Note on Course Numbers

Each Carnegie Mellon course number begins with a two-digit prefix which designates the department offering the course (76-xxx courses are offered by the Department of English, etc.). Although each department maintains its own course numbering practices, typically the first digit after the prefix indicates the class level: xx-1xx courses are freshmen-level, xx-2xx courses are sophomore level, etc. xx-6xx courses may be either undergraduate senior-level or graduate-level, depending on the department. xx-7xx courses and higher are graduate-level. Please consult the Schedule of Classes (https://enr-apps.as.cmu.edu/open/SOC/SOCServlet) each semester for course offerings and for any necessary pre-requisites or co-requisites.

24-101 Fundamentals of Mechanical Engineering
Fall and Spring: 12 units
The purpose of this course is to introduce the student to the field of mechanical engineering through an exposition of its disciplines, including structural analysis, mechanism design, fluid flows, and thermal systems. By using principles and methods of analysis developed in lectures, students will complete two major projects. These projects will begin with conceptualization, proceed with the analysis of candidate designs, and culminate in the construction and testing of a prototype. The creative process will be encouraged throughout. The course is intended primarily for CIT freshmen. 3 hrs. lec., 2 hrs. rec./lab.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-200 Machine Shop Practice
Fall and Spring: 1 unit
24-200 Machine Shop Practices Fall and Spring Semesters, 1 units, 6 week mini course This course familiarizes students with the operation and safety of machine tools. This gives students knowledge of what goes into engineering designs in building a prototype and also enables them to operate shop machinery as a part of future courses. Prerequisite: Undergraduate Mechanical Engineering standing 2 hours lab Machine Shop Practices should be completed prior to Design II 24-441. However, if necessary, it may be scheduled concurrently with Design II in the first mini of the semester.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-201 Engineering Graphics
Spring: 9 units
Introduction to the use and preparation of manually and computer generated engineering drawings, including the following topics: basic drafting techniques; dimensioning of orthographic drawings; auxiliary and oblique views; sectional drawings; working drawings; blueprint reading; freehand sketching; production standards, methods, and symbols; simplified drawing techniques; intersection and development; basic applied descriptive geometry. Free elective credit only- not acceptable as a Mechanical Engineering Technical Elective. 3 hrs. rec., 3 hrs. lab.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-202 Introduction to Computer Aided Design
Fall: 1 unit
Introduction to computer aided mechanical design using SolidWorks 3D CAD software. Includes the creation and analysis of components and assemblies, generation of drawings, and exporting for manufacture. Two hours of guided computer lab work each week.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-221 Thermodynamics I
Fall: 10 units
Temperature and thermometry: equations of state for fluids and solids; work, heat, and the first law; internal energy, enthalpy, and specific heats; energy equations for flow; change of phase; the second law, reversibility, absolute temperature, and entropy; combined first and second laws; availability, power and refrigeration cycles. Applications to a wide range of processes and devices. 3 hrs. lec., 1 hour recitation
Prerequisites: 33-106 and 24-101 and (21-123 or 21-122).
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-231 Fluid Mechanics
Spring: 10 units
Prerequisites: 33-106 and (21-123 or 21-122).
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-261 Statics
Fall: 10 units
This course is the first in a two-semester sequence on the solid mechanics of engineering structures and machines. The course begins with a review of the statics of rigid bodies, which includes the identification of statically indeterminate problems. Two- and three-dimensional statics problems are treated. Thereafter, the course studies stresses and deflections in deformable components. In turn, the topics covered are: simple tension, compression, and shear; thin-walled pressure vessels; torsion; and bending of beams. For each topic, statically indeterminate problems are analyzed and elementary considerations of strength are introduced. 3 hrs. lec., 1 hr. rec./lab.
Prerequisites: (21-123 or 21-118 or 21-122) and 33-106.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-262 Stress Analysis
Spring: 12 units
This course is the second in a two-semester sequence on the solid mechanics of engineering structures and machines. The basic topics of uniaxial tension/compression, torsion, and flexural deformation from 24-261 are reviewed. Combined loadings and stresses are then treated, which lead to a consideration of failure criteria. Two-dimensional elasticity and the finite element method are introduced. Stress concentrations are quantified analytically, numerically, and with the use of engineering handbooks. Cyclic failure criteria are introduced, and both static and cyclic failure criteria are applied to results from numerical analysis. 3 hrs. lec., 1 hr. rec./lab.
Prerequisites: 33-106 and 24-261.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-302 Mechanical Engineering Seminar I
Fall and Spring: 2 units
The purpose of this course is to help students develop good presentation skills and to provide a forum for presentations and discussions of professional ethics. Students will make at least two presentations, one of which is related to professional ethics. Student grades will be based on their presentation skills and their participation in class discussions. 1 hr. rec.
Prerequisites: Junior standing or permission of instructor.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-311 Numerical Methods
Fall: 12 units
Use of numerical methods for solving engineering problems with the aid of a digital computer. The course will contain numerical methods such as roots of equations, linear algebraic equations, optimization, curve fitting, integration, and differential equation solving. MATLAB will be used as the programming language. Programming Cluster laboratory times will be available twice a week. Problems will be drawn from all fields of interest to mechanical engineers. 3 hrs. lecture plus lab
Prerequisite: 21-260.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-321 Thermofluids Experimentation and Design
Spring: 12 units
24-321 Thermal-Fluids Experimentation and Design Spring: 12 units This is a capstone course for the thermal-fluids core-course sequence. This course is comprised of two elements: experimentation and design. The experimental experience covers techniques of measurement, uncertainty analysis, and realization of systems, which demonstrate fundamental principles in thermodynamics, fluid mechanics, and heat transfer. The practice of designing a thermal system is also integrated into this course. 4 hrs. lec./lab Pre-requisites: 24-221 (Thermodynamics I), 24-231 (Fluid Mechanics), 24-322 (Heat Transfer)
Prerequisites: 24-231 and 24-221 and 24-322.
Course Website: http://www.cmu.edu/me/undergraduate/index.html
24-322 Heat Transfer
Fall: 10 units
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-324 Energy and Thermal Systems Analysis
Fall: 9 units
Fall: 9 units Energy and Thermal Systems Analysis Performance studies of various thermal processes and devices with emphasis on energy utilization. The concepts of gas mixtures, chemical potential, and energy (availability) analysis will be introduced and applied. Examples will be drawn from cogeneration and nuclear power plants, jet propulsion, internal combustion engines, desalination, and fuel cells. 3 hrs. rec. Prerequisites: 24-221, 24-231.

