MECHANICAL ENGINEERING

Mechanical engineering prepares students for careers in a variety of industrial sectors including transportation, energy, manufacturing, aerospace, biomedical and environmental. Career opportunities include work in basic and applied research and development, design, manufacturing, project management, consulting and teaching. Mechanical engineers are employed by a wide variety of industrial, governmental and educational organizations. A mechanical engineering background also provides a firm foundation for other professional careers such as engineering management, law and medicine.

A mechanical engineering education from the CU Boulder will prepare students for a future in a broad range of fields in science and technology. Students receive a hands-on education that breaks out of the classroom to give them real experience in the industry. They learn from and work with a diverse faculty conducting groundbreaking research that is shaping the future of our world.

Course code for this program is MCEN.

Bachelor's Degree

- Mechanical Engineering - Bachelor of Science (BSME)
  (catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/mechanical-engineering/mechanical-engineering-bachelor-science-bsme)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Affrunti, Andrew J. (https://experts.colorado.edu/display/fisid_149937)
  Instructor; MSEE, University of Illinois at Urbana–Champaign

Ahmed, Alan A. (https://experts.colorado.edu/display/fisid_144736)
  Associate Professor; PhD, University of Michigan

Borden, Mark A. (https://experts.colorado.edu/display/fisid_148514)
  Associate Professor; PhD, University of California, Davis

Branch, Melvyn C.
  Professor Emeritus

Bright, Victor Mark (https://experts.colorado.edu/display/fisid_112696)
  Professor; PhD, Georgia Institute of Technology

Brower, Timothy L. (https://experts.colorado.edu/display/fisid_147553)
  Senior Instructor; PhD, Colorado State University

Bruns, Carson J. (https://experts.colorado.edu/display/fisid_159851)
  Assistant Professor; PhD, Northwestern University

Carlson, Lawrence E.
  Professor Emeritus

Castro, Francisco (https://experts.colorado.edu/display/fisid_147992)
  Instructor; PhD, University of Colorado Boulder

Daily, John W. (https://experts.colorado.edu/display/fisid_100131)
  Professor; PhD, Stanford University

Datta, Subhendu K.
  Professor Emeritus

Ding, Xiaoyun (https://experts.colorado.edu/display/fisid_158563)
  Assistant Professor; PhD, Pennsylvania State University

Ding, Yifu (https://experts.colorado.edu/display/fisid_146088)
  Associate Professor; PhD, University of Akron

Ferguson, Virginia L. (https://experts.colorado.edu/display/fisid_110131)
  Associate Professor; PhD, University of Colorado Boulder

Geers, Thomas L.
  Professor Emeritus

Greenberg, Alan R.
  Professor Emeritus

Hamlington, Peter Edward (https://experts.colorado.edu/display/fisid_149800)
  Assistant Professor, Associate Chair; PhD, University of Michigan Ann Arbor

Hannigan, Michael P. (https://experts.colorado.edu/display/fisid_122655)
  Professor, Chair; PhD, California Institute of Technology

Henne, Daven Ker (https://experts.colorado.edu/display/fisid_144858)
  Associate Professor; PhD, California Institute of Technology

Hertzberg, Jean R. (https://experts.colorado.edu/display/fisid_105315)
  Associate Professor; PhD, University of California, Berkeley

Humbert, J. Sean (https://experts.colorado.edu/display/fisid_156202)
  Professor; PhD, California Institute of Technology

Kassoy, David R.
  Professor Emeritus

Keppler, Christoph M. (https://experts.colorado.edu/display/fisid_156421)
  Assistant Professor; PhD, Johannes Kepler Universität Linz (Austria)

Knapp, Svenja A. (https://experts.colorado.edu/display/fisid_139588)
  Associate Research Professor; PhD, Rheinische Friedrich-Wilhelms-Universität (Germany)

Knutsen, Jeffrey S. (https://experts.colorado.edu/display/fisid_145534)
  Senior Instructor; PhD, University of Colorado Boulder

Kotsys-Schwartz, Daria (https://experts.colorado.edu/display/fisid_144738)
  Senior Instructor; PhD, University of Colorado Boulder

Labbe, Nicole J. (https://experts.colorado.edu/display/fisid_157742)
  Assistant Professor; PhD, University of Massachusetts, Amherst

Lee, Sehee (https://experts.colorado.edu/display/fisid_144739)
  Professor; PhD, Seoul National University (South Korea)

Lee, Yung-Cheng (https://experts.colorado.edu/display/fisid_103170)
  Professor; PhD, University of Minnesota Twin Cities

Li, Baowen (https://experts.colorado.edu/display/fisid_156203)
  Professor; PhD, Carl von Ossietzky Universität Oldenburg (Germany)
Courses

MCEN 1024 (4) Chemistry for Energy and Materials Science
Covers the basic physical and chemical fundamentals underlying the disciplines of energy and materials, with a focus on topics relevant to your mechanical engineering education. These fundamentals include atomic structure, stoichiometry, the periodic table, chemical bonding, states of matter, thermochemistry and chemical reactions. Department enforced prerequisite: one year of high school chemistry.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 1211
Requisites: Restricted to Mechanical Engineering or students with a plan of Mechanical Engineering Concurrent Degree or General Engineering Plus students with a MCEN subplan.
Grading Basis: Letter Grade
Additional Information: Departmental Category: Materials

MCEN 1025 (4) Computer-Aided Design and Fabrication
Introduces CAD software and relevant concepts, including orthographic projection, sections, engineering drawing, geometric dimensioning and tolerancing, and an introduction to manufacturing methods. Final design project involves rapid prototyping.
Requisites: Restricted to Mechanical Engineering (MCEN) or Engineering Physics (EPEN) majors only.
Additional Information: Departmental Category: Design

MCEN 1208 (1-4) Special Topics in Mechanical Engineering
Subject matter to be selected from topics of current interest. Credit to be arranged.
Requisites: Restricted to students with 0-26 units (Freshmen) Mechanical Engineering (MCEN) majors only.
Additional Information: Departmental Category: Special Topics
MCEN 2000 (1) Mechanical Engineering as a Profession
Provides an introduction to the profession of mechanical engineering. Specific topics addressed include career opportunities in mechanical engineering, internship search skills, expectations for professional behavior in the classroom and in industry, and current events/ethics topics relevant to the field. Course format may include additional evening/weekend activities.

Requisites: Restricted to students with 27-180 credits (Sophomores, Juniors or Seniors) Mechanical Engineering (MCEN) majors only.
Grading Basis: Letter Grade

Additional Information: Departmental Category: Miscellaneous

MCEN 2023 (3) Statics and Structures
Covers statics of particles, equivalent force systems, rigid bodies, equilibrium of rigid bodies in two and three dimensions, analysis of truss and frame structures, uniaxially-loaded members, distributed force systems and friction.

Equivalent - Duplicate Degree Credit Not Granted: CVEN 2121 or GEEN 2851
Requisites: Requires prereqs of (APPM 1360 or MATH 2300) PHYS 1110 (all min grade C). Restricted to students w/ 27-180 credits (So/Jr/Sr) Mechanical (MCEN) or Environmental (EVEN) or General Engineering Plus (GEEN-BS) students with a sub-plan of Mechanical (MEC).

Additional Information: Departmental Category: Solids

MCEN 2024 (3) Materials Science
Provides an overview of the structure, properties and processing of metallic, polymeric and ceramic materials. Specific topics include perfect and imperfect solids, phase equilibria, transformation kinetics, mechanical behavior and material degradation. Approach incorporates both materials science and materials engineering components.

Requisites: Requires prereq course of MCEN 1024 or CHEN 1211 and CHEM 1221 or CHEM 1113 and 1114, and PHYS 1110 (min grade C). Restricted to students with 27-180 credits (Soph/Jrs/Srs) MECH or EVEN or GEEN-BS students, with a sub-plan of MEC.

Additional Information: Departmental Category: Solids

MCEN 2043 (3) Dynamics
Covers dynamic behavior of particle systems and rigid bodies; 2-D and 3-D kinematics and kinetics; impulse, momentum, potential, and kinetic energy; and work, collision, and vibration.

Requisites: Requires prerequisite courses of MCEN 2023 or CVEN 2121 or GEEN 2851 and APPM 1360 or MATH 2300 (all require minimum grade C). Restricted to students with 27-180 credits (Soph/Jrs/Srs) MECH or EVEN or GEEN-BS students, with a sub-plan of MEC.

Additional Information: Departmental Category: Materials

MCEN 2063 (3) Mechanics of Solids
Covers shear force and bending moment, torsion, stresses in beams, deflection of beams, matrix analysis of frame structures, analysis of stress and strain in 2-D and 3-D (field equations, transformations), energy methods, stress concentrations and columns.

Equivalent - Duplicate Degree Credit Not Granted: CVEN 3161
Requisites: Requires prereq courses of MCEN 2023 or CVEN 2121 or GEEN 2851 and APPM 1360 or MATH 2300 (all require min grade C). Restricted to students with 27-180 credits (Soph/Jrs/Srs) MECH or EVEN or GEEN-BS students, with a sub-plan of MEC.

Additional Information: Departmental Category: Solids

MCEN 3012 (3) Thermodynamics
Explores fundamental concepts and basic theory, including first and second laws of thermodynamics, properties, states, thermodynamic functions and cycles.

Equivalent - Duplicate Degree Credit Not Granted: GEEN 3852
Requisites: Requires prereq course of APPM 2350 or MATH 2400 (minimum grade C). Restricted to students with 27-180 credits (Soph, Jrs or Srs) Mechanical (MCEN) or Environmental (EVEN) or General Engr Plus (GEEN-BS) students, with a sub-plan of Mechanical (MEC).

Additional Information: Departmental Category: Thermal

MCEN 3017 (3) Circuits and Electronics
Introductory course covers analysis of electric circuits by use of Ohm’s law, network reduction, node and loop analysis, Thevenin’s and Norton’s theorems, DC and AC signals, transient response of simple circuits, transfer functions, basic diode and transistor circuits and operational amplifiers.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 3010
Requisites: Requires prerequisite courses of APPM 2360 and PHYS 1140 (all minimum grade C). Restricted to students in the MSC/CU-Boulder Mechanical Engineering Partnership Program only.

Additional Information: Departmental Category: Miscellaneous

MCEN 3021 (3) Fluid Mechanics
Examines fundamentals of fluid flow with application to engineering problems. Topics covered include fluid statics and kinematics, Bernoulli’s equations, laminar and turbulent viscous boundary layers, laminar and turbulent pipe flow, and conservation equations for mass, momentum and energy.

Equivalent - Duplicate Degree Credit Not Granted: CHEN 3200 and CVEN 3313
Requisites: Requires prereq of MCEN2023 or CVEN2121 or GEEN2851 and APPM2350 or MATH2400. All require C or higher. Restricted to students with 27-180 credits (Soph/Jrs/Srs) MECH or EVEN or GEEN-BS students, with a sub-plan of MEC.

Additional Information: Departmental Category: Fluids

MCEN 3022 (3) Heat Transfer
Studies fundamentals of heat transfer by conduction, convection, and radiation. Emphasizes problem formulation and selection of appropriate solution techniques. Provides applications to modern engineering systems, which may include energy, biological, environmental, and materials engineering problems.

Requisites: Requires prereq courses of MCEN 3021 or CVEN 3313, and MCEN 3012 or AREN 2110 or GEEN 3852, and APPM 2360 or MATH 2130 and 3430 (all min grade C). Restricted to students with 57-180 credits (Jrs/Srs) MECH or EVEN or GEEN-BS students with sub-plan of MEC

Additional Information: Departmental Category: Thermal

MCEN 3025 (3) Component Design
Application of mechanics and materials science to the detailed design of various machine elements including shafts, bearings, gears, brakes, springs, and fasteners. Emphasizes application and open-ended design problems.

Requisites: Requires prereqs of MCEN 1025 and MCEN 2024 and MCEN 2063 (all minimum grade C). Restricted to students with 57-180 credits (Jrs/Srs) Mechanical (MCEN) or Environmental (EVEN) or General Engr Plus (GEEN-BS) students, with a sub-plan of Mechanical (MEC).

Additional Information: Departmental Category: Design
MCEN 3030 (3) Computational Methods
Studies fundamental numerical techniques for the solution of commonly encountered engineering problems. Includes methods for linear and nonlinear algebraic equations, data analysis, numerical differentiation and integration, ordinary and partial differential equations.
Requisites: Requires prerequisite courses of APPM 2360 and CHEN 1310 or CSCI 1300 or CSCI 1310 or CSCI 1320 (all minimum grade C). Restricted to students with 57-180 credits (Jrs/Srs) Mechanical or Environmental Engineering majors only.
Additional Information: Departmental Category: Math

MCEN 3032 (3) Thermodynamics 2
Offers advanced topics and applications for thermal system design and analysis. Topics include thermodynamics of state, entropy, thermodynamic cycles and reacting and nonreacting mixtures. Provides application to power generation, refrigeration and HVAC with conventional and advanced technologies. Most assignments are design oriented.
Requisites: Requires prerequisite courses of MCEN 3021 and MCEN 3012 or GEEN 3852 and APPM 2360 (all minimum grade C). Restricted to students with 57-180 credits (Junior/Senior) Mechanical or Environmental Engineering majors only.
Additional Information: Departmental Category: Thermal

MCEN 3047 (4) Data Analysis and Experimental Methods
Learn to plan and carry out experiments and analyze the results. Topics covered include measurement fundamentals, design of experiments, elementary statistics and uncertainty analysis. Topics in statistics include probability, error propagation, confidence intervals, hypothesis testing, linear regression, one- and two-factor ANOVA and time series analysis. Formerly MCEN 3037.
Equivalent - Duplicate Degree Credit Not Granted: GEEN 3853
Requisites: Prereq APPM2360 PHYS1140 MCEN2063. Prereq or Coreq (ECEN3010 or MCEN3017) (MCEN3030 APPM4650) and (WRTG3030 or WRTG3055 or HUEN1010 or HUEN3100) (min grade C). Restricted to students with 57-180 credits (Junior/Senior) Mechanical Engineering majors only.
Additional Information: Departmental Category: Miscellaneous

MCEN 3028 (1-4) Special Topics in Mechanical Engineering
Subject matter to be selected from topics of current interest.
Repeatable: Repeatable for up to 15.00 total credit hours.
Requisites: Requires prerequisite courses of APPM 2360 PHYS 1140 and prerequisite courses of ECEN 3010 and WRTG 3030 or WRTG 3035 or HUEN 1010 or 3100 (all min grade C). Restricted to students with 57-180 credits (Jrs/Srs) Mechanical Engineering (MCEN) majors only.
Additional Information: Departmental Category: Special Topics

MCEN 3930 (6) Mechanical Engineering Cooperative Education
Students enrolled in this course participate in a previously arranged, department-sponsored education program with a university, government agency, or industry. This course is offered only through Continuing Education.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: At least a 2.75 cumulative GPA is required. Restricted to Mechanical Engineering or students with a plan of Mechanical Engineering Concurrent Degree or General Engineering Plus students with a MCEN subplan.
Recommended: Prerequisite 3.00 GPA or higher.
Grading Basis: Pass/Fail
Additional Information: Departmental Category: Math

MCEN 4010 (3) Microsystems Integration
A microsystem consists of microelectronic, optoelectronic, microwave, microelectromechanical and energy components interconnected. Thermal, electrical, fabrication and assembly issues for Microsystems represented by iPhone series will be studied. The packaging and interconnection technologies used to establish the design and manufacturing infrastructure of Microsystems will be reviewed. Other optoelectronic, MEMS and bater components for Microsystems will also be studied.
Equivalent - Duplicate Degree Credit Not Granted: MCEN 5010
Requisites: Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering (MCEN) majors only.
Grading Basis: Letter Grade

MCEN 4026 (3) Manufacturing Processes and Systems
Examines manufacturing processes for metals, polymers, and composites as well as manufacturing systems that integrate these processes. Lecture topics include forming, machining, joining, assembling, process integration, computer-aided manufacturing, and manufacturing system engineering.
Requisites: Requires prerequisite course of MCEN 2024 or GEEN 3024 (minimum grade C). Restricted to students with 57-180 credits (Jrs/Srs) Mechanical Engineering majors only.
Additional Information: Departmental Category: Manufacturing and Systems

MCEN 4032 (3) Sustainable Energy
Examines sustainability of our current energy systems, including transportation, using environmental and economic indicators. Uses systems analysis that addresses energy supply and demand. Explores the science and technology as well as environmental and economic feasibility of efficiency measures and renewable energy technologies. Additional emphasis is given to the global nature of the challenges and the potential for locally optimal solutions.
Equivalent - Duplicate Degree Credit Not Granted: MCEN 5032
Requisites: Requires prerequisite course of MCEN 3012 and MCEN 3022 (minimum grade C).
Grading Basis: Letter Grade
Additional Information: Departmental Category: Thermal

MCEN 4037 (2) Measurements Lab
Conduct experiments designed to introduce method of experimentation and data analysis. Experiments taken from solid mechanics, fluid mechanics, thermal science and materials science. Emphasizes planning an experiment, applying sound scientific procedures, keeping proper records and communicating results orally and in written reports. Projects extend over two or more weeks.
Requisites: Requires prerequisite of MCEN 2063 3047 WRTG 3030 or 3035 or HUEN 1010 or 3100 (all min grade C). Restricted to students with 57-180 credits (Jrs/Srs) MECH or EVEN or GEEN-BS students, with a sub-plan of MEC.
Additional Information: Departmental Category: Miscellaneous

MCEN 4043 (3) System Dynamics
Covers linear dynamic systems and mathematical tools for understanding them, input-output relationships, modeling templates, complex variables, Laplace transform, time-harmonic forcing and response, Fourier series and discrete Fourier transform, and coupled systems.
Requisites: Requires prerequisite courses of MCEN 2043 ECEN 3010 or MCEN 3017 APPM 2360 (min grade C) a prerequisite course of MCEN 3030. Restricted to students with 57-180 credits (Jrs or Srs) MCEN or GEEN-BS students, with a sub-plan of Mechanical (MEC).
Additional Information: Departmental Category: Miscellaneous
### MCEN 4045 (3) Mechanical Engineering Design Project 1
First part of a two-course capstone design experience in mechanical engineering. Covers problem definition, determining design requirements, alternative design concepts, engineering analysis, proof-of-concept prototype and CAD drawings. Students make several oral design reviews, a final design presentation, and prepare a written report. GEEN-BS and GEEN-BSGE students are not required to complete MCEN 2000, MCEN 3022, MCEN 3030 or MCEN 4026 but have additional prerequisites of GEEN 1400, 2400 and 3400.

**Requisites:** Prereqs ECEN3010/CSCI1320/GEEN1400/ APPM1350/1360/2350/2360/PHYS1110/1120/1140 MCEN2000/2024/2043/2063/3012/3021/3025/3030 min grd C. Pre or coreqs MCEN3022/3047/4026/4043/WRTG3030. Restricted to stdnts w 87-180 units, MCEN or GEEN stdnts w sub-plan ME

**Additional Information:** Departmental Category: Design

### MCEN 4047 (2) Measurements 2
Emphasizes experiment planning, applying sound experimental procedures, using statistics, keeping proper records, and communicating results orally, visually, and through written reports. Projects extend over several weeks and relate to solid mechanics, acoustics, electronics, and/or other ME-related disciplines.

**Requisites:** Requires prerequisite courses of MCEN 2024 and MCEN 4037 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.

**Additional Information:** Departmental Category: Miscellaneous

### MCEN 4057 (3) Environmental Modeling
Enables students to develop and evaluate pollutant transport, fate, exposure, and risk models for air, water, and multi-media systems, with a special emphasis on air. Emphasizes the fundamental physics and chemistry that govern contaminant fate and transport and the basic mathematical equations and numerical approaches for describing these processes.

**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5057

**Requisites:** Requires prerequisite courses of CHEN 1211 or CHEM 1113 or MCEN 1024 and CSCI 1300 or CSCI 1320 (all minimum grade C).

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Miscellaneous

### MCEN 4064 (3) Soft Machines
Introduces soft machines as a new paradigm of engineering that starts to impact healthcare, consumer electronics, renewable energy and collaborative robotics. Prepares students to participate in research on soft machines by starting with fundamentals of soft materials and by covering soft robotics, stretchable electronics, energy harvesting and functional polymers. Includes guest lectures, a literature review and a hands-on lab project.

**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5046 and MSEN 5046

**Requisites:** Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering (MCEN) majors only.

**Grading Basis:** Letter Grade

### MCEN 4085 (3-4) Mechanical Engineering Design Project 2
Second part of a two-course capstone design experience in mechanical engineering. Includes refinement of prototype, design optimization, fabrication, testing, and evaluation. Students orally present the final design and prepare a written report and operation manual for the product. GEEN-BS and GEEN-BSEPL students are not required to complete MCEN 4026.

**Requisites:** Requires prerequisite of MCEN 4026, MCEN 4045 and WRTG 3030 or WRTG 3035 or HUEN 1010 or HUEN 3100 and prereq or coreq of MCEN 3022, 3047 and 4043 (all minimum grade C). Restricted to students with 87-180 units, MCEN or GEEN-BS students, with a sub-plan of MEC.

**Additional Information:** Departmental Category: Design

### MCEN 4086 (1) Writing for Design Projects
Communicate professionally in writing to the technical and nontechnical audience. Develop skills to analyze rhetorical situations and compose documents, such as reports, technical manuals and user guides, that achieve a specific purpose and meet the needs of a particular audience. Writing with clarity, conciseness and correctness will be emphasized.

**Requisites:** Requires enrollment in corequisite course of MCEN 4085.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Manufacturing and Systems

### MCEN 4115 (3-4) Mechatronics and Robotics I
Focuses on design and construction of microprocessor-controlled electro-mechanical systems. Lectures review critical circuit topics, introduce microprocessor architecture and programming, discuss sensor and actuator component selection, robotic systems and design strategies for complex, multi-system devices. Lab work reinforces lectures and allows hands-on experience with robotic design. Students must design and build an autonomous robotic device. Project expenses may be incurred ($50 maximum).

**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5115

**Requisites:** Requires prerequisite courses of ECEN 3010 or 2250 and ECEN 1310 (formerly GEEN 1300/COEN 1300) or CSCI 1300 or 1310 or 1320 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.

**Additional Information:** Departmental Category: Design

### MCEN 4117 (3) Anatomy and Physiology for Engineers
Explores human physiological function from an engineering, specifically mechanical engineering, viewpoint. Provides an introduction to human anatomy and physiology with a focus on learning fundamental concepts and applying engineering (mass transfer, fluid dynamics, mechanics, modeling) analysis.

**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5117

**Requisites:** Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.

**Additional Information:** Departmental Category: Design

### MCEN 4123 (3) Vibration Analysis
Highlights free and forced vibration of discrete and continuous systems. Examines Lagrange's equation, Fourier series, Laplace transforms, and matrix and computational methods. Applies knowledge to practical engineering problems.

**Equivalent - Duplicate Degree Credit Not Granted:** ASEN 4123

**Requisites:** Requires prerequisite course of MCEN 3030 or ASEN 3112 (minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.

**Additional Information:** Departmental Category: Solids
### MCEN 4124 (3) Mechanical Behavior of Materials
Addresses the relationship between material structure and the fundamental processes of deformation, yield, and fracture. Examines elements of elasticity theory, introduction to plasticity, and formulation of failure criteria. Studies basic deformation processes in terms of dislocation mechanics and macroscopic mechanical behavior. Takes into consideration the influence of compositional and processing strengthening mechanisms on mechanical properties.
**Requisites:** Requires prerequisite courses of MCEN 2024 and MCEN 2063 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
**Additional Information:** Departmental Category: Materials

### MCEN 4125 (3) Optimal Design
Focuses on linear optimization and will introduce non-linear optimization. Formulating Engineering applications as optimization problems that can be solved using industry known solvers will be learned. Some of these applications will include minimum cost mechanical design, wind farm power maximization, minimum energy control, production control, and more. Previous programming experience required.
**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5125
**Requisites:** Requires prerequisite courses of MCEN 3030 (all minimum grade C). Restricted to students with 57-180 credits (Junior, Senior, Fifth Year Senior) Mechanical Engineering majors only.
**Additional Information:** Departmental Category: Design

### MCEN 4127 (3) Biomedical Ultrasound
Covers the design of ultrasound systems for medical imaging and therapy, including the physics of wave propagation, transducers, acoustic lenses, pulse-echo imaging and cavitation dynamics, with an emphasis on current topics in biomedical ultrasound. Includes lectures on theory, practice and special topics; a laboratory on wave propagation; oral presentations on current literature; and a design project.
**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5127
**Requisites:** Requires prerequisite course of MCEN 3021 (minimum grade C). Restricted to students with 57-180 credits (juniors/seniors).
**Grading Basis:** Letter Grade
**Additional Information:** Departmental Category: Miscellaneous

### MCEN 4131 (3) Air Pollution Control Engineering
Introduces air quality regulations, meteorology and modeling. Examines methods for controlling major classes of air pollutants, including particulate matter and oxides of sulfur and nitrogen, as well as control technology for industrial sources and motor vehicles. Requires interdisciplinary design projects.
**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5131
**Requisites:** Requires prerequisite courses of MCEN 3012 and MCEN 3021 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical or Environmental Engineering majors only.
**Additional Information:** Departmental Category: Miscellaneous

### MCEN 4133 (3) Biomechanics
Focuses on developing an understanding of the fundamental mechanical principles that govern the response of hard and soft biological tissue to mechanical loading. Specifically, covers mechanical behavior of biological materials/tissues, classical biomechanics problems in various tissues, the relationship between molecular, cellular and physiological processes and tissue biomechanics, and critical analysis of related journal articles.
**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5133
**Requisites:** Requires prerequisite courses of MCEN 2024, MCEN 2063 and MCEN 3021 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
**Additional Information:** Departmental Category: Materials

### MCEN 4135 (3) Wind Energy and Wind Turbine Design
Focuses on understanding and applying principles related to current wind energy technology. Students will apply technical coursework from throughout the ME curriculum (fluids, dynamics, circuits, economics) to the process of designing a wind turbine and determining whether their proposal is feasible from an economic standpoint.
**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5135
**Requisites:** Requires prerequisite courses of MCEN 3021 and ECEN 3010 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical or Environmental Engineering majors only.
**Additional Information:** Departmental Category: Design

### MCEN 4137 (3) Anatomy and Physiology 2
Provides in-depth understandings of anatomy and physiology as well as introductions to transport phenomena, flow mechanics and solid mechanics in several organ systems: the cardiovascular, pulmonary, kidney, endocrine and digestive systems. Introduces artificial physiological systems to replace or assist physiological functions and introduce the concepts of physiological barriers that prevent diagnosis or effective therapeutics.
**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5137
**Requisites:** Requires prerequisite course of MCEN 4117 (minimum grade C). Restricted to students with 57-180 credits (juniors/seniors).
**Grading Basis:** Letter Grade
**Additional Information:** Departmental Category: Miscellaneous

### MCEN 4141 (3) Indoor Air Pollution
Describes the impact of indoor air pollutants on human health, including an introduction to key pollutants and their sources. Students will estimate emission factors, calculate generation/ventilation rates, quantify the impact of deposition and chemical reactions and explore relevant control technology. Current issues will also be addressed, including climate change, green building design, economic concerns and relevance to the developing world.
**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5141
**Requisites:** Requires prerequisite courses of MCEN 3021 and MCEN 3022 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
**Additional Information:** Departmental Category: Miscellaneous

### MCEN 4151 (3) Flow Visualization
Explores techniques for the visualization of the physics of fluid flows including seeding with dyes, particles and bubbles, and shadowgraphy and schlieren. Reviews optics and fluid physics, especially atmospheric clouds. Assignments are student-driven, to individuals and mixed teams of graduates, undergraduates, engineering majors and photography/video majors.
**Equivalent - Duplicate Degree Credit Not Granted:** ARTF 5200, CINE 4200, MCEN 5151, ATLS 4151 and ATLS 5151
**Requisites:** Requires prerequisite course of MCEN 3021 (minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
**Additional Information:** Departmental Category: Miscellaneous

### MCEN 5141 (3) Indoor Air Pollution
Describes the impact of indoor air pollutants on human health, including an introduction to key pollutants and their sources. Students will estimate emission factors, calculate generation/ventilation rates, quantify the impact of deposition and chemical reactions and explore relevant control technology. Current issues will also be addressed, including climate change, green building design, economic concerns and relevance to the developing world.
**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 5141
**Requisites:** Requires prerequisite courses of MCEN 3021 and MCEN 3022 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
**Additional Information:** Departmental Category: Miscellaneous

### MCEN 5151 (3) Flow Visualization
Explores techniques for the visualization of the physics of fluid flows including seeding with dyes, particles and bubbles, and shadowgraphy and schlieren. Reviews optics and fluid physics, especially atmospheric clouds. Assignments are student-driven, to individuals and mixed teams of graduates, undergraduates, engineering majors and photography/video majors.
**Equivalent - Duplicate Degree Credit Not Granted:** ARTF 5200, CINE 4200, MCEN 5151, ATLS 4151 and ATLS 5151
**Requisites:** Requires prerequisite course of MCEN 3021 (minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
**Additional Information:** Departmental Category: Miscellaneous
MCEN 4152 (3) Introduction to Combustion
Focuses on the mechanisms by which fuel and oxidizers are converted into combustion products. Application to practical combustion devices such as Otto, Diesel, gas turbine and power plant combustion systems. Consideration of combustion-generated air pollution, fire safety and combustion efficiency.
Equivalent - Duplicate Degree Credit Not Granted: MCEN 5152
Requisites: Requires prerequisite course of MCEN 3012 (minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
Recommended: Prerequisites MCEN 3021 and MCEN 3022.
Additional Information: Departmental Category: Thermal

MCEN 4154 (3) Biocolloids and Biomembranes
Covers the thermodynamics and mechanics of biological membranes and biomedical colloids. Considers intermolecular and surface forces, self-assembly and colloidal stability. Addresses structure-property relationships and design principles for biomedical applications. Focuses on monolayers, bilayers, micelles, filomicelles, liposomes, polymersomes, emulsions, microbubbles, polyplexes and polyelectrolyte multilayer capsules.
Equivalent - Duplicate Degree Credit Not Granted: MCEN 5154
Requisites: Requires prerequisite courses of APPM 2360 and PHYS 1120 (all minimum grade C). Restricted to students with 57-180 credits (juniors/seniors).
Grading Basis: Letter Grade
Additional Information: Departmental Category: Materials

MCEN 4162 (3) Energy Conversion
Examines common energy-conversion methods and devices. Topics include power-cycle thermodynamics, turbo compressor and expander processes, combustion systems, and applications and limitations of direct energy-conversion systems.
Requisites: Requires prerequisite course of MCEN 3012 (minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
Additional Information: Departmental Category: Thermal

MCEN 4173 (3) Finite Element Analysis
Introduces the theory behind and applications of the finite element method as a general and powerful tool to model a variety of phenomena in mechanical engineering. Applications include structural mechanics, mechanics of elastic continua and heat conduction.
Equivalent - Duplicate Degree Credit Not Granted: MCEN 5173
Requisites: Requires prerequisite courses of MCEN 2023 and MCEN 2063 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
Additional Information: Departmental Category: Solids

MCEN 4183 (3) Mechanics of Composite Materials
Introduces various kinds of composite materials, composite fabrication techniques, the physical and mechanical behavior of composites, and analytical and experimental methodologies.
Equivalent - Duplicate Degree Credit Not Granted: MCEN 5183
Requisites: Requires prerequisite courses of MCEN 2024 and MCEN 2063 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
Additional Information: Departmental Category: Solids

MCEN 4194 (3) Electrochemical Energy Conversion and Storage
Presents the fundamentals, principles and experimental techniques of electrochemistry, the background of ionic or electronic conduction of metal, semiconductor, inorganic and polymer materials and applications in the areas of batteries, fuel cells, electrochemical double layer capacitors, electrochemical photonics, sensors and semiconductor electrochemistry.
Equivalent - Duplicate Degree Credit Not Granted: MCEN 5194
Requisites: Requires prereq courses of MCEN 2024 and 3032 (all minimum grade C). Restricted to graduate students or to students with 87-180 credits (Seniors) in the College of Engineering and Applied Science or to Mech Engr Concurrent Degree students only.
Grading Basis: Letter Grade
Additional Information: Departmental Category: Materials

MCEN 5154 (3) Biocolloids and Biomembranes
Covers the thermodynamics and mechanics of biological membranes and biomedical colloids. Considers intermolecular and surface forces, self-assembly and colloidal stability. Addresses structure-property relationships and design principles for biomedical applications. Focuses on monolayers, bilayers, micelles, filomicelles, liposomes, polymersomes, emulsions, microbubbles, polyplexes and polyelectrolyte multilayer capsules.
Equivalent - Duplicate Degree Credit Not Granted: MCEN 5154
Requisites: Requires prerequisite courses of APPM 2360 and PHYS 1120 (all minimum grade C). Restricted to students with 57-180 credits (juniors/seniors).
Grading Basis: Letter Grade
Additional Information: Departmental Category: Materials

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Equivalent - Duplicate Degree Credit Not Granted: MCEN 5173
Requisites: Requires prerequisite courses of MCEN 2023 and MCEN 2063 (all minimum grade C). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Mechanical Engineering majors only.
Additional Information: Departmental Category: Solids

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Equivalent - Duplicate Degree Credit Not Granted: MCEN 5183
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Equivalent - Duplicate Degree Credit Not Granted: MCEN 5194
Requisites: Requires prereq courses of MCEN 2024 and 3032 (all minimum grade C). Restricted to graduate students or to students with 87-180 credits (Seniors) in the College of Engineering and Applied Science or to Mech Engr Concurrent Degree students only.
Grading Basis: Letter Grade
Additional Information: Departmental Category: Materials