory course is structured to reinforce the various principles taught in the corresponding 3-credit lecture course - M E 410, Heat Transfer. The laboratory includes several different experiments whose objective is to reintroduce and reinforce the various principles associated with conduction, convection, radiation and heat exchangers. Each laboratory session begins with a thorough review of the relevant material covered in the lecture course, including the use of energy conservation on control volumes related to the experiment and related simplifications. Prior to conducting any experiment, the students are informed about the particular safety issues that vary from one experiment to another. The students are then briefed about the setup of the data acquisition systems, what type of data the need to be collected, and how the data then is coupled to the review of the specific laboratory topic. At the end of the semester, the students should be able to interface a typical data acquisition system with those used in industry and elsewhere. The students generally work in groups to collect data, with reports prepared individually after an experiment is completed.

Prerequisite: M E 320 . Prerequisite or concurrent: M E 345 , M E 410

ME 320: Fluid Flow

3 Credits

This course is an introduction to fluid mechanics, and emphasizes fundamental concepts and problem-solving techniques. Topics to be covered include fluid properties (density, viscosity, vapor pressure, surface tension); fluid statics (hydrostatic pressure, pressure forces on planar and curved surfaces); fluid kinematics (flow visualization, vorticity, Reynolds transport theorem); control volume analysis (conservation laws of mass, momentum, and energy, Bernoulli equation); dimensional analysis (dimensional homogeneity, method of repeating variables, experimental testing, similarity); internal flows (pipe flows, major and minor losses, piping networks, matching pumps to systems); differential analysis (Navier-Stokes equation, creeping flow, potential flow, boundary layers); external flows (lift and drag, pressure vs. friction drag); and compressible flow (isentropic flow through nozzles, shock waves). Brief introductions to computational fluid dynamics (CFD), and turbomachinery (pumps and turbines) will also be provided.

Prerequisite: E MCH212 , MATH 251 ; M E 201 or M E 300 ; MATH 230 or MATH 231

ME 325: Fluids Laboratory

1 Credits

The course is designed for students to understand basic concepts of fluid mechanics through analysis of experimental data from various sources. The course emphasizes hands-on experience to take measurements, analyze and interpret experimental data. An important component of this course fosters an ability to write laboratory reports and to creatively generate independent ideas that involve the study of fluid mechanics through development and execution of final project. The course aims to developed teamwork (no hyphen needed, this is one word) skills and advanced proficiency in professional communications and interactions.

Prerequisite: M E 320 , M E 345

ME 340: Mechanical Engineering Design Methodology

3 Credits

The design process; problem definition, conceptual design, system design, detail design, evaluation and test, implementation, documentation and communication. M E 340 Mechanical Engineering Design Methodology (3) This course is intended to provide mechanical engineering students with the fundamental tools to produce an effective design solution in a realistic professional environment with conflicting customer needs and technical capabilities. The students will identify the system design targets through interaction with the "customer", develop multiple conceptual designs, select the best design solution and produce a functional prototype. The course is project driven with significant input from the students in defining the work objectives and goals. Initially several mini-projects will be assigned with specific objectives such as identifying customer needs, quantifying technical design specifications and decision making. The course culminates with a student team based design competition. The competition provides an opportunity to apply the design process to an open-ended mechanical engineering problem.

Prerequisite: EDSGN100 ; Prerequisite or concurrent: M E 320 or BME 409 ; M E 360

ME 345: Instrumentation, Measurements, and Statistics

4 Credits

Fundamentals of statistics, sensors, instrumentation, and measurement of mechanical phenomena such as temperature, flow, pressure, force, stress, displacement, and acceleration. M E 345 Instrumentation, Measurements, and Statistics (4) This course is required for all mechanical engineering students, and is taken in the junior year. It serves as an introduction to the fundamental principles of instrumentation and measurement, along with statistics, and integrates and applies what the students have learned in their electrical engineering course.The course includes a 3-hour-per-week hands-on laboratory where students apply the material learned in the lecture. For many students this is the first time they have actual hands-on experience with electronics and measurement equipment, such as oscilloscopes, breadboards, function generators, digital data acquisition systems, integrated circuits strain gages, displacement meters, thermocouples, tachometers, dynamometers, filters, volume flow meters, velocity meters, pressure transducers, etc. Students learn not only how to use these devices in the lab, but also the fundamental principles of their operation. Statistical analysis is integrated into the course, especially in the hands-on laboratories, where statistics is used to analyze and interpret acquired data.

Prerequisite: Prerequisite or concurrent: E E 212 or E E 211 or equivalent

ME 345W: Instrumentation, Measurements, and Statistics

4 Credits

Measurement concepts, probability and statistics, error analysis; electro- mechanical transducers, applied electrical and mechanical measurements, electrical and electronics instruments, data acquisition and instrumentation systems.

Prerequisite: Prerequisite or concurrent: E E 212 or E E 211 or equivalent Writing Across the Curriculum

ME 347: Computer-Aided Engineering

3 Credits

Introduction to the tools and techniques of computer-aided design, including CAD, spreadsheets, numerical methods, and finite element analysis. M E 347 Computer-Aided Engineering (3) In this course students learn how to use a variety of computer tools for engineering analysis and design. These tools include Computer-Aided Design software such as solid modeling, spreadsheets, numerical methods, and finite element analysis. A major emphasis of the course is the development and solution of mathematical models of engineering systems or components. Students see how simplified analysis diagrams (free-body diagrams, block diagrams and control volumes) can be developed for real systems and components, and how these diagrams can be used to develop the mathematical models. Numerical techniques for solving these models, including systems of equations, non-linear equations, ordinary and partial differential equations, numerical differentiation and integration, and curve fitting are discussed. Students are also taught how to learn a new computer package with minimal formal instruction. Students are evaluated through the use of written exams during the semester, a comprehensive written final, weekly homework assignments, and a design project. This course is required in the Mechanical Engineering program, integrates material from a number of previous courses, and provides the student with tools that will be used in a number of subsequent courses. It is offered annually in the fall semester.

Prerequisite: CMPSC201 or CMPSC202 ; EDSGN100 or EDSGN100S . Prerequisite or concurrent: E MCH213 , MATH 220 , MATH 251

ME 349: Intermediate Mechanics of Materials

3 Credits

Intermediate topics in mechanics of materials with computer applications. M E 349 Intermediate Mechanics of Materials (3) This course introduces students to intermediate and applied topics in mechanical behavior of materials with an emphasis on design and computation. This course will give students the tools to do practical analysis and the foundation needed to prepare them for other mechanical engineering courses in design and other elective courses. Subjects covered include stress analysis, deformation & deflection, material failure and finite element analysis. Stress analysis includes the study of stress concentrations, stress transformations and principal stresses. Stress-based static failure theories for brittle and ductile materials are investigated. Two-way bending of beams is covered as well as torsional deformation of non-circular cross sections. Buckling and pressure vessels are introduced as separate topics while the finite element

analysis is introduced as a computational tool to study stress and deformation. Throughout the course students will use a commercial finite element program to verify and visualize results from analysis of the various topics. During the course, students are introduced to the basic theory of the finite element method.

Prerequisite: E MCH213 , EDSGN100S Prerequisite or concurrent: CMPSC200 , MATH 220

ME 355: Dynamic Systems Laboratory

1 Credits

Experimental investigation of simple position, velocity, and temperature control systems with analog and digital controllers. M E 355 Dynamic Systems Laboratory (1) The objective of the Dynamic Systems Laboratory is to enable students to experimentally investigate the calibration, response characteristics, modeling, and control of mechanical and fluid systems. This course is intended to allow students to develop some hands-on experience and working knowledge of basic dynamic and control systems. Specifically, to 1. Identify the actuators, sensors, plants, and controllers of physical control systems.2. Calibrate encoders, temperature, laser displacement, and flow sensors.3. Measure steady state, step, and frequency response of thermal, fluid, and mechanical systems.4. Compare simulation and experimental results to validate theoretical model.5. Design PID controllers for thermal, fluid, and mechanical systems.6. Implement and test PID controllers for thermal, fluid, and mechanical systems.

Prerequisite: M E 345 ; Prerequisite or concurrent: M E 450

ME 357: System Dynamics

3 Credits

Mathematical modeling and analysis of linear dynamic systems; performance and design of simple controllers. M E 357 System Dynamics (3)This course is to explore the modeling of linear systems via transfer functions and state-space models; analysis of systems in the time and frequency domain using transfer functions and stat-space models; development of control techniques based on PID. The use of software Matlab and Simulink is another emphasis. Students are evaluated through the use of written exams during the semester, a comprehensive written final, weekly homework assignments, and a design project. This course is required in the ME BD program at Behrend, integrates material from a number of previous courses, and provides the student with tools that will be used in a number of subsequent courses.

Prerequisite: CMPSC200 , E E 211 or E E 212 , MATH 251

ME 360: Mechanical Design

3 Credits

Specification of components such as shafts, bearings, and power transformers; optimal designs for operational, environmental, and manufacturing requirements. M E 360 Mechanical Design (3) This course is required for all mechanical engineering students, and is taken in the junior year. It is an introduction to analysis and design of mechanical components. It helps provide practical insight into theory provided by prerequisites in engineering mechanics and materials science. Students initially perform yielding and fatigue failure predictions for general structural elements and then focus on specific mechanical components such as gears, fluid film bearing, rolling element bearings, screws, shafts and springs. Use and interpretation of finite element analyses (FEA)

are also introduced. The overall goals are for students to learn to make basic design decisions regarding the suitability of different materials in mechanical components (e.g. steel versus aluminum); and to make basic design decisions regarding the suitability of different components in a mechanical system (e.g. ball bearings versus fluid film bearings).

Prerequisite: Prerequisite or concurrent: CMPSC200 and E MCH315

ME 360H: Mechanical Design

3 Credits

Specification of components such as shafts, bearings, and power transformers; optimal designs for operational, environmental, and manufacturing requirements.

Honors

ME 365: Materials Testing Laboratory

1 Credits

Laboratory for materials testing, property identification and modification, failure analysis, and metallurgical testing. M E 365 Materials Testing Laboratory (1)This laboratory course provides an integrated approach to materials science and engineering. The laboratory examines the important relationships between processing, microstructure, and the properties of materials. The course provides an introduction to basic characterization techniques for materials, such as microscopy, hardness testing, fracture testing and analysis, fatigue testing, and impact testing. In addition, material selection and heat treatment topics are covered. The course requires hands-on involvement by the students in the planning of experiments as well as data manipulation and analysis of results. The laboratory exercises are intended to provide students with a broad appreciation of the breadth of material science and engineering and the principles behind material characterization and property modification. Students work in groups, and written reports are the primary basis for grading.

Prerequisite: Prerequisite or concurrent: MATSE259

ME 367: Machine Design

3 Credits

Design and selection of machine components and connections. Stress analysis and modes of failure of materials used in machine components. M E 367 Machine Design (3) This course introduces students to the process for selection, design and failure analysis of various common machine elements. This course will give students the foundation to design mechanical systems and the tools to design, select, or analyze machine components for practical applications necessary for their senior design projects and other mechanical engineering electives. Subjects include the reliability, safety factors, and the design of machine elements including shafts, roller bearings, brakes, clutches, gears, belt and chain drives, and additional topics such as screws, springs, journal bearings, and connections. Both static and cyclic loading are considered as part of the design and analysis process. Extensive use is made of material properties, design tables, figures and graphs to assist in the design and analysis process. The course includes a comprehensive project that incorporates several of the topics covered in the course in the design of a mechanical system. The goal of the project is for students to learn how various machine components and procedures are used in the Machine

Design process as well as giving them further experience in teamwork and presentation skills.

Prerequisite: M E 349 Prerequisite or concurrent: MATSE259

ME 370: Vibration of Mechanical Systems

3 Credits

Modeling and analysis of vibration characteristics of mechanical systems with single degree and multiple degrees of freedom. Vibration control by isolation, absorption and balancing. M E 370 Vibration of Mechanical Systems (3) The course studies vibration characteristics of mechanical systems and vibration control. It is divided into four main topics. Fundamental aspects of mechanical vibrations are studied first. Types and causes of various vibratory motions are described. The concepts of mathematical modeling of the vibratory systems are presented. Model elements including mass/inertia, spring and damper elements and their corresponding describing equations are studied. Single degree-of-freedom vibrations are modeled and analyzed. Equations describing free vibrations of undamped and damped systems are derived. Natural frequency and damping ratio are defined and their physical significance discussed. Harmonically excited vibrations are studied with many practical application problems; resonance and its physical significance are emphasized. The theoretical aspects of general periodic vibrations and non-periodic vibrations are formulated by means of Fourier analysis and convolution integral. Vibrations of multiple degrees-of-freedom systems are studied. Mathematical models governing free vibrations are formulated. Equations determining the natural frequencies and mode shapes of the system are derived with relation to eigenvalue problems. Harmonically excited vibrations are analyzed with practical applications. Vibration control in relation to engineering design is the last topic studied. Various vibration control concepts and techniques are presented including vibration isolation, vibration absorption and balancing to reduce the intensity of the source of excitation.

Prerequisite: E MCH212 , CMPSC200 , MATH 220 , MATH 251

ME 375: Vibrations Laboratory

1 Credits

Experimental measurement and analysis of mechanical system dynamics. This laboratory course provides an opportunity to apply the fundamental vibrations theory taught in ME 370 to actual mechanical hardware. The experiments illustrate fundamental concepts from an experimental vibration perspective. Experimental vibration measurement methods are applied to estimate simplified dynamic models for vibrating mechanical systems. The students compare analytical to experimental results to gain a sense of the limitations of both modeling and experimentation. Experiments include: free vibration of linear and nonlinear systems, response, measurement of translational and rotational, forced harmonic vibration, spectral analysis of vibration signals, experimental data uncertainty and comparison of finite element model dynamic results to experimental data. Throughout the course the students will: 1. Plan, implement and debug instrumentation to measure vibrations of mechanical systems. 2. Implement experimental test systems using vibration transducers and data acquisition to maximize measurement quality. 3. Recognize the dominant behavior seen in many larger, more complicated engineering systems. 4. Estimate the system vibration parameters 5. Use software to compare measured and predicted dynamic behavior. 6. Recognize dominant nonlinear behavior and implement a nonlinear simulation using software. 7. Verify the results

of computer analyses of dynamic systems by various methods including experimental measurement and analytical modeling.

Prerequisite: or concurrent: M E 370 , M E 345

ME 380: Machine Dynamics

3 Credits

Kinematic analysis of mechanisms such as linkages, flywheels, cams and gears. Dynamic forces and vibrations of mechanisms. M E 380 Machine Dynamics (3)In this course students learn how to apply the techniques of dynamics to analyze both the motion and forces associated with planar mechanisms. Students learn how to model and solve for the position, velocity, acceleration and forces on linkages using vectors. They also study the kinematics of gears, flywheels and cams. Machine vibrations is introduced as an integral part of Machine Dynamics. Students learn how to model simple mechanical systems as vibrating systems and then analyze the vibratory response of these systems. Once these analytical skills have been developed, the students can apply these skills to the design of linkages, internal combustion engines, gears, shafts and cams. Several in-class exams are used to evaluate students' performance. Computer problems are assigned so students can experience the solution methods to some of the more complex problems. This required course integrates material from calculus and dynamics to provide the student with tools that can be used to analyze the motion of machinery and can be used in the design of machinery and machine components. It is offered annually in the Fall semester and occasionally in the Spring semester.

Prerequisite: E MCH212 , MATH 251

ME 395: Internship

1-18 Credits/Maximum of 18

Supervised off-campus, nongroup instruction including field experiences, practica, or internships. Written and oral critique of activity required.

Prerequisite: prior approval of proposed assignment by instructor Full-Time Equivalent Course

ME 397: Special Topics

1-9 Credits/Maximum of 9

Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest.

ME 399: Foreign Studies

1-12 Credits/Maximum of 12

Courses offered in foreign countries by individual or group instruction.

International Cultures (IL)

ME 400: Thermodynamics of Propulsion and Power Systems

3 Credits

Analysis and modeling of propulsion and power systems, including combustion, compressible flow through nozzles, chemical equilibrium, and moist air systems. M E 400 Thermodynamics of Propulsion and Power Systems (3) This course is specifically designed to take advantage of the senior level standing of the student by providing an integrative modeling and analysis approach to thermal-fluids systems. The course

emphasizes the integration and application of fundamental principles of mass, momentum, and energy conservation to relatively complex systems. These systems include spark-ignition and diesel engines, gas-turbine engines for power production, and turbojet engines. The integration of the topics of combustion, compressible flow, and psychrometrics allow these systems to be analyzed in their totality. Emphasis is on creating engineering models of these systems. The course aims to integrate previous knowledge and develop skill in "thinking like an engineer."

Prerequisite: M E 300 and M E 320 ; Prerequisite or concurrent: M E 410

ME 401: Refrigeration and Air Conditioning

3 Credits

Theoretical principles, design, performance, and selection of various refrigeration and air-conditioning systems; building heat and cooling loads; solar heating.

Prerequisite: M E 410

ME 402: Power Plants

3 Credits

A study of fossil-fuel steam generation and utility plants, including cogeneration, gas turbine, and combined cycles. M E 402 Power Plants (3) This course serves as an introduction to fossil-fuel plants for both steam generation and electricity production. Following an overview of an entire plant and an introduction to combustion processes, each subsystem of a fossil-fuel plant will be considered. The subsystems include fuel preparation and handling, boiler types and the fundamentals of steam generation, water systems (condensate-feedwater, makeup, cooling, and waste), and turbomachinery. Consideration will be given to environmental aspects of steam and power generation as well as operations, maintenance, and controls issues. Students will spend time at the West Campus Steam Plant (WCSP) to observe the various systems discussed in class. Data taken from the WCSP will be used in problem solving and in an assessment of the plant.Course Objectives: To acquaint students with both steam generation and electricity production and to present some of the engineering calculations encountered in practice.Objectives that students will meet at the end of the course: I . list the subsystems of a plant, indicating the function of each subsystem 2. sketch typical subsystems of a power plant (example: sketch the coal and ash handling system) 3. perform basic analyses associated with each subsystem 4. sketch the flow of water-steam, fuel, and air through a plant 5. analyze a heat balance, perform an availability analysis, and interpret the results of those analyses 6. select the type of plant appropriate for a given application 7. perform an energy audit on the auxiliary systems 8. perform a water audit on the plant 9. use DoE Best Practices (or equivalent program) to assess a steam plantStudents will be required to draw on material from core undergraduate courses in thermodynamics (M E 030 and M E 031), fluid mechanics (M E 033), and heat transfer (M E 412). Students must be able to: � sketch the configuration and draw a T-s diagram for a Rankine cycle and a Brayton cycle � indicate the general trends for the ideal cycles (example: for a Brayton cycle, how does the efficiency depend on the pressure ratio, inlet temperature, etc.) � define the basic modifications to the simple Rankine cycle and simple Brayton cycle � discuss the significance of the modifications � state the definition of the adiabatic efficiency for turbines and pumps � perform an energy balance given a particular

cycle � use the Darcy-Weisbach equation to determine the friction losses in pipes and ducts � perform simple analysis of a heat exchanger

Prerequisite: M E 410

ME 403: Polymer Electrolyte Fuel Cell Engines

3 Credits

Introduction to Fundamentals of Polymer Electrolyte Fuel Cells (PEFCs). Includes fundamentals of electrochemistry, thermodynamics, fluid mechanics, heat transfer materials, and manufacturing issues of PEFCs. A brief survey of other fuel cell types is also included. M E 403 Polymer Electrolyte Fuel Cell Engines (3) This course is intended for the engineering student interested in obtaining a fundamental background required for polymer electrolyte fuel cell (PEFC) modeling and diagnosis. Those students with interest in the basic design, operation, and characteristics of PEFC systems should also benefit. This course serves as an introduction to the fundamental principles of electrochemistry, thermodynamics, heat and mass transfer, materials and manufacturing issues related to PEFC engines. The various types of PEFC components and technologies are dissected in detail, including direct inject alternative fuel systems. A survey of cutting-edge issues in fuel cell technology including the future direction of PEFC technology will be presented as time permits. The student will also participate in an experimental lab study to aide in the understanding of these systems, a computer-based simulation project, and a group-based fuel cell system design project. Issues of specific interest to mechanical engineers, including water management and heat and mass transfer in thin film porous media, will be dealt with in depth. A brief survey of other fuel cell types is also presented.

Prerequisite: M E 300 Prerequisite or concurrent: M E 320; Concurrent: M E 410, or equivalent

ME 404: Gas Turbines

3 Credits

This course enables students with the proper background to gain specialized knowledge as a step towards becoming practitioners in the field of gas turbines. The information imparted covers from basic cycles to properties of materials required to put together these impressive machines. Competent course performance requires knowledge of basic thermodynamics, fluids and heat transfer. The homework is carefully graduated in order to highlight key aspects already covered in the lectures, with new thinking an unavoidable part. As an optional part of the course, students can run and acquire data in an actual gas turbine. Additionally, those with a strong background in fluids can design blades and study the flow around them with CDF. Course Objectives: Upon completion of this course, students should be able to: 1. Analyze cogeneration plants. 2. Analyze turbofans, jets and turbojets. 3. Specify a typical gas turbine installation, including auxiliaries. 4. Carry out conceptual design of gas turbine engines for different applications. 5. Specify construction materials to withstand typical operating conditions. 6. Demonstrate professionalism in interactions with colleagues, faculty, and staff. Program Objectives: This course covers the following program objectives: 1. demonstrate ability to solve differential equations 2. demonstrate familiarity with linear algebra 3. perform analysis of thermal/fluids components 4. perform analysis of thermal/fluids systems 5. work effectively on multidisciplinary teams 6. demonstrate ability to communicate effectively with the written word 7. demonstrate ability

to communicate effectively in oral communications 8. demonstrate professionalism in interactions with colleagues, faculty, and staff

ME 405: Indoor Air Quality Engineering

3 Credits

Prediction of the motion of contaminants (both gaseous particulate) in gas streams; analysis of ventilation systems and air pollution control systems; comparison of experimental sampling techniques. M E 405 Indoor Air Quality Engineering (3) This course serves as an introduction to environmental health engineering, which presents the quantitative relationships describing generation, movement, and control of pollutants inside the workplace. Although some aspects of the course can be applied to outdoor air pollution, the course concentrates on applications related to indoor air quality. In particular, students are taught how to measure and predict concentrations of air pollutants, both gaseous and particulate, in rooms. In addition, they are taught how to design both local and general ventilation systems to maintain acceptable indoor air quality. In addition, the design of air pollution control systems that remove both gaseous and particulate contaminants from the air is discussed.The relationships are described by mass and energy balances that relate pollutant generation and movement to process parameters. The course is designed for seniors and graduate students in Mechanical, Chemical, Environmental and Civil Engineering, and Meteorology.To work effectively in environmental health engineering, students must be proficient in applying the thermal sciences. The course uses principles of mathematics and thermal sciences included in accredited programs of engineering. Most students will have mastered some of these principles, but few will have mastered them all. The course reviews all the necessary thermal science principles before using them, but some students will need to review this material in more detail than others.This course is offered once per year.Course Objectives:a. Demonstrate the ability to analyze and compare risks associated with various activities and with exposure to hazardous chemicals.b. Demonstrate a working knowledge of the physiology and function of the respiratory system, including diseases of the lung.c. Demonstrate the ability to estimate pollutant emission rates using emission factors and fundamental mass balance techniques.d. Analyze practical problems of general and local ventilation requirements.e. Design local ventilation systems using standard guidelines from ACGIH and ASHRAE.f. Predict the motion of particles in air, and analyze pollution control devices which remove particles from the air.g. Demonstrate professionalism in interactions with colleagues, faculty, and staff.Program Objectives:a. demonstrate knowledge of chemistryb. demonstrate ability to solve differential equationsC. demonstrate familiarity with statisticsd. perform analysis of thermal/fluids components and thermal/fluids systemse. demonstrate an appreciation of the economic, global, social, and ethical context of their workf. demonstrate professionalism in interactions with colleagues, faculty, and staffg. make effective use of spreadsheets as an analysis and design toolh. use software such as Matlab and MathCAD to solve engineering problems including ODE'S, systems of linear equations, and numerical integration

Prerequisite: M E 320 or equivalent

ME 406: Introduction to Statistical Thermodynamics

3 Credits

Statistical description of systems composed of large numbers of particles in the context of classical and quantum mechanics; basic concepts of probability theory and thermodynamics as they relate to statistical mechanics. M E (NUC E) 406 Introduction to Statistical Thermodynamics (3) This course is an introduction to probabilistic and statistical concepts in the physical sciences, which we refer to as "statistical thermodynamics." In areas such as design and processing of electronic devices, materials engineering, chemical engineering, and combustion engineering, the science of statistical mechanics is a particularly necessary, powerful, and important tool for the engineer. The underlying foundation of statistical mechanics is developed by (1) reviewing the basic ideas from probability theory, (2) deriving the binomial, Poisson, and Gaussian probability distributions, and (3) using these models to analyze several examples taken from science and engineering. To make a connection between macroscopic quantities and the corresponding probabilistic representation, classical thermodynamics is reviewed using the internal energy, entropy, and free energy functions in the context of the first and second laws. Statistical mechanics for classical and quantum-mechanical systems is presented via the micro-canonical, canonical, and grand canonical ensembles using the associated partition functions. During the syntheses of ideas, applications from various branches of science are presented. Some examples of applications are the Einstein crystal, the Debye crystal, the ideal gas, and black body radiation.This course covers the following program objectives: 1. Demonstrate knowledge of basic chemistry and physics. 2. Demonstrate a knowledge of atomic and nuclear physics. 3. Demonstrate a knowledge of thermodynamics, heat transfer, and fluid flow. 4. Understand and apply the basic concepts of particle transport. 5, Understand and apply thermodynamics and heat transfer principles to the analysis of nuclear power components and systems.

Prerequisite: M E 300 or M E 201 or M E 302 or CH E 303 ; MATH 230 or MATH 231
Cross-listed with: NUCE 406

ME 408: Energy Systems

3 Credits

Theory, analysis, design, selection, and application of energy conversion systems. This course is intended for mechanical engineering students to reinforce the topics taught in thermodynamics, fluid mechanics, and heat and mass transfer; gives students familiarity with energy conversion systems using traditional and renewable energy sources which are typically encountered by mechanical engineers, and improves students' analytical and design skills. Coverage of materials include heat exchanger analysis, selection, and design with respect to heat transfer, pressure drop, and fluid pumping requirements; analysis and design of power cycles based on thermodynamic principles; fundamentals of combustion processes; introduction to wind energy and wind turbine aerodynamic analysis; fuel cell fundamentals and analysis of fuel cell problems and systems based on thermodynamics and heat transfer principles. Students will be evaluated by homework assignments; individual and small team projects; and exams.

Prerequisite: M E 320 , M E 410

ME 410: Heat Transfer

3 Credits

Thermal energy transfer mechanisms: conduction (steady, transient), convection (internal, external), radiation; lumped parameter method; heat exchangers; introduction to numerical methods. M E 410 Heat Transfer (3) M E 410, Heat Transfer, is a required course for mechanical and nuclear engineering students. The course presents the three modes of heat transfer: conduction, convection, and radiation. One-dimensional steady and transient conduction is studied for planar, cylindrical, and

spherical geometries. The lumped capacitance analysis is used for transient conduction when appropriate. Analytical and numerical methods are presented for two-dimensional conduction problems, including the analysis of extended surfaces. Convection heat transfer is studied in both internal and external geometries and under laminar and turbulent flow regimes. External flows include cooling on flat plates due to laminar and turbulent boundary layer flows, and cooling of cylinders due to cross flow. The convection heat transfer analysis in internal flows considers laminar and turbulent pipe flows. Free convection is also considered where heat transfer is due to flow induced by fluid buoyancy. Boiling and condensation considers the effect of two-phase flows on surface heat transfer. Radiation heat transfer is studied by considering both the general characteristics of radiation as well as the properties of radiating surfaces and radiation heat transfer between surfaces. Methods for solving multi-mode heat transfer are presented throughout the course. Heat exchangers and heat transfer from extended surfaces are two applications studied in the course

Prerequisite: M E 320 or BME 409 ; CMPSC200 or CMPSC201 ; MATH 220 or NUC E309

ME 410H: Heat Transfer

3 Credits

Transient heat conduction; convection in laminar and turbulent flow; heat exchanger devices; boiling and condensation; radiation.

Honors

ME 411: Heat-Exchanger Design

3 Credits

Thermal design and application of different heat-exchanger types, including surface selection and design optimization.

Prerequisite: M E 410

ME 420: Compressible Flow I

3 Credits

Introductory compressible flow (gas dynamics), mathematical background, and physical concepts of isentropic flow, shock waves, expansion waves, and applications.

Prerequisite: M E 320

ME 421: Viscous Flow Analysis and Computation

3 Credits

Apply analytical and computational methods to solve the differential equations describing fluid flow. Incompressible external flows past objects and internal flows in pipes and ducts are some problems considered. M E 421 Viscous Flow Analysis and Computation (3) M E 421 is an intermediate course in fluids mechanics that bridges between the required undergraduate fluid mechanics course and the graduate fluid mechanics courses. Steady and unsteady flows are considered past objects and in pipes, ducts, and annuli. Analytical and numerical methods are used to solve the boundary layer and Navier-Stokes equations that describe fluid motion. Analytical methods include solutions for steady and unsteady internal flows with heat transfer. Similarity equations for boundary layer flows are derived and then solved numerically using the Runge-Kutta method. Finite difference methods for viscous flows are

introduced and applied. Turbulence modeling is presented and applied in a boundary layer code. The stages of transition from laminar to turbulent flow and methods for the prediction of transition are introduced. Topics in M E 421 include:1. Analytical solutions for one-dimensional viscous flows in Cartesian and cylindrical coordinates with heat transfer.2. Unsteady viscous flow solutions using Separation of Variables.3. Boundary layer similarity solutions using the Runge-Kutta method.4. Panel method for incompressible inviscid flows.5. Finite-differenced equations for viscous flows and the accuracy and stability of the schemes.6. Using a commercial CFD code for a simple geometry.7. Algebraic turbulence models and the approximations of each.8. Higher-order turbulence models and the approximations used.9. Stages of transition from laminar to turbulent flow.10. Methods to predict boundary layer stability and transition.

Prerequisite: M E 201 , M E 320 , AERSP308 , AERSP311 , or C E 361 ; CMPSC200 or CMPSC201 or CMPSC202 ; MATH 220 ; MATH 250 or MATH 251

ME 422: Principles of Turbomachinery

3 Credits

Conservation laws pertinent to energy conversion and fluid mechanics are applied to pumps, centrifugal compressors, axial compressors and turbines, hydro turbines and wind turbines. Ideal performance is established, and conventional loss correlations are applied to define potential performance of turbomachinery. The applications of similarity and dimensionless parameters towards characterizing turbomachines are outlined. The course objectives are; 1. Review/acquire thermofluids concepts applicable to turbomachinery such as Reynolds transport theorem, First and Second laws, isentropic efficiencies, potential flow, dissipative flows. 2. Develop an understanding of working principles applicable to centrifugal, axial and mixed flow machinery. Extend concepts applicable to hydro and wind turbines. Develop approximations for both compressible and incompressible flows. 3. Gain an understanding of loss calculations.

Prerequisite: ME 320

ME 427: Aerodynamics for Mechanical Engineers

3 Credits

The primary objective of this course is to teach students how to apply concepts relating to incompressible flows to solve aerodynamic design problems. In incompressible aerodynamics, fundamental concepts such as lift, drag, aerodynamic moment, induced drag, viscous drag, pressure drag, separation, stall, circulation, downwash, camber, thickness ratio, and lift distribution are discussed. Students use these concepts primarily to determine aerodynamic lift and drag using a variety of techniques, including potential flow theory and wind tunnel testing. Based on instructor preference and expertise, additional topics relating to incompressible and/or compressible aerodynamics may be also discussed. Students will be evaluated through the use of written exams during the semester, a comprehensive written final, and weekly homework assignments. This course is a technical elective in the ME programs at the Behrend, Berks and Harrisburg campuses and allows students who have completed ME 320, Elementary Fluid Mechanics, to improve their understanding of fluids and thermodynamics by covering the subject in more detail and applying it specifically to aerodynamic problems. It will usually be offered annually.

Prerequisite: M E 320

ME 428: Applied Computational Fluid Dynamics

3 Credits

Introduction to theory and application of computational techniques for solving fluid flow and heat transfer. M E 428 Applied Computational Fluid Dynamics (3) The purpose of this course is to teach students how to use a commercial CFD code to solve real-world engineering fluid flow problems. The definition of appropriate problem domain, set of governing equations, boundary conditions, and fluid properties is discussed. Sufficient theory of CFD is covered so that students are able to select appropriate elements or interpolation techniques and options, mesh size, pressure-correction technique and solution technique. Students are also taught how to interpret the results of a CFD simulation, including determination that the solution is physically realistic, conforms to the governing equations, is converged and grid independent, and determination of important engineering quantities such as net force, pressure drop and flow rate. Students are evaluated through the use of written exams during the semester, a comprehensive written final, weekly homework assignments, and a semester project. This course is a technical elective in the Mechanical Engineering program and allows students who are interested in fluid mechanics and heat transfer to further their study. It is offered periodically.

Prerequisite: M E 320 , M E 410

ME 430: Introduction to Combustion

3 Credits

Concepts related to laminar and turbulent premixed and nonpremixed combustion with applications to propulsion and stationary systems. EGEE (M E) 430 Introduction to Combustion (3) This course provides an introductory treatment of combustion science. The objectives of the course are to develop in the students an understanding of combustion kinetics, combustion thermochemistry, flame dynamics, flame stability, and pollutant formation. Coverage includes laminar and turbulent flames, premixed and diffusion flames, and detonations. Emphasis is placed on the role that Kinetics, heat transfer, mass transfer, and fluid dynamics have on flame structure and flame stability. The course includes some laboratory demonstrations of flat flame and diffusion flame burners, and incorporates numerical calculations of thermodynamic and kinetic combustion phenomena. The course begins with a review of transport phenomena, physical gas dynamics, and thermochemistry. Then, the concept of the laminar flame speed is introduced in the context of a one-dimensional flame and a propagating chemical wave. Issues of premixed flame structure and stability are presented along with a discussion of flammability limits. Next, laminar diffusion flames are presented via the Burke-Schumann analysis. From laminar flames, the emphasis shifts to turbulent premixed and diffusion flames, and the concepts of flame stretch and strain. Detonations are considered, with emphasis on thermodynamic analysis of the detonation and the structure of the detonation wave. Details of chemical kinetics for the hydrogen-oxygen and hydrocarbon-air reaction systems are presented, with linkage back to earlier topics such as flame stabilization and flammability limits. After kinetic phenomena, the course then considers pollutant formation focusing on soot and NOx. The fundamental aspects of combustion are applied to analysis of the combustion process and pollutant formation in international combustion engines and catalytic combustors. The course wraps up with discussion of atmospheric chemistry, the fate of pollutants, and the formation of secondary pollutants.

Prerequisite: M E 201 or M E 300 or EME 301
Cross-listed with: EGEE 430

ME 431: Internal Combustion Engines

3 Credits

This course is specifically designed to take advantage of the senior level standing of the student by providing an integrative modeling and analysis approach to thermal-fluids systems. The course emphasizes the integration and application of fundamental principles of mass, momentum, and energy conservation to relatively complex systems. These systems include spark-ignition and diesel engines, gas-turbine engines for power production, and turbojet engines. The integration of the topics of combustion, compressible flow, and psychrometrics allow these systems to be analyzed in their totality. Emphasis is on creating engineering models of these systems. The course aims to integrate previous knowledge and develop skill in "thinking like an engineer."

ME 432: Rocket Propulsion

3 Credits

Design and performance of rocket propulsion components and systems; thermodynamics, solid and liquid fuels, heat transfer, materials, controls, and instrumentation.

Prerequisite: M E 320 , M E 410

ME 433: Fundamentals of Air Pollution

3 Credits

Natural and man-made sources of pollution; atmospheric dispersion; biological and health effects; control systems; legislation and regulations. This course is an introduction to air pollution, with an emphasis on outdoor rather than indoor air pollution. Topics to be covered include sources (emissions) of air pollution, both gaseous and particulate, interaction of air pollution with our bodies and the environment, and methods of measuring, quantifying, analyzing, and controlling air pollution. A brief introduction to government regulations related to air pollution will also be provided. Students are expected to be proficient in applying mathematics (e.g., integration, differentiation, and application of differential equations), and some basic chemistry, statistics, thermodynamics, and fluid mechanics.

Prerequisite: M E 201 or M E 300

ME 440: Mechanical Systems Design Project

3 Credits

Design and analysis of mechanical components and systems. Application of fundamental design and analysis methods to open ended engineering problems. Students develop and practice skills and techniques for managing and executing engineering design projects. These skills are applied to an industry-sponsored project. Project teams perform all facets of product and process design. This includes problem identification, planning of the project, formulation of design specifications, the development and evaluation of alternative conceptual designs, the development of detailed designs, the specification of manufacturing processes, prototyping of manufacturing processes and parts, and analysis and documentation of results. Students will visit industrial sites to gain an understanding of existing processes and problems and to assess the customer's needs. Students will present their

design process and final design in several formats: oral presentations, poster presentations, web pages, and reports.

Prerequisite: ME 340; CONCURRENT: IE 312, ENGL 202C
Writing Across the Curriculum

ME 441: Thermal Systems Design Project

3 Credits

Design of thermal systems through component design and/or selection, system simulation and optimization. Assessment of system economics and energy efficiency. ME 441 Thermal Systems Design Project (3) Students develop and practice skills and techniques for managing and executing engineering design projects related more to thermal design but not excluding mechanical design. These skills are applied to projects mostly sponsored by the industry. Project teams perform all facets of product and process design either on paper via use of computer models and/or as a physical product. This includes problem identification, planning of the project, formulation of design specifications, the development and evaluation of alternative conceptual designs, the development of detailed designs, the specification of manufacturing processes, prototyping of manufacturing processes and parts, design computations, drawings and performance via use of CFD and analysis and documentation of results. Students will visit industrial sites when possible to gain an understanding of existing processes and problems and to assess the customer's needs. Students will present their design process and final design in several formats: oral presentations, poster presentations, web pages and reports.

Prerequisite: M E 340 ; M E 410 Prerequisite or concurrent: ENGL 202C
Writing Across the Curriculum

ME 442: Advanced Vehicle Design I

2 Credits

Part one of a two course sequence; applications of design and analysis methods to open-ended advanced transportation vehicles. Two semester course; satisfies Senior Design or ME Technical Elective requirements (when combined with M E 443W). Students develop and practice skills and techniques for managing and executing engineering design projects. This is done in the context of an international University-level engineering design competition that is sponsored by government agencies and/or by industry. The competitions are structured to span a full calendar year, with the competition itself taking place in late Spring. For that reason, the course is spread over two semesters. In the Fall semester, there is approximately equal emphasis on classroom lectures and hands-on laboratory activities; in the Spring semester, the emphasis is on hands-on laboratory activities. The focus is advanced powertrain technology for personal transportation vehicles. Broader aspects of energy efficiency, security, and sustainability also will be discussed. The specific technologies that are targeted will evolve with time to remain ahead of what is available in current production vehicles. Project teams perform all facets of product and process design. This includes problem identification, planning of the project, formulation of design specifications, the development and evaluation of alternative conceptual designs, the development of detailed designs, the specification of manufacturing processes, prototyping of manufacturing processes and parts, and analysis and documentation of results. Students also will participate in broader aspects of the design competition. This may include securing sponsorship and funding, participating in outreach and public relations events, developing a business plan, developing a web site, and traveling to competition workshops and to the annual

competition. Students will present their design process and final design in several formats: oral presentations, poster presentations, web pages, and reports.

Prerequisite: ME 340; CONCURRENT: IE 312, ENGL 202C
Writing Across the Curriculum

ME 443: Advanced Vehicle Design II

1 Credits

Part two of a two course sequence; applications of design and analysis methods to open-ended advanced transportation vehicles. Two semester course; satisfies Senior Design or ME Technical Elective requirements (when combined with M E 442W). M E 443W Advanced Vehicle Design II (1) Students develop and practice skills and techniques for managing and executing engineering design projects. This is done in the context of an international University-level engineering design competition that is sponsored by government agencies and/or by industry. The competitions are structured to span a full calendar year, with the competition itself taking place in late Spring. For that reason, the course is spread over two semesters. In the Fall semester, there is approximately equal emphasis on classroom lectures and hands-on laboratory activities; in the Spring semester, the emphasis is on hands-on laboratory activities. The focus is advanced powertrain technology for personal transportation vehicles. Broader aspects of energy efficiency, security, and sustainability also will be discussed. The specific technologies that are targeted will evolve with time to remain ahead of what is available in current production vehicles. Project teams perform all facets of product and process design. This includes problem identification, planning of the project, formulation of design specifications, the development and evaluation of alternative conceptual designs, the development of detailed designs, the specification of manufacturing processes, prototyping of manufacturing processes and parts, and analysis and documentation of results. Students also will participate in broader aspects of the design competition. This may include securing sponsorship and funding, participating in outreach and public relations events, developing a business plan, developing a web site, and traveling to competition workshops and to the annual competition. Students will present their design process and final design in several formats: oral presentations, poster presentations, web pages, and reports.

Prerequisite: M E 442W
Writing Across the Curriculum

ME 444: Engineering Optimization

3 Credits

Problem formulation, algorithms and computer solution of various engineering optimization problems. M E 444 Engineering Optimization (3)Students will learn to formulate and solve a variety of engineering optimization problems. Basic concepts, problem formulation, scaling, use of different optimizers, effect of tuning parameters and starting points and solution interpretation will be taught. Example problems will be taken from mechanical, aerospace, nuclear, civil, chemical, electrical and other engineering disciplines. This course will complement other engineering design courses, such as capstone design. Students will learn how optimization can reduce product turnaround time, and to make decisions involving weight, stiffness, strength, performance, energy utilization, and other attributes. Pedagogy will focus on hands-on experience through computational problem-solving and graphical understanding. Technology

classrooms and computer labs for instruction will be used. A by-product of this course is increased math and computer skills.

Prerequisite: MATH 220 , MATH 230 or MATH 231 , CMPSC201 or CMPSC202 or CMPSC200

ME 445: Microcomputer Interfacing for Mechanical Engineers

4 Credits

Interfacing of electro-mechanical systems to microcomputers for data acquistion, data analysis and digital control.

Prerequisite: M E 345 and seventh-semester standing

ME 446: Reliability and Risk Concepts in Design

3 Credits

Introduction to reliability mathematics. Failure data collection and analysis. Components and systems reliability prediction. Effects of maintenance on reliability. Risk Analysis. Case studies in engineering applications. ME 446 / NUCE 446 Reliability and Risk Concepts in Design (3) The course covers materials reliability in design including mechanical, electrical and system aspects. Five main topics will be studied. The course starts by introducing engineering risk and reliability, highlighting its interdisciplinary nature and its significance in system design. The concept of reliability as a probability is introduced and the basic laws of probability are reviewed. The discussion centers on the mathematics needed to understand and analyze complex systems including components in series and parallel. The topics include the independence, mutual exclusivity, truth tables and Venn diagrams. These concepts are then applied to simple systems consisting of one, two and three components in various configurations. The equivalency of the various methods is discussed. The effect of maintenance on a system's reliability is presented along with discussions of various maintenance strategies. Then, the failure modes and effects analysis is introduced and examples discussed. The concept of fault trees and event trees and their application to reliability analysis are presented. Risk analysis is then introduced as a case study in the application of reliability analysis. A nuclear power plant system is analyzed to quantify the risk to the public from its operation.

Prerequisite: MATH 250 or MATH 251 ; M E 345 or NUC E309
Cross-listed with: NUCE 446

ME 448: Engineering Design Concepts

3 Credits

Engineering design and modelling, engineering economic analysis techniques, technical communication skills, project planning and design. M E 448 Engineering Design Concepts (3)This course is the first of a two-part sequence of courses that make up the capstone design experience in the ME BD major (the second course is M E 449, Mechanical Design Projects). In this course students study the engineering design process, begin working on their senior design project, and learn about professional topics related to industry. Topics in the engineering design process include customer needs identification, development of engineering specifications, concept generation, concept selection, costing, and project planning. Professional topics include communication, team work, ethics, safety, sustainability, globalization, and engineering economics. Students are evaluated on the design process and professional topics through assignments and quizzes. A major component of the course is to begin work on a capstone design project. Students work in

teams of 3 to 4 on an industrially-sponsored project or other project approved by the faculty. The student teams work with the sponsor to develop specifications and a project plan, perform background research necessary to fully understand the project, begin to solve the problem, and make two presentations during the semester. The first presentation is a formal project proposal; the second presentation at the end of the semester is a progress report. Students are evaluated on both their technical and presentation skills, as well as their ability to function as a team. This course is required in the Behrend Mechanical Engineering (ME BD) program, and integrates material from a number of previous courses.

Prerequisite: M E 380 , seventh-semester standing. Prerequisite or concurrent: M E 367 , M E 410

ME 449: Mechanical Design Projects

3 Credits

Group or individual design projects in the areas of mechanical engineering.

Prerequisite: M E 448 , eighth-semester standing

ME 450: Modeling of Dynamic Systems

3 Credits

Modeling and analysis of dynamic interactions in engineering systems. Classical and state variable methods; digital simulation; stability and dynamic response. M E 450 Modeling of Dynamics Systems (3) This course covers modeling, analysis, and control of single and multiple degree-of-freedom dynamical systems, including mechanical, electrical, thermal, fluid systems and their combinations (mixed systems). The processes of energy storage and dissipation, which are common for different kinds of dynamic systems, will be emphasized in investigating general principles for modeling various dynamic systems. Basic concepts in system theory such as state variables and stability notions will be introduced. Most of the content will be restricted to linear-time-invariant systems (LTIs); however, local linearization around nominal operating points will be taught to analyze nonlinear systems. Introduction to classical control analysis and design methods will also be given.

Prerequisite: M E 370 ; Prerequisite or concurrent: M E 345

ME 452: Vehicle Road Dynamics

3 Credits

This course conducts investigations of one-dimensional, two-dimensional, and three-dimensional dynamics, kinematics and design integrated into the study of vehicle dynamics. Topics include body kinematics, steady state body dynamics, transient stability, tire forces, suspension, automatic control, and driver interaction. The emphasis is on the analysis of a vehicle as a complex system, recognizing how to abstract observed behaviors into appropriate mathematical models, how to decompose behaviors into subsystems, how to construct and perform numerical simulations, and how to design and analyze experiments to test models and simulations to gain insights into design goals and tradeoffs.

Prerequisite: prerequisite or concurrent: M E 450

ME 453: Powertrain System Modeling, Simulation, and Control

3 Credits

This course introduces students to the control-oriented state-space and transfer function modeling of powertrain components and systems. Relevant application domains include conventional automotive powertrains, hybrid powertrains, locomotive propulsion systems, marine and submarine propulsion systems, and stationary power generation systems. The course introduces students to the use of fundamental principles from thermodynamics, fluid mechanics, and rigid body mechanics for powertrain modeling. Simple, control-oriented models are emphasized. Model integration and simulation topics, including numerical stiffness, solver selection, and integration step size selection are emphasized. Applications of powertrain modeling and control covered in the course include servo-control problems (e.g., air-fuel ratio control) and supervisory power management in hybrid powertrains.

Prerequisite: ME 370 CONCURRENT: ME 357; ME 450

ME 455: Automatic Control Systems

3 Credits

This course covers the characterization and feedback control of linear time invariant (LTI) dynamic systems, classical feedback control theories will be emphasized. Basic concepts of analyzing, predicting and specifying the performance of dynamic systems, including transfer functions, dynamic response, block diagram, stability notions and sensitivity will be introduced. A thorough treatment of feedback controller design via Root-Locus method will be provided, which includes the design of lead/lag compensation and PID controller. Frequency domain controller design will also be introduced thoroughly, from the characterization of open-loop frequency response using Bode plot to the analysis of closed-loop frequency response. In this process, the notions of gain-phase relationship, Nyquist stability criterion, and stability margin will be discussed. Finally, the method of adding dynamic compensation to adjust the frequency response and improve the stability and performance of the system will be introduced.

Prerequisite: M E 320, M E 450 or M E 357

ME 456: Introduction to Robotics

3 Credits

This course is a technical elective where students learn about the present and future status of robot applications, and are required to apply fundamental knowledge of physics, mechanics, and mathematics to develop software to analyze and control robots. The course deals with mechanics and control of mobile robots, flying robots and robot manipulators. First, students are taught to describe position and orientation of a rigid body, including rotation matrix, roll-pitch-yaw angles and Euler angles. In addition, a brief introduction to feedback control system is provided. After these background materials, students learn about the following topics: a. kinematics and control of wheeled mobile robots, car-like mobile robots and quadrotor and b. 3-D kinematics, statics, dynamics and control of robot manipulators. Sensors, actuators and software used in industrial robots are discussed.

Prerequisites: EMCH 212, ME 360; ME 367
Cross-Listed

ME 460: Advanced Machine Design Problems

3 Credits

This course is designed to approach and analyze fundamental problems in the design of advanced level machine components and systems. It integrates advanced concepts in fatigue, vibrations, mechanics of materials and tribology for component and system level reliability. The course emphasizes elements of power transmission through detailed discussion on kinematics and reliability-based design of cams, flywheels, transmission couplings and gear chains. Example cases involve single and multiple cylinder automotive engine system with analysis of dynamics and balancing, power transmission through both flexible and rigid elements as well as different kinds of differentials built of spur, helical, bevel and worm gears. Another thrust is the application of tribology on machine design with special focus on hydrostatic and hydrodynamic bearings. Through case studies drawn from design and failure from real life systems, the course develops knowledge and skills for translating design concepts from components to system level.

Prerequisite: M E 360 , M E 370
Cross-Listed

ME 461: Finite Elements in Engineering

3 Credits

Computer modeling and fundamental analysis of solid, fluid, and heat flow problems using existing computer codes. E MCH (M E) 461 Finite Elements in Engineering (3) This is an introductory course in the Finite Element Method. Through this course, students gain knowledge in finite element theory and problem modeling. The mathematical formulation of the method is presented and then applied to problems in elasticity and heat transfer. Projects are assigned to demonstrate the finite element method in simplified problems using hand- calculations and computer programs such as Matlab. The use of commercial FEA programs is introduced and problems of increased complexity are assigned to demonstrate their use in a computer lab. Finally, problems of realistic complexity are assigned such that students can practice solving, documenting and presenting their use of commercial FEA programs.

Prerequisite: E MCH213 , E MCH210H , or E MCH210 ; CMPSC200 , CMPSC201 or CMPSC202
Cross-listed with: EMCH 461

ME 462: Lubrication in Machine Design

3 Credits

Lubricants and lubrication with applications to design aspects of machines and mechanisms including bearings, gears, cams, and automotive engines. M E 462 Lubrication in Machine Design (3) The course covers interdisciplinary materials on lubrication in machine design including mechanical, mechanics and chemistry aspects. Six main topics will be studied. The course starts by introducing engineering tribology, highlighting its interdisciplinary nature and its significance in machine design. Surfaces of machine components in contact are studied, including surface physiochemistry, surface topography, topographical measurements and characterization and classification of regimes of lubrication. Lubricants used in machine design are discussed in length, including types of industrial lubricants, properties of lubricating oils: compositions, viscosity and additives, synthetic lubricants and engine oils. The course will develop the theory of fluid-film lubrication, including the mechanisms of pressure generation, configuration of tribo-contacts

and the Reynolds equation. Hydrodynamic lubrication is studied. The topics include the machine components with hydrodynamic lubrication, thrust bearings, journal bearings and design considerations of these devices. The last topic to be covered is the theory and application of Elastohydrodynamic lubrication (EHL). First, the machine components with concentrated contacts are introduced. Then, the Hertz theory of contact in studied and the governing equations for EHL are derived. Thermal EHL and traction are studied, and design calculations for rolling bearings, cams and gears are developed in relation to the geometrical and kinematic features of these components.

Prerequisite: MATH 251 , M E 360

ME 465: Introduction to Manufacturing Laboratory

1 Credits

A laboratory-based introduction to manufacturing processes including material removal, forming, casting and joining for metals and non-metals. M E 465 Introduction to Manufacturing Laboratory (1)This laboratory course provides an integrated approach to Manufacturing Science and Engineering. The laboratory examines common techniques for fabricating parts; providing an introduction to several basic processes for creating both metallic and polymeric parts. As a part of this course, students will be exposed to compressive, tensile, sheet, bending, casting and powder metal processes. Using basic material science principles, students will examine concepts such as material flow, springback, and cold working. The course requires hands-on involvement by the students in the planning of experiments as well as data manipulation and analysis of results. The laboratory exercises are intended to provide students with a broad appreciation of the breadth of Manufacturing Science and Engineering. Students work in groups. Written reports and in-class exercises are the primary basis for grading. This course is a technical elective.

Prerequisite: Prerequisite or concurrent: M E 468

ME 467: Applied Finite Element Analysis

3 Credits

Review of matrix algebra; discretization; finite element formulation; application of finite element computer codes.

PREPREQUISITE: ME 349 CONCURRENT: ME 410

ME 468: Engineering for Manufacturing

3 Credits

Manufacturability, the selection of the most effective materials and processes, and quality assurance. M E 468 Engineering for Manufacturing (3) This course will present an overview of the various manufacturing techniques that are currently used within industry. The advantages and disadvantages of each manufacturing technique will be discussed along with common defects that occur with each process. The start-up, operating, maintenance, and labor costs of each process will be presented along with general manufacturing economical concerns. Statistics and Quality assurance topics will also be covered, along with manufacturability and design for manufacturing concepts.

Prerequisite: MATSE259

ME 468H: Engineering for Manufacturing

3 Credits

Manufacturability, the selection of the most effective materials and processes, and quality assurance. M E 468 Engineering for Manufacturing (3) This course will present an overview of the various manufacturing techniques that are currently used within industry. The advantages and disadvantages of each manufacturing technique will be discussed along with common defects that occur with each process. The start-up, operating, maintenance, and labor costs of each process will be presented along with general manufacturing economical concerns. Statistics and Quality assurance topics will also be covered, along with manufacturability and design for manufacturing concepts.

ME 469: Metallic Manufacturing Processes

3 Credits

Principles of metal working and introduction to current theories; analysis of deformation, joining, and metal removal processes. M E 469 Metallic Manufacturing Processes (3)In this integrated lecture/laboratory course students will learn a) metal deformations techniques such as: forging, rolling, extrusion and drawing, b) metal removal techniques for single, multi and infinite point cutting, and c) metal fastening techniques, including bolts, rivets and welds. As a part of the learning process, students will directly compare existing standards and theories to actual laboratory results. Students will learn how to assess the accuracy of both theoretical derivations and experimental procedures by first deriving theoretical equations in the classroom and then directly examining the ability of the equations to predict the given behavior by actually performing the manufacturing operation in the laboratory. Based on in-depth discussions regarding assumptions, approximations, and experimental error, students will assess the ability of the current state-of-the-art techniques to accurately predict the forces generated/required during various manufacturing metal working operations. In addition, students will derive their own theories by removing/improving some assumptions within the existing theories. For processes where multiple theories exist, students will compare and contrast the predictive abilities of the various techniques to those found through controlled laboratory experiments. Similar comparisons will also be made for processes where both engineering standards and theoretical techniques exist.

Prerequisite: M E 349 . Prerequisite or concurrent: M E 468

ME 470: Analysis and Design in Vibration Engineering

3 Credits

Application of Lagrange's equations to mechanical system modeling, multiple- degree-of-freedom systems, experimental and computer methods; some emphasis on design applications. In this course, students will learn basic techniques for modeling and analyzing linear multidegree-of-freedom (MDOF) mechanical systems, and will learn how to use these techniques for mechanical design. Students will learn to obtain equations of motion using energy methods (Lagrange's equations), with emphasis on the efficient formulation and reduction to the linear case. The basic theory of MDOF systems will be presented, including: eigenvalue problems; natural frequencies and normal modes; superposition and modal analysis; and frequency response. Numerical methods for solving static, dynamic and eigenvalue problems will be presented. Introductions to the theory of linear continuous systems and experimental methods of vibrations will be presented. A substantial portion of the course will be spent discussing design applications of the basic theory, such as:

finite element numerical analysis and experimental modal analysis of beams and plates; vehicle suspension design; and vibration isolation and absorption.

Prerequisite: E MCH212 or E MCH212H ; M E 370 or E SC 407H Cross-listed with: EMCH 470

ME 471: Noise Control in Machinery

3 Credits

Nature of noise sources in machine elements and systems. Propagation and reduction of noise. Effects of noise on man. M E 471 Noise Control in Machinery (3) Course Objectives: This course prepares students to perform effectively as noise control engineers in industries with noise and vibration applications, e.g., during the early stages in product design or environmental noise control in industrial settings. Much of the material presented builds on second and third year courses covering such topics as dynamics, vibration, fluid mechanics and electrical components. Hands-on laboratory experiments (both programmed and open-ended) coordinated with focused lectures provide students with a working knowledge of the disciplines associated with noise and vibration and their practical applications for identifying, analyzing, and solving real world problems. The first part of the course centers on learning modules that cover the fundamentals of acoustics and noise control. Each module consists of two lectures followed with a laboratory experiment that demonstrates the relevant principles. These take place in small group settings (8 students maximum). Students are required to write individual reports based on the results of each of the laboratory experiments. The modules are followed with a laboratory project competition wherein each small group is given a noisy, small machine with the challenge to reduce its noise and vibration signatures. The course concludes with formal Power Point presentations of the results from each small group to an assessment team consisting of the industrial sponsors and selected professors and graduate students. This course is offered annually during the fall semester with an enrollment limited to 32 students (8/laboratory group).

Prerequisite: M E 320 , M E 370

ME 480: Mechanism Design and Analysis

3 Credits

Design and analysis of mechanical linkages including kinematic synthesis and dynamic analysis. Linkages for a variety of applications are considered. M E 480 Mechanism Design and Analysis (3) The student who takes this course will develop a basic understanding of the analysis and synthesis of planar linkage mechanisms. Students will develop the ability to model real linkage mechanisms using kinematic diagrams, including identification of links and joints. They will also learn to use Gruebler’s equation to calculate the mobility or number of degrees of freedom of linkages based on the kinematic diagram. Students will also become familiar with real mechanism applications in the context of mechanism synthesis, where they will learn to determine the required dimensions of a mechanism for a specific application. Students will apply these dimensional synthesis methods in a design project which includes building a simple linkage prototype. They will learn kinematic analysis methods, i.e., analysis of position, velocity, and acceleration of planar linkages. These methods consist of graphical, algebraic, and complex number approaches. Students will also learn to use commercial software packages, e.g. Working Model, to predict position, velocity, and acceleration of planar linkages, and will compare their predictions to those using analytical approaches. Finally, students will learn to do

dynamic force analysis of planar linkages to predict joint forces and motor torques. They will use commercial software packages to predict joint forces and motor torques of planar linkages, and will compare their predictions to those using analytical approaches.

Prerequisite: E MCH212 . Prerequisite or Concurrent: CMPSC200

ME 481: Introduction to Computer-Aided Analysis of Machine Dynamics

3 Credits

Techniques and formulations for computer based kinematic and dynamic analyses of machines. M E 481 Introduction to Computer-Aided Analysis of Machine Dynamics (3) This course addresses computer methods for kinematic and dynamic analyses of two-dimensional (2D) multi-body machines at the advanced undergraduate and introductory graduate level. The course introduces the formalism of kinematic mobility and topology to help students recognize constrained kinematic chains embedded in larger engineering systems. Classic kinematic and Newtonian dynamic methods are reformulated using modern matrix methods. The latter half of the course focuses on underlying algorithms and theory behind commercially available mechanism analysis software packages that employ differential-algebraic equation (DAE) solvers. Students program their own numerical integration methods for time domain simulation of forward dynamics of a simple system to reinforce the theory. The overall goals are for students to be able to identify forward versus inverse dynamic problems; and to be able to plan, implement and debug an appropriate computer-based design tool to analyze kinematics and dynamics of 2D constrained mechanisms.

Prerequisite: E MCH212 ; Prerequisite or concurrent: CMPSC200

ME 491: Bioengineering Applications of Mechanical Engineering

3 Credits

Application of mechanical engineering knowledge in the context of life sciences. M E 491 Bioengineering Applications of Mechanical Engineering (3)The primary objective of this course is to teach students how to apply mechanical engineering knowledge in the context of life sciences. Fundamental mechanical engineering knowledge such as solid mechanics, fluid mechanics and system dynamics will be reviewed first. Then, different topics in bioengineering, such as motion biomechanics, physiological fluid mechanics, modeling of physiological systems, and rehabilitation engineering will be discussed. Throughout the semester, students also work in groups to solve several simplified real-life bioengineering projects. Students will be evaluated through these projects plus a final project presentation, an application presentation and several homework assignments. This course is a technical elective in the ME BD program and allows students who have completed their junior year to learn the application of mechanical engineering knowledge in the life science context.

Prerequisite: E E 211 , M E 320 , M E 357 , E MCH213 , M E 349 or permission of program

ME 492: Dynamics and Vibration Lab

1 Credits

This lab is about Dynamic systems and Vibration. It studies the step response of first order system and second-order system: how to quantify transient response using parameters such as amplitude, frequency, overshoot, rising time, etc; and relate them to the modeling parameters such as time constant, damping ratio and natural frequency. It also

studies free vibration and harmonically excited vibration of SDOF, MDOF, and continuous mechanical systems: how to identify the resonance of vibration and measure/derive the transmissibility, and relate them to the modeling parameters such as damping ratio, natural frequency, and mode shapes. The proper implementation of those relation in the vibration isolation and absorption are also studied.

Prerequisite: ME 357 CONCURRENT: ME 370

ME 494: Research Project

1-12 Credits/Maximum of 12

Supervised student activities on research projects identified on an individual or small-group basis.

ME 494H: Senior Thesis

1-9 Credits/Maximum of 9

Students must have approval of a thesis adviser before scheduling this course. M E 494H Senior Thesis (1-9) All Schreyer Scholars are required to complete an undergraduate honors thesis. This work represents the culmination of a student's honors experience. Through the thesis, the student demonstrates a command of relevant scholastic work and a personal contribution to that scholarship.The thesis project can take many forms - from laboratory experiments all the way to artistic creations. The thesis document captures the relevant background, methods and techniques, as well as describing the details of the completion of the individual project. Two Penn State faculty members judge the merits of this Scholar's honors thesis, the student's self-selected thesis supervisor and the department-selected honors adviser in the student's area of honors.

Honors

ME 495: Internship

1-18 Credits/Maximum of 18

Supervised off-campus, nongroup instruction including field experiences, practica, or internships. Written and oral critique of activity required.

Prerequisite: prior approval of proposed assignment by instructor

ME 496: Independent Studies

1-18 Credits/Maximum of 18

Creative projects, including nonthesis research, which are supervised on an individual basis and which fall outside the scope of formal courses.

ME 496A: **SPECIAL TOPICS**

1-6 Credits

ME 496H: Honors Research

1-6 Credits

Honors research that fulfills Shreyer's Honor College requirements. This research will serve as a basis for my honors thesis. Research regarding the development and manufacturing of micro fuel cells. Course will be graded on a scale similar to a traditional class.

Honors

ME 497: Special Topics

1-9 Credits/Maximum of 9

Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest.

ME 499: Foreign Studies

1-12 Credits/Maximum of 12

Courses offered in foreign countries by individual or group instruction.

International Cultures (IL)