24-331 Viscous Flow
Intermittent: 10 units
The concept of fluid shear and viscosity and viscous flow in tubes and channels. Hydrodynamic lubrication of bearings. The concept of turbulence and turbulent flow in tubes and channels. The boundary layer concept and applications to momentum transfer (drag), energy transfer (heat convection), and mass transfer (evaporation, etc.). 3 hrs. rec. Prerequisites: 24-221 and 21-260 and 21-259 and 24-231.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-332 Potential Flow Aerodynamics
Intermittent: 9 units
Development of the fundamental equations of incompressible frictionless flow. Concepts of circulation, vorticity, irrotationality, stream function, and velocity potential. Two-dimensional low speed airfoil theory; lift and moment calculations for the infinite span wing; empirical airfoil data for real airfoils; thin airfoil theory. Three-dimensional effects; flow distribution; Prandtl’s wing theory; induced drag; the elliptic lift distribution; the general lift distribution. 3 hrs. rec. Prerequisites: 24-231 and 21-260 and 21-259.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-333 Gas Dynamics
Intermittent: 9 units

24-341 Manufacturing Sciences
Spring: 9 units
This course has two broad concerns: an introductory review of manufacturing systems organization and a review of common manufacturing processes from the point of view of design for manufacturability. The features of mass and batch production are quantitatively considered. The basic principles of group technology and production planning are outlined. The use of computers in manufacturing is described, together with a review of the current capabilities of industrial robots. Students will be involved in weekly seminars, which will describe the basic features of common manufacturing processes, including metal machining, metal forming, polymer processing, casting techniques, joining techniques, ceramic processing, and powder processing. Case studies from industry and films may be used. 3 hrs. rec. Prerequisite: 24-262.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-351 Dynamics
Fall: 10 units
This first course on the modeling and analysis of dynamic systems concentrates on the motion of particles, systems of particles, and rigid bodies under the action of forces and moments. Topics include the kinematics of motion in rectangular, polar, and intrinsic coordinates; relative motion analysis with multiple reference frames; and planar kinetics through the second law, work-energy method, and impulse-momentum method. Time and frequency domain solutions to first and second order equations of motion are discussed. 3 hrs. lec. 1 hr rec. Prerequisite: 24-261.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-352 Dynamic Systems and Controls
Spring: 12 units
This second course on the modeling and analysis of dynamic systems emphasizes the common features, which are exhibited by physical systems that include mechanical, hydraulic, pneumatic, thermal, electrical, and electromechanical elements. State equations and the concepts of equilibrium, linearization, and stability are discussed. Time and frequency domain solutions are developed. 4 hr. lec. Prerequisites: 24-261 and 21-260 and 33-107.
Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-355 Kinematics and Dynamics of Mechanisms
Intermittent: 9 units
This design-oriented course addresses the kinematics and dynamics of mechanisms with applications to linkage systems, reciprocating engines, and industrial machinery. Conventional as well as innovative rigid-body dynamic systems are studied. Problems of kinematics and dynamics are framed in a form suited for computer analysis. The course bridges analysis and design by emphasizing the synthesis of mechanisms. To stimulate a creative approach, homework and project work draw upon actual engineering design problems. 3 hrs. rec. Prerequisite: 24-351.

24-356 Engineering Vibrations
Intermittent: 11 units
Frequency response of linear mechanical systems, with and without damping. Use of computational methods for simulating system response and the use of modal analysis for understanding the vibratory response of complex systems. Lumped and distributed mass systems. Applications include isolation, stability, and balancing. 3 hrs. lec., 1 hr. rec. Prerequisite: 21-260.

24-357 Special Topics in Material Selection for Mechanical Engineers
Intermittent: 9 units
This course provides a methodology for selecting materials for a given application. It aims to provide an overview of the different classes of materials (metal, ceramic, glass, polymer, elastomer or hybrid) and their properties including modulus, strength, ductility, toughness, thermal and electrical conductivity, and resistance to corrosion in various environments. Students will also learn how materials are processed and shaped (e.g., injection molding, casting, forging, extrusion, welding, grinding, and polishing), and will explore the origins of the properties, which vary by orders of magnitude. The course accomplishes the materials selection objective in part through example applications and in part through the use of CES EduPack software (a visual way to explore the world of materials and processes). Topics include: Materials selection by stiffness, weight, strength, fracture toughness, corrosion and oxidation, and thermal properties. Materials at high temperatures, materials shaping. Phase diagrams and phase transformations. Prerequisite: Junior Standing in Mechanical Engineering. Stress Analysis 24-262.
Course Website: http://www.cmu.edu/me/
24-358 Special Topics in Culinary Mechanics
Intermittent: 9 units
This course discusses how mechanical quantities and processes such as force, motion, and deformation influence food and the culinary arts. The aim of the course is to apply important aspects of mechanics to ideas in cooking. Specific topics include: (1) how do stress and strain affect food and its perceived taste; (2) what is the role of cell mechanics in the resulting microstructure of both consumed plant and animal tissues; (3) how can mechanics be used to alter nutrition; (4) what are the roles of common and uncommon mechanical tools such as a knife or mortar and pestle in food preparation. Emphasis will be placed on the biomechanics of edible matter across multiple length scales, including at the tissue, cellular, and molecular levels; additionally, impact on global health and engineering implications will be elucidated. During this course, we will introduce you to these concepts, train you to use them in real world applications, and allow you to pursue a creative group-defined project, which will be shared in both written and oral formats. We will integrate a hands-on kitchen experience in at least 3 specific laboratory classes so that students will get a true feel and understanding for culinary mechanics. We also will be visiting the restaurant of at least one first-rate Pittsburgh chef to gain real world insight into mechanics and cooking.

Course Website: http://www.cmu.edu/me/24-358

24-361 Intermediate Stress Analysis
Intermittent: 10 units
This course first reviews important solutions from strength of materials, Mohr’s circle, and multiaxial failure theories. Students are then introduced to the theory of elasticity with an emphasis on understanding the field equations and boundary conditions. A short introduction to the theory of finite element methods is given. Additional topics covered include buckling, stress concentrations, plasticity, and fracture mechanics. An important aspect of the course is teaching students how topics covered in class can be applied to predict or understand failures in engineering applications. Another important skill that is emphasized is the application of fundamentals from the lectures and physical intuition to interpret results generated by finite element models. 3 hrs. lec., 1 hr. lab.

Prerequisites: 24-262 and 21-259.

Course Website: http://www.cmu.edu/me/24-361

24-365 Special Topics: Applied Finite Element Analysis
Intermittent: 9 units
This is an introductory course for the finite element method with emphasis on application of the method to a wide variety of problems. The theory of finite element analysis is presented and students learn various applications of the method through labs using ANSYS. Various types of analyses are considered including static, pseudo-static, dynamic, modal, buckling, contact, heat transfer, thermal stress and thermal shock. The students use truss, beam, spring, solid, plate, and shell elements in the models created. 9 units

Prerequisite: 24-262.

Course Website: http://www.cmu.edu/me/24-365

24-370 Engineering Design I: Methods and Skills
Spring: 12 units
24-370 Engineering Design I: Methods and Skills Spring: 12 Units In this course, students will learn methods and skills for the engineering design process, consisting of four stages: concept design, detail design, analysis, and manufacturing. The course covers the engineering design process in a holistic fashion by discussing theories and practices of the four stages and inter-relating them. Hands-on assignments, including computational and physical projects, are given to enhance the learning outcome. After taking this course, students will be able to: express ideas in sketches; interpret and create engineering drawings; select and apply machine elements; model detailed shapes with CAD tools; analyze product performance with CAE tools; choose materials and manufacturing schemes, and create and test prototypes. Recommended: 24-200 (machine shop practice). Co-requisites: 24-262 (stress analysis) and junior status.

Corequisite: 24-262.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-380 Special Topics in Mechanical Engineering
Intermittent: 9 units
The Special Topics in Mechanical Engineering courses provide students with exposure to a variety of advanced concepts related to Mechanical Engineering and are offered on an “as available” basis. The final digit reflects the primary application area of the material, where 0 is professional; 1 is mathematics; 2 is thermal engineering; 3 is fluid mechanics; 4 is design and manufacturing; 5 is dynamics and controls; and 6 is solid mechanics.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-391 Mechanical Engineering Project
All Semesters
Practice in the organization, planning, and execution of appropriate engineering projects. These investigations may be assigned on an individual or a team basis and in most cases will involve experimental work. 9 hrs. lab.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-392 Mechanical Engineering Project
All Semesters
Practice in the organization, planning, and execution of appropriate engineering projects. These investigations may be assigned on an individual or a team basis and in most cases will involve experimental work. 9 hrs. lab.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-415 Microfluidics
Intermittent: 9 units
24-415 – Microfluidics 9 units This course offers an introduction to the emerging field of microfluidics with an emphasis on chemical and life sciences applications. During this course students will examine the fluid dynamical phenomena underlying key components of “lab on a chip” devices. Students will have the opportunity to learn practical aspects of microfluidic device operation through hands-on laboratory experience, computer simulations of microscale flows, and reviews of recent literature in the field. Throughout the course, students will consider ways of optimizing device performance based on knowledge of the fundamental fluid mechanics. Students will explore selected topics in more detail through a semester project. Major course topics include pressure-driven and electrokinetically-driven flows in microchannels, surface effects, microfabrication methods, micro/nanoparticles for biotechnology, biochemical reactions and assays, mixing and separation, two-phase flows, and integration and design of microfluidic chips, 3 hrs. lec. Prerequisites: 24-231 or 24-232 or 06-261 or 12-355 Cross-listed with 24-715.

24-421 Internal Combustion Engines
Fall: 12 units
This course discusses working principles of internal combustion engines found in many practical applications. Focus is given to understanding the design of air handling system, in-cylinder fuel/air mixing, geometric design of the combustion chamber, engine performance and calibration, and mechanism of pollutant formation and reduction. Introductory discussion of advanced automotive engine concepts, alternative fuels, gas turbine engines, rocket engines, and hybrid electric vehicles is also provided. The course relies on a number of lab experiments, analysis of actual experimental data, and a combination of analytical and numerical homework assignments. 24-231 and 24-221 or equivalent 3 hrs. lecture 2 hrs. lab

Prerequisites: 24-231 and 24-221

Corequisite: 24-232.

Course Website: http://www.andrew.cmu.edu/user/satbir/24421/

24-423 Direct Energy Conversion
Intermittent: 9 units
Principles of energy conversion between various forms of energy including heat, electricity, and light. Applications: Theory of thermoelectric, thermionic, magnetohydrodynamic, and photovoltaic direct conversion devices. Principles of chemical and mechanical energy storage.

Prerequisites: 24-231 and 24-221 and 33-107.

24-424 Energy and the Environment
Intermittent: 9 units
Fuel cycles for conventional and non-conventional energy resources; relationships between environmental impacts and the conversion or utilization of energy; measures of system and process efficiency; detailed study and analysis of coal-based energy systems including conventional and advanced power generation, synthetic fuels production, and industrial processes; technological options for multi-media (air, water, land) pollution control; mathematical modeling of energy-environmental interactions and tradeoffs and their dependence on technical and policy parameters; methodologies for energy and environmental forecasting; applications to issues of current interest. 3 hrs lecture.

Course Website: http://www.cmu.edu/me/undergraduate/index.html
24-425 Combustion and Air Pollution Control
Intermittent: 9 units
Formation and control of gaseous and particulate air pollutants in combustion systems. Basic principles of combustion, including thermochemical equilibrium, flame temperature, chemical kinetics, hydrocarbon chemistry, and flame structure. Formation of gaseous and particulate pollutants in combustion systems. Combustion modifications and post-combustion technologies for pollutant control. Relationship between technology and regional, national, and global air pollution control strategies. The internal combustion engine and coal-fired utility boiler are used as examples. 3 hours lecture Cross listed as 24-740 and 19440/19-740.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-441 Engineering Design II: Conceptualization and Realization
Fall and Spring: 12 units
24-441 - Engineering Design II: Conceptualization and Realization Fall and Spring 12 units. This course guides students through the design process in the applied design of a practical mechanical system. Lectures describe the typical design process and its associated activities, emphasizing methods for innovation and tools for design analysis. Professional and ethical responsibilities of designers, interactions with clients and other professionals, regulatory aspects, and public responsibility are discussed. The design project is typically completed in teams and is based on a level of engineering knowledge expected of seniors. Proof of practicality is required in the form of descriptive documentation. Frequently, a working model will also be required. Oral progress reports and a final written and oral report are required. 3 hrs. rec., 3 hrs lab Prerequisites: 24-262 (Stress Analysis) and senior standing. Co-requisite: Design I 24-370 (preferred as a prerequisite) Machine Shop Practice 24-200 (preferred as a prerequisite) Prerequisite: 24-262 Corequisite: 24-370.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-451 Feedback Control Systems
Fall: 12 units
Fundamentals of feedback control with emphasis on classical techniques and an introduction to discrete-time (computer controlled) systems. Topics include the following: frequency domain modeling and state space modeling of dynamical systems; feedback control system concepts and components; control system performance specifications such as stability, transient response, and steady state error; analytical and graphical methods for analysis and design - root locus, Bode plot, Nyquist criterion; design and implementation of proportional, proportional-derivative, proportional-integral-derivative, lead, lag, and lead-lag controllers. Extensive use of computer aided analysis and design software. 4 hrs lec. Prerequisites: (15-100 or 15-111) and 24-352.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-452 Mechanical Systems Experimentation
Fall: 9 units
24-452 Mechanical Systems Experimentation Fall : 9 Units Experimentation in dynamic systems and controls. The course will cover translational and rotational systems. Topics will include mechanical elements, natural frequencies, mode shapes, free and forced response, frequency response and Bode plots, time constants, transient response specifications, feedback controls such as PID control, and stability for single-degree-of-freedom and multi-degree-of-freedom systems. The course will introduce and use state-of-the-art experimentation hardware and software. 1 hr. lecture, 2 hrs. lab. Co-requisite: 24-352 (Dynamic Systems and Control) (due to scheduling is typically and ideally a pre-requisite) and senior status. THIS COURSE IS FALL ONLY - DSC IS SPRING ONLY Prerequisite: 24-352.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-484 Decision Tools for Engineering Design and Entrepreneurship
Intermittent: 12 units
24-484 Decision Tools for Engineering Design and Entrepreneurship 12 Units This course provides engineers with a multidisciplinary mathematical foundation for integrated quantitative engineering principles and enterprise planning decisions in an uncertain, competitive market. Topics include economics in product design, manufacturing and operations modeling and accounting, consumer choice modeling, survey design, conjoint analysis, decision-tree analysis, optimization, game theory, model integration, and professional communication skills. Students will apply theory and methods to a team project for a new product or emerging technology of their choice, developing a business plan to defend technical and economic competitiveness. Students may choose to select emerging technologies from research at Carnegie Mellon for study in the course, and in some years venture capitalists and other industry leaders will take part in critiquing student projects. This course assumes some prior programming experience in Matlab. Prerequisites: Senior standing and 21-259 or instructor approval (Cross listed with 24-784, 19-484 and 19-784) Prerequisite: 21-259.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-491 Department Research Honors
Fall and Spring
This course is designed to give students increased exposure to "open-ended" problems and research type projects. It involves doing a project on a research or design topic and writing a thesis describing that project. The project would be conducted under the supervision of a mechanical engineering faculty member (the advisor), and must be approved by the advisor before inception. This course can be taken at any time after the junior year and before graduation which includes the summer after the junior year. Completion of 18 units of this course with a grade of B or better is a partial fulfillment of the requirements for Departmental Research Honors.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-492 Department Research Honors
Fall and Spring
This course is designed to give students increased exposure to "open-ended" problems and research type projects. It involves doing a project on a research or design topic and writing a thesis describing that project. The project would be conducted under the supervision of a mechanical engineering faculty member (the advisor), and must be approved by the advisor before inception. This course can be taken at any time after the junior year and before graduation which includes the summer after the junior year. Completion of 18 units of this course with a grade of B or better is a partial fulfillment of the requirements for Departmental Research Honors.

Course Website: http://www.cmu.edu/me/undergraduate/index.html

24-614 Microelectromechanical Systems
Intermittent: 12 units
This course introduces fabrication and design fundamentals for Microelectromechanical Systems (MEMS): on-chip sensor and actuator systems having micron-scale dimensions. Basic principles covered include microstructure fabrication, mechanics of silicon and thin-film materials, electrostatic force, capacitive motion detection, fluidic damping, piezoelectricity, piezoresistivity, and thermal micromechanics. Applications covered include pressure sensors, micromirror displays, accelerometers, and gas microsensors. Grades are based on exams and homework assignments. 4 hrs. lecture Prerequisite for undergraduates: 18-321 or 24-351 Prerequisite for: 18-724/24-724. Cross-listed 18-614. Prerequisites: 18-321 or 24-351.

Course Website: http://www.cmu.edu/me/graduate/index.html
24-615 Microfluidics
Intermittent: 12 units
This course offers an introduction to the emerging field of microfluidics with an emphasis on chemical and life sciences applications. During this course students will examine the fluid dynamic phenomena underlying key components of "lab on a chip" devices. Students will have the opportunity to learn practical aspects of microfluidic device operation through hands-on laboratory experience, computer simulations of microscale flows, and reviews of recent literature in the field. Throughout the course, students will consider ways of optimizing device performance based on knowledge of the fundamental fluid mechanics. Students will explore selected topics in more detail through a semester project. Major course topics include: pressure-driven and electrokinetically-driven flows in microchannels, surface effects, micro-fabrication methods, micro/nanoparticles for biotechnology, biochemical reactions and assays, mixing and separation, two-phase flows, and integration and design of microfluidic chips. Undergraduate Fluid Mechanics prerequisite or instructor permission 4 hrs. lecture.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-616 Tribology-Friction, Lubrication and Wear
Intermittent: 12 units
24-616 - Tribology – Friction, Lubrication and Wear Intermittent: 12 units Covers the science of surfaces interacting via dry, lubricated, and mixed (i.e., dry + lubricated) contact. Fundamental aspects include the Reynolds Equation, thermal-tribology, friction, and wear. Applied topics include bearings, surface analysis, nanomanufacturing, and biotribology. The course will conclude with a team project which will require computer programming. 4 hrs lec. Prerequisite: None.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-623 Molecular Simulation of Materials
Spring: 12 units
24-623: Molecular Simulation of Materials Spring: 12 units The purpose of this course is to expose engineering students to the theory and implementation of numerical techniques for modeling atomic-level behavior. The main focus is on molecular dynamics and Monte Carlo simulations. Students will write their own simulation computer codes, and learn how to perform calculations in different thermodynamic ensembles. Consideration will be given to heat transfer, mass transfer, fluid mechanics, mechanics, and materials science applications. The course assumes some knowledge of thermodynamics and computer programming. 4 hrs lec. Prerequisite: None.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-626 Special Topics in Air Quality Engineering
Intermittent: 12 units
Problems and methodologies for studies of environmental management, with an emphasis on air pollution. Key topics include sources of pollutants, focusing on combustion chemistry for a hydrocarbon fuel; behavior of gaseous and particulate pollutants in the atmosphere including the role of meteorology and the use of dispersion equations; effects of pollutants on human health and global climate; and procedures by which air pollution standards are developed and enforced by regulatory agencies. Statistical treatment of data is included at several places in the course. 12 units.
Course Website: http://www.cmu.edu/me/

24-642 Fuel Cell Systems
Fall: 12 units
Fuel cells are devices that convert chemical potential energy directly into electrical energy. Existing fuel cell applications range from the small scale, such as portable cell phone chargers, to the large scale, such as MW-scale power plants. Depending on the application, fuel cell systems offer unique advantages and disadvantages compared with competing technologies. For vehicle applications, they offer efficiency and environmental advantages compared with traditional combustion engines. In the first half of the course, the focus is on understanding the thermodynamics and electrochemistry of the various types of fuel cells, such as calculating the open circuit voltage and the sources of voltage loss due to irreversible processes for the main fuel cells types. PEM/SOFC/MCFC. The design and operation of several real fuel cells are then compared against this theoretical background. The second half of the course focuses on the balance-of-plant requirements of fuel cell systems, such as heat exchangers, pumps, fuel processors, compressors, as well as focusing on capital cost estimating. Applying the material learned from the first and second halves of the class into a final project, students will complete an energy & economic analysis of a fuel cell system of their choice. Prerequisite- Undergraduate Thermodynamics course 12 units.
Prerequisites: 24-221 or 06-221 or 27-215.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-655 Cellular Biomechanics
Intermittent: 9 units
24-655 - Cellular Biomechanics Intermittent: 9 units This course discusses how mechanical quantities and processes such as force, motion, and deformation influence cell behavior and function, with a focus on the connection between mechanics and biochemistry. Specific topics include: (1) the role of stresses in the cytoskeleton dynamics as related to cell growth, spreading, motility, and adhesion; (2) the generation of force and motion in stress fibers; (3) stretch-activated ion channels; (4) protein and DNA deformation; (5) mechanochemical coupling in signal transduction. If time permits, we will also cover protein trafficking and secretion and the effects of mechanical forces on gene expression. Emphasis is placed on the biomechanics issues at the cellular and molecular levels; their clinical and engineering implications are elucidated. 3 hrs lec. Prerequisite: Instructor permission.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-656 Advanced Manufacturing
Intermittent: 12 units
24-656 Advanced Manufacturing Intermittent: 12 units This course focuses on modeling of material removal processes, including the turning, milling, boring, and drilling processes. The course also includes introduction on economics of material removal, non-traditional material removal processes, stability of machining processes, tool wear and tool life, dimensional and surface metrology, and experimental methods in manufacturing. A term project that may involve experimentations is an integral part of the course. 4 hrs lec. Prerequisite: Senior or Graduate Standing.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-657 Molecular Biomechanics
Intermittent: 9 units
This class is designed to present concepts of molecular biology, cellular biology and biophysics at the molecular level together with applications. Emphasis will be placed both on the biology of the system and on the fundamental physics, chemistry and mechanics which describe the molecular level phenomena within context. In addition to studying the structure, mechanics and energetics of biological systems at the nano-scale, we will also study and conceptually design biomimetic molecules and structures. Fundamentals of DNA, global and structured proteins, lips and assemblies thereof will be covered. Prerequisites: Thermodynamics (06-221 or 24-221) or permission from the instructor.
Course Website: http://www.cmu.edu/me

24-658 Computational Bio-Modeling and Visualization
Spring: 12 units
Biomedical modeling and visualization play an important role in mathematical modeling and computer simulation of real/Artificial life for improved medical diagnosis and treatment. This course integrates mechanical engineering, biomedical engineering, computer science, and mathematics together. For the student include medical imaging, image processing, geometric modeling, visualization, computational mechanics, and biomedical applications. The techniques introduced are applied to examples of multi-scale modeling and simulations at the molecular, cellular, tissue, and organ level scales. 4 hrs. lec.,lab.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-661 Vibrations of Linear and Dynamic Systems
Intermittent: 12 units
The subject area for this course is mechanical vibration, at a level appropriate for first-year graduate students. Classical techniques in mechanical vibration are developed for the modeling and analysis of discrete and continuous linear systems. Continuous systems are described within the broader context of operator theory to emphasize the physical and mathematical analogies with discrete systems. Specific topics include: Discrete systems. Equations of motion for multiple degree of freedom systems through Lagrange's method; linearization about equilibrium; symmetry and definiteness properties; forced vibration; matrix eigenvalue problems; orthogonality; Rayleigh quotient; generalized coordinates; transient and forced response through modal analysis. Continuous systems. Classical rod, shaft, string, beam, membrane and plate models; Hamilton's principle; eigenvalues and boundary conditions through variational methods; essentials of functional analysis; exact solution of eigenvalue problems; response through modal analysis and Green's function methods; global discretization; Galerkin's method; essential and suppressible boundary conditions; Kalmke quotient; introduction to elastic wave propagation. Lecture 4.0 hours.
Course Website: http://www.cmu.edu/me/
24-673 Special Topics: Soft Robots: Mechanics, Design and Modeling
Spring: 12 units
Soft, elastically-deformable machines and electronics will dramatically improve the functionality, versatility, and biological compatibility of future robotic systems. In contrast to conventional robots and machines, these “soft robots” will be composed of elastomers, gels, fluids, gas and other non-rigid matter. We will explore emerging paradigms in soft robotics using mathematical insights from solid mechanics, shell theory, contact mechanics, and classical electromagnetism. Specific topics include artificial muscles, peristaltic robotics, soft pneumatic robotics, fluid-embedded elastomers, and particle jamming. This course will include team projects in which students are expected to design, model, and simulate or build a novel soft pneumatic actuator. 4 hrs lecture. Prerequisites: Statics and Stress Analysis or equivalents.
Course Website: http://www.cmu.edu/me/

24-674 Design of Biomechatronic Systems for Humans
Intermittent: 12 units
This course explores methods for the design of electromechanical devices that physically interface with humans to improve biomechanical performance, such as robotic prosthetics and orthoses. Students will learn about common physical disabilities and methods for generating and evaluating potential interventions. Students will learn about state-of-the-art actuation and sensing systems, and design selected types to meet dynamic performance criteria. We will cover technology for interfacing these devices with humans, and implications for the resulting biomechatronic systems. Students will learn experimental methods for evaluating intervention effectiveness, including inverse dynamics and metabolics analyses. Students will complete a final project that involves introduction of novel elements to a biomechatronic system. Students need a foundation in machine design and numerical tools such as Matlab, and will benefit from knowledge of dynamics and biomechanics. Lecture 4 hrs. 12 units.
Course Website: http://www.cmu.edu/me/

24-675 Micro/Nano Robotics
Spring: 12 units
24-675- Micro/Nano Robotics Spring: 12 units This course focuses on the design, modeling, fabrication, and control of miniature mobile robot and micro/nano-manipulation systems for graduate and upper level undergraduate students. It provides an overview of the state-of-the-art micro- and nanoscale sensors, actuators, manipulators, energy sources, robot design, and control methods. It requires active student participation, interaction, and in-class discussions. In addition to the basic background, it includes many case studies of current miniature robots and micro/nano-systems, challenges and future trends, and potential applications. The course requires a final project involving novel theoretical and/or experimental ideas for micro/nano-robotic systems with a team of students. Depending on the equipment availability, these projects can also involve hands-on experience and experimental demonstrations. 4 hrs. lec. Prerequisites: Permission of the instructor.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-676 Bio-Inspired Robotics
Fall: 12 units
This course will explore design and control of biologically inspired robots. Locomotion principles of many agile animals such as lizards, snakes, insects, fishes, and birds will be studied with corresponding bio-inspired robotic platforms. Required bio-inspired robotic mechanisms, materials, actuators, sensors, and power sources to enable similar locomotion principles will be taught. Besides the basic background knowledge, it will include the current trends in literature, detailed case studies and discussions, and guest lecturer talks. Course projects will involve theoretical and hands-on topics on design, manufacturing and control of bio-inspired robots. 4 hrs.lec.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-681 Computer-Aided Design
Intermittent: 12 units
24-681 – Computer Aided Design Intermittent: 12 units This course is the first section of the two-semester sequence on computational engineering. Students will learn how computation and information technologies are rapidly changing the way engineering design is practiced in industry. The course covers the theories and applications of the measurement, representation, modeling, and simulation of three-dimensional geometric data used in the engineering designed process. Students taking this course are assumed to have knowledge of the first course in computer programming. 4 hrs lecture, 2 hrs computer cluster Prerequisites: None.
Course Website: http://www.andrew.cmu.edu/course/24-681/

24-682 Computer-Aided Engineering
Intermittent: 12 units
24-682 – Computer Aided Engineering Intermittent: 12 units This course is the second in the two-semester sequence on computational engineering. Students will learn how computation and information technologies are rapidly changing the way engineering analysis is practiced in industry. The course covers the theories and applications of finite element methods, finite element mesh generation, robot manipulator kinematics, and inverse kinematics, and manufacturing process optimization. Students taking this course are assumed to have knowledge of the first course in computer programming. 4 hrs lecture, 2 hrs computer cluster Prerequisites: None.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-683 Design for Manufacture and the Environment
Fall: 12 units
Design for Manufacturing and the Environment examines influences of manufacturing and other traditionally downstream issues on the overall design process. Manufacturing is one facet that will be examined. Other downstream influences that will be studied include: assembly, robustness and quality, platform design, maintenance and safety, economics and costing, lean manufacturing and globalization. In addition, a core part of the course will focus on environment-based design issues. The class will study basic fundamentals in each of these areas and how they affect design decisions. Prerequisites: Senior standing in mechanical engineering, or permission of instructor.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-687 Special Topics Grand Challenges: Technology Identification and Product Design
Intermittent: 12 units
Grand Challenges: Technology Identification and Product Design. There are many challenges to society that must be solved over the next century. The National Academy of Engineers have laid out 14 “Grand Challenges” for engineering to solve. However, in addition to the technology that must be identified or invented, the technology must be incorporated within a product (physical, system, infrastructure, service) that delivers value to society through its use. This class is a combination of design research and creation. Students will investigate the technological issues of a Grand Challenge in regards to product needs, then design products that meets short term and long term needs and capabilities to help solve the Grand Challenge. 3 hr. lecture.
Course Website: http://www.cmu.edu/me/graduate

24-688 Introduction to CAD and CAE Tools
Fall: 12 units
This course offers the hands-on training on how to apply modern CAD and CAE software tools to engineering design, analysis and manufacturing. In the first section, students will learn through 7 hands-on projects how to model complex free-form 3D objects using commercial CAD tools. In the second section, students will learn through 7 hands-on projects how to simulate complex multi-physics phenomena using commercial CAE tools. Units: 12 Format: 2 hrs. Lec., 2 hrs. computer lab Prerequisites: 24-231 and 24-262 Corequisite: 24-351.
Course Website: http://www.cmu.edu/me/

24-751 Introduction to Solid Mechanics I
Fall: 12 units
This is the first course in a two-part professionally oriented course sequence covering a variety of important problems in solid mechanics. Topics covered typically include torsion of non-circular cross sections, the field equations of elasticity and boundary conditions, and a number of classical plane stress/ plane strain solutions in rectangular and polar coordinates. Emphasis is placed on not only elasticity theory and how classical elasticity solutions are derived, but also on their use in constructing and interpreting the results from finite element simulations of applied engineering problems. Where applicable, comparisons are also made between solutions derived via the full theory of elasticity and simplified solutions developed in strength of materials courses. 4 hrs. lec.
Corequisite: 24-701.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-751 Introduction to Solid Mechanics I
24-781 Engineering Computation Project
Fall
24-781 This project course is the first section of the two-semester sequence of Computational Engineering Projects. The course provides the students with hands-on problem-solving experience by using commercial computational tools and/or developing their own custom software. Each student, individually or along with other students, will work on a project under the guidance of Carnegie Mellon faculty members and/or senior engineers from industry. Students may select a project topic from those presented by advising faculty members and/or industry engineers. Alternatively, a student may propose and work on his/her own project topic if he/she can identify a sponsoring faculty member or industry engineer.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-784 Decision Tools for Engineering Design and Entrepreneurship
Intermittent: 12 units
This course provides engineers with a multidisciplinary mathematical foundation for integrated modeling of engineering design and enterprise planning decisions in an uncertain, competitive market. Topics include economics in product design, manufacturing and operations modeling and accounting, consumer choice modeling, survey design, conjoint analysis, decision-tree analysis, optimization, game theory, model integration, and professional communication skills. Students will apply theory and methods to a team project for a new product or emerging technology of their choice, developing a business plan to defend technical and economic competitiveness. Students may choose to select emerging technologies from research at Carnegie Mellon for study in the course, and in some years venture capitalists and other industry leaders will take part in critiquing student projects. This course assumes fluency with calculus and some prior programming experience. Graduate students will conduct an additional independent research project.

24-793 Supervised Reading
Fall and Spring
This independent study is designed to give students an opportunity to explore pertinent subjects through faculty directed reading. Variable hrs. Prerequisite: permission of the instructor.
Course Website: http://www.cmu.edu/me/graduate/index.html

24-794 Master of Science Project
Fall and Spring
This course is designed to be a training opportunity in engineering research and associated professional activity. Content includes a series of investigations under the student’s initiative culminating in comprehensive reports, with special emphasis on orderly presentation and effective English composition for Master of Science candidates. Variable hrs. Prerequisite: permission of the instructor.
Course Website: http://www.cmu.edu/me/graduate/index.html