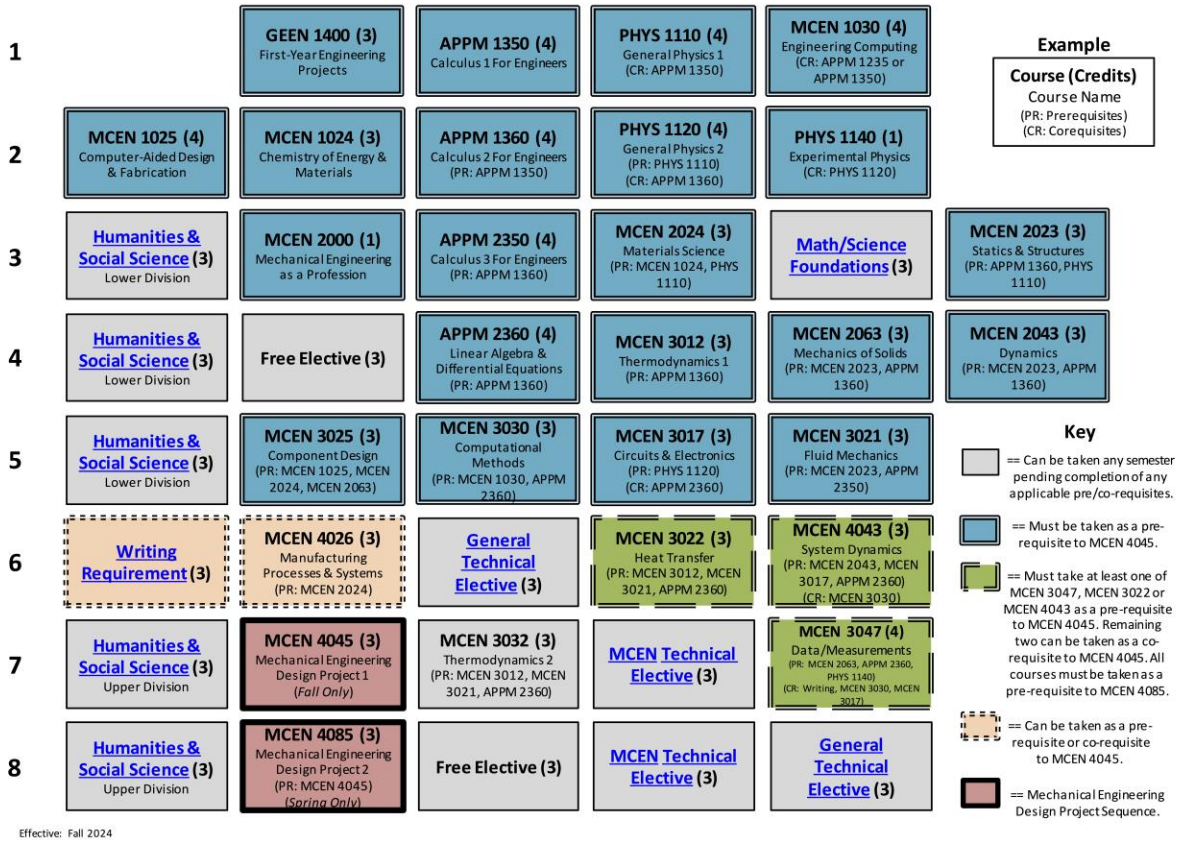
Paul M. Rady Department of Mechanical Engineering Undergraduate Core Courses

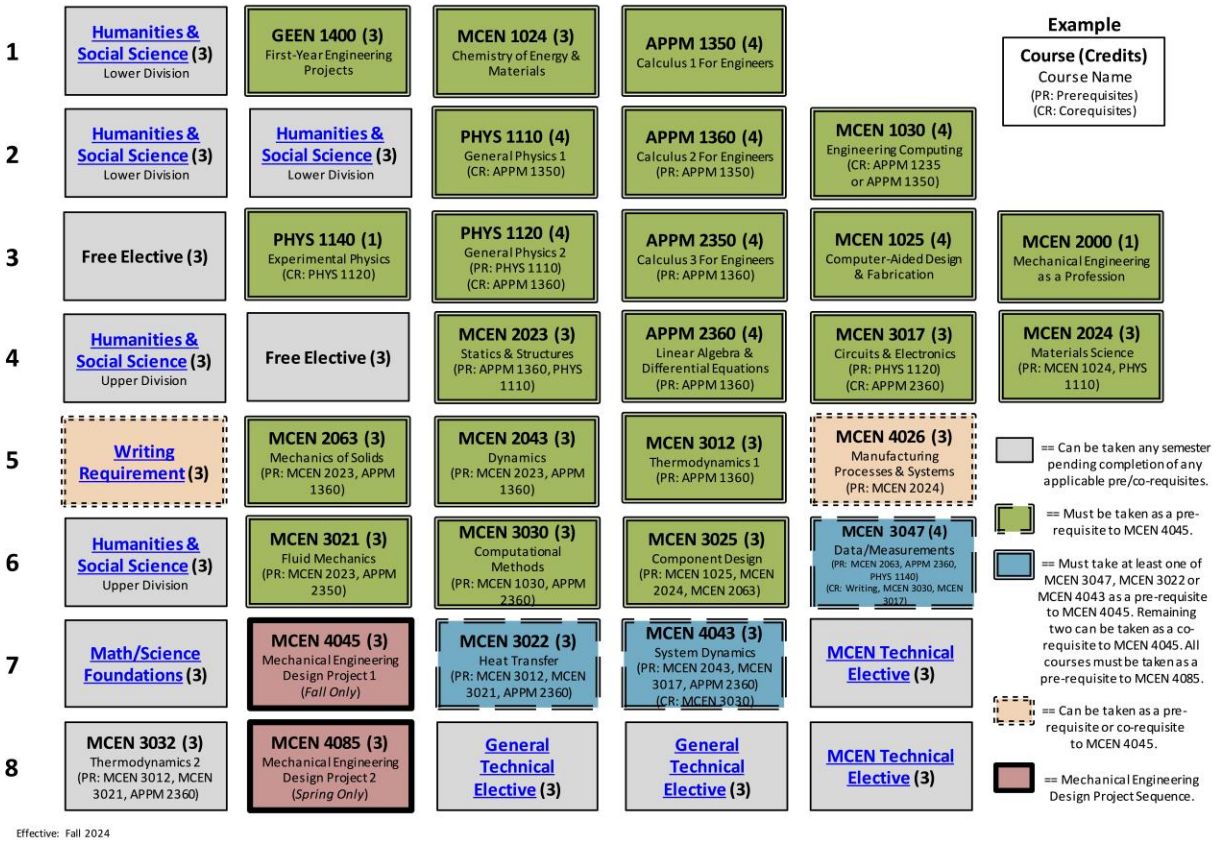
As a student in Mechanical Engineering, you'll take courses that combine to form a strong foundation in many different areas. You can use this guide to learn about the classes you'll take, how they fit together, and how the content is applied in engineering practice. More information about the curriculum is available on the ME website.

MECHANICAL ENGINEERING CURRICULUM – BLUE 4-YEAR PLAN



Effective: Fall 2024

MECHANICAL ENGINEERING CURRICULUM – GREEN 4-YEAR PLAN



Effective: Fall 2024

MCEN 1024: Chemistry for Energy and Material 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.

Prerequisites
None

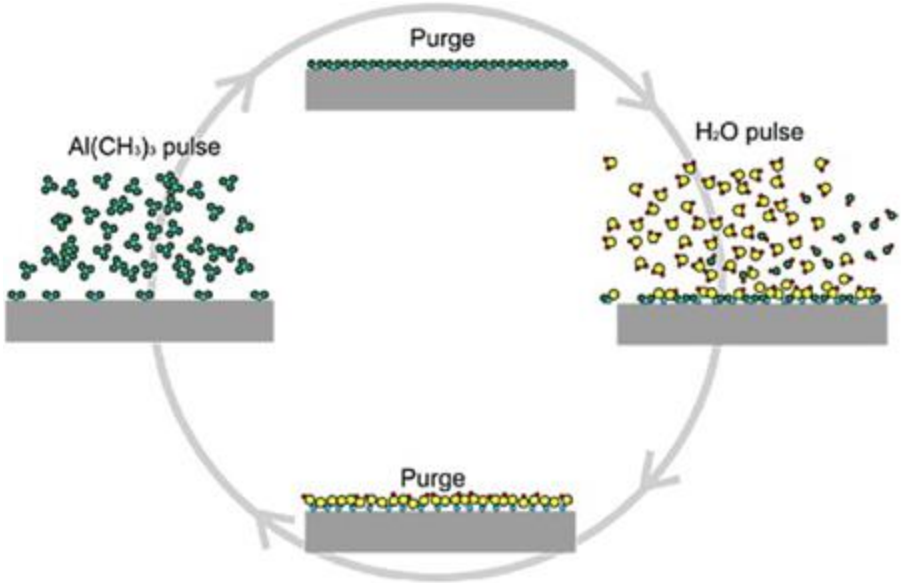
Next Course in Sequence
MCEN 2024 Material Science

How this fits into the big picture: As a mechanical engineer, you will work with a large variety of substances in order to complete complex products and processes. This course lays the college-level foundation for the atomic building blocks that make up engineering materials so that their properties are better understood in future classes/work.

Example application: Forge Nano uses atomic layer deposition processes to create accurate thickness and surface finishes on microelectronic components.

Insider insight/things that are good to know in advance: MCEN 1024 is one of the first ME courses that students complete here at CU. It is a great introduction course and more focused on the intersection between chemistry and mechanical engineering than the general chemistry courses engineering students are able to take. Additionally, MCEN 1024 does not have a corresponding lab section.

Alternate options to complete: CHEM 1113, CHEM 1400, CHEN 1201, CHEN 1211



Atomic layer deposition (ALD) process
www.sciencedirect.com/topics/chemical-engineering/atomic-layer-deposition

MCEN 1030: Introduction to Engineering Computing

Introduces concepts and methods of computer programming with emphasis on applications to mechanical engineering. Includes vector/array manipulation, for/if/else/while loops, function definition, problem solving with programming. Covers MATLAB/Python with no previous experience expected.

Prerequisites
APPM 1235 or APPM 1340 or APPM 1345 or APPM 1350 or MATH 1150 or MATH 1300 or MATH 1310

Next Course in Sequence
MCEN 3030 Computational Methods

How this fits into the big picture: Programming skills are critical for a modern engineer. This course teaches the basics of computer programming, with emphasis on MATLAB, a core programming language for later Mechanical Engineering classes, and Python, which is frequently used by the businesses that hire our graduates.

Insider insight/things that are good to know in advance: If you're considering a computer science minor, take CSCI 1300 instead, since MCEN 1030 is not accepted as an alternative to CSCI 1300 by the CSCI department.

Alternate options to complete: ASEN 1320, CSCI 1300, ECEN 1310

MCEN 1025: Computer-Aided Design and Fabrication

Introduces CAD software and relevant concepts, including modeling best practices, sketching, engineering drawing standards, geometric dimensioning and tolerancing, and an introduction to manufacturing methods. Final design project involves multiple fabrication techniques, including rapid prototyping.

Prerequisites
None

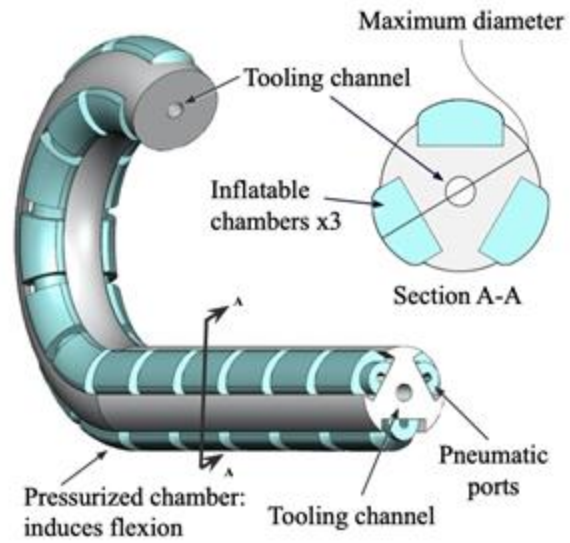
Next Course in Sequence
MCEN 3025 Component Design

How this fits into the big picture: Modeling and documenting a design is essential to the work that mechanical engineers do in almost every field. You can have the best idea for a solution, but if it cannot be communicated in a way that is understood by manufacturers and clients, the solution will never be successfully implemented. You will also get an introduction to multiple fabrication techniques, such as turning, milling, and sheet metal processes.

Example application: Medtronic uses CAD throughout their product design, documentation, and sustaining engineering processes for the medical device industry.

Insider insight/things that are good to know in advance: MCEN 1025 is a great skill-building class that will make you useful to potential employers, especially for internships. In this course, you will learn about principles of CAD and how to use SOLIDWORKS to create professional, high-quality engineering drawings. The course ends with a professional certification in the software.

Alternate options to complete: None



Soft Robot for Surgical Interventions designed by ME students for Medtronic
www.colorado.edu/mechanical/team-07-soft-robot-surgical-interventions

MCEN 2000: Mechanical Engineering as a Profession

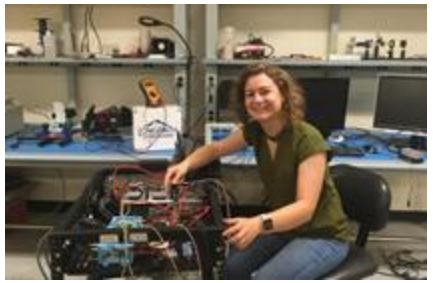
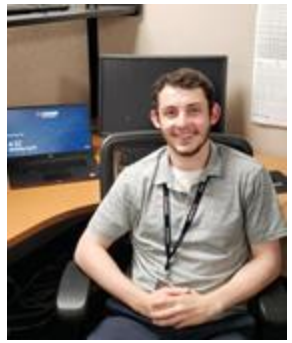
Provides an introduction to the profession of mechanical engineering specific topics addressed include career opportunities in mechanical engineering, internship search skills, expectations for professional behavior in the classroom and in industry, and current events/ethics topics relevant to the field. Course format may include additional evening/weekend activities.

Prerequisites
None

Next Course in Sequence
MCEN 4045 Senior Design

How this fits into the big picture: The end goal of a degree in mechanical engineering is to take your experiences from college and apply them to your future goals, whether that is industry engineering, research, or something else entirely. This course focuses on helping you build the skills to form professional networks and advocate for yourself successfully in job applications or interviews. A team of student apprentices who have completed previous internships or research opportunities will help guide you through the experience and serve as peer mentors.

Insider insight/things that are good to know in advance: MCEN 2000 is very much a course where you get out what you put in. If you apply yourself and work hard at making professional connections and finding internship or research opportunities, you can set yourself up well to gain invaluable experiences. Many students leverage the lessons from this course in order to get their first internships or professional work experience during the summer after their second year.


MCEN 2000 TAs interning at Siemens Gamesa Renewable Energy, LongPath Technologies, ALD Nanosolutions, and L3Harris Technologies

www.colorado.edu/mechanical/academics/professional-development/student-apprentices

MCEN 2023: 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.

Prerequisites
APPM 1360 or equivalent
PHYS 1110

Next Course in Sequence
MCEN 2043 Dynamics
MCEN 2063 Solids
MCEN 3021 Fluids

How this fits into the big picture: Statics and structures is another foundational ME course that explores some of the most common and recognizable applications of mechanical engineering such as trusses and simple machines. The tools in this course will later be used to analyze more complicated systems in future ME courses and projects.

Example application: RockSol is a civil engineering consulting group that provides expertise in several fields such as bridge and structural engineering and environmental services.

Insider insight/things that are good to know in advance: MCEN 2023 is usually one of the first courses you'll take that utilizes the ME homework format. Spending some extra time to get familiar with the format will not only save some time in the course, but also ensure your future work can be clear, communicable, and standalone.

Alternate options to complete: GEEN 2851, CVEN 2121, or ASEN 2001/2701/2401

RockSol consulted on US 34 Big Thompson Canyon construction starting in 2016
www.rocksol.com/project-2

MCEN 2024: 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.

Prerequisites
MCEN 1024 or equivalent
PHYS 1110

Next Course in Sequence
MCEN 3025 Comp Design
MCEN 4026 Manufacturing

How this fits into the big picture: Materials play a crucial role in what engineering projects are physically possible to implement. So much so that entire "ages" of human civilization have been named after the cutting-edge material of the time (i.e. Bronze, Iron). Every day, new materials are being created and discovered, and with each addition, the possibilities of engineering and science are expanded.

Example application: Solid Power uses material science principles to create solid state batteries that are safer, store more energy, and are cheaper than current technologies.

Insider insight/things that are good to know in advance: MCEN 2024 builds off of the the knowledge base started in MCEN 1024 Chemistry for Energy and Material Science and helps to build intuition around the materials you will work with in your engineering career. It is highly beneficial to learn about material property trends and resources that you can refer back to when selecting specific materials in later years at CU Boulder or in industry/research.

Alternate options to complete: ASEN 1022, GEEN 3024

Battery material and example solid state battery
solidpowerbattery.com/

MCEN 2043: 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.

Prerequisites
MCEN 2023 or equivalent
APPM 1360 or equivalent

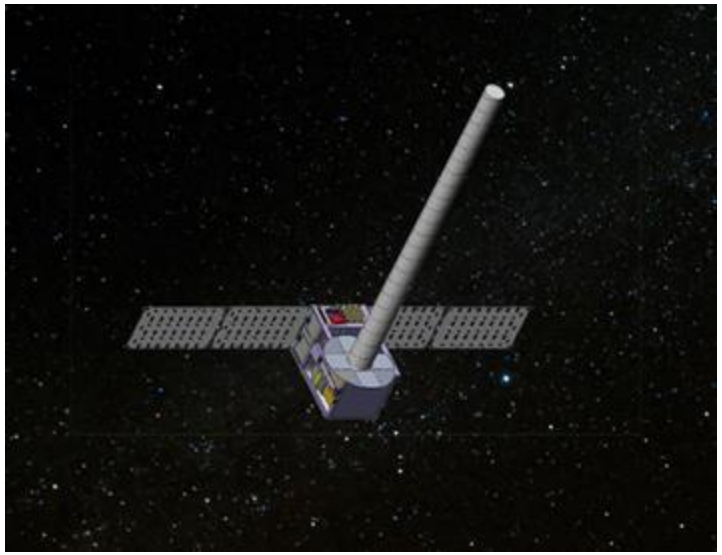
Next Course in Sequence
MCEN 4043 System Dynamics

How this fits into the big picture: Dynamics focuses on the study of objects in motion. It allows mechanical engineers to understand the forces on objects in motion, so that they can anticipate how those forces will impact their design.

Example application: Redwire develops deployable space systems including antennas, solar arrays, and solar sails. Their engineers use principles covered in dynamics to ensure that their hardware will both deploy and function effectively in a space environment.

Insider insight/things that are good to know in advance: Because many of you will take this course immediately after taking Statics (MCEN 2023), you will be inclined to say that the sum of forces acting on an object is zero. Remember that in this class the acceleration is almost never zero and forces will rarely be in balance. You will get very good at drawing free-body diagrams!

Alternate options to complete: CVEN 3111, PHYS 3210, or ASEN 2003/2703/2403



Rendering of a helical L-band antenna
redwirespace.com/newsroom/roccor-creates-helical-l-band-antenna/?rdws=nnn.xffxcv.tfd&rdwj=3094 1

MCEN 2063: 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.

Prerequisites
MCEN 2023 or equivalent
APPM 1360 or equivalent

Next Course in Sequence
MCEN 3025 Component Design

How this fits into the big picture: Failure, specifically material or component failure, is a critical part of engineering. Designs need to have predictable and safe modes of failure to prevent injuries and expensive damages. In order to understand these modes, it is first important to understand the mechanics of internal reactions to loads, and the types of features that will have the biggest impacts on those reactions.

Example application: Siemens Gamesa analyzes the potential stresses within their turbine blades due to the elevated risk for both extreme and fatigue failure under dynamic loading.

Insider insight/things that are good to know in advance: MCEN 2063 combines a lot of the material from MCEN 2023 Statics and MCEN 2024 Materials Science to explain topics like deflection and torsion which later tie into material failure. The course provides many shorthand approximation techniques that will be useful in "back-of-the-napkin" calculations when first brainstorming solutions or determining where critical failure points are likely located.

Alternate options to complete: CVEN 3161, ASEN 3401

Offshore wind turbines often experience significant forces from strong wind
www.windpowerengineering.com/a-u-s-offshore-wind-market-update-from-siemens-gamesa/

MCEN 3012: Thermodynamics

Explores fundamental concepts and basic theory, including first and second laws of thermodynamics, properties, states, thermodynamic functions and cycles.

Prerequisites
APPM 1360 or equivalent

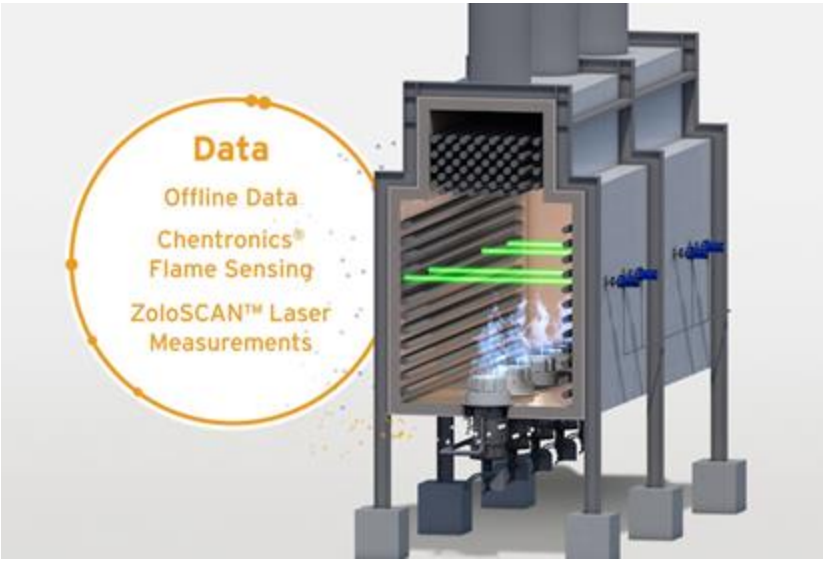
Next Course in Sequence
MCEN 3022 Heat Transfer
MCEN 3032 Thermo 2

How this fits into the big picture: As a mechanical engineer, you will often find yourself working with systems that manipulate energy to accomplish a goal. MCEN 3012 lays the foundation for understanding systems through the approach of energy balances. This first level understanding allows you to quickly analyze the effectiveness and feasibility of thermodynamic processes.

Example application: John Zink Hamworthy is global leader in the emissions control field with over 1,000 patents in a variety of fields. Their leading products deal with designing smart combustion processes.

Insider insight/things that are good to know in advance: The first unit of MCEN 3012 builds a foundation of terminology, types of energy, and other building blocks. Making sure you understandthese core ideas will make recognizing components of a system and building a representative energy balance much easier later in the semester.

Alternate options to complete: AREN 2210, ASEN 2402, EVEN 3012, GEEN 3852



John Zink Hamworthy Smart Combustion Process Design: How it Works
www.youtube.com/watch?v=0BUFXL4Z0f4

MCEN 3017: 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.

Prerequisites
APPM 2360 or equivalent
PHYS 1120

Next Course in Sequence
MCEN 4043 System Dynamics
MCEN 4045 Senior Design

How this fits into the big picture: Many mechanical engineering jobs nowadays require some type of interfacing with electronic components or tools. MCEN 3017 builds off of the basic electrical foundation provided in Physics 2 and explores some of the circuits and electronics such as low pass filters that you may see in your career or in school.

Example application: Xtreme Power Conversion designs and manufactures a large number of systems that provide and safeguard power distribution. These systems are at a crucial junction between electrical and mechanical disciplines as capabilities are balanced with constraints such as heat management.

Insider insight/things that are good to know in advance: In addition to a lecture portion, MCEN 3017 has a lab portion of the class where you can build the circuits and test the electronics you are learning about. This is a great opportunity to understand the material at a deeper level and gain hands on experience you can draw on when faced with similar problems in the future.

Alternate options to complete: ASEN 3503, ECEN 2250/2260/2270, ECEN 3010, GEEN 3010

Portable cooling unit designed and manufactured by XPC
https://www.xpcc.com/products/xc/

MCEN 3021: Fluid Mechanics

Examines fundamentals of fluid flow with application to engineering problems. Topics covered include fluid statics and kinematics, Bernoulli equations, laminar and turbulent viscous boundary layers, laminar and turbulent pipe flow, and conservation equations for mass, momentum and energy.

Prerequisites
MCEN 2023 or equivalent
APPM 2350 or equivalent

Next Course in Sequence
MCEN 3022 Heat Transfer
MCEN 3032 Thermo 2

How this fits into the big picture: Fluids are utilized in many engineering applications such as cooling combustion engines, oxygen transport in the human body, and designing wind turbines to harvest renewable energy. Predicting the effects and behavior of fluids is crucial to understanding how to optimize engineering designs.

Example application: Micro Motion makes flow meters that use the Coriolis effect to directly and accurately measure flow speed. Their products are used in many industries including water systems, energy production, wood/paper products, and food/beverage manufacturing.

Insider insight/things that are good to know in advance: MCEN 3021 is significantly different from many of the previous undergrad ME courses. Be prepared to learn a large variety of new concepts and applications. Spending some extra time understanding the course material at the beginning will yield huge dividends throughout the rest of the semester.

Alternate options to complete: AREN 2120, CHEN 3200, CVEN 3313

Micro Motion Coriolis Flowmeter
www.emerson.com/en-us/automation/micro-motion

MCEN 3022: 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.

Prerequisites
MCEN 3021 or equivalent
MCEN 3012 or equivalent
APPM 2360 or equivalent

Next Course in Sequence
MCEN 4045 Senior Design

How this fits into the big picture: MCEN 3022 investigates the three modes of heat transfer: conduction, convection, and radiation. Within each mode, common systems are explored and first level analysis is carried out in order to approximate the behavior of those systems.

Example application: Electro-Mechanical Products (EMP) is a global leader in the manufacture of thermal management products. Their engineers consult with customers in order to turn their thermal management needs into manufacturable and cost effective solutions.

Insider insight/things that are good to know in advance: Engineering Equation Solver (EES) is an extremely valuable tool for MCEN 3022. The built in property and scenario functions allow you to quickly model a system utilizing the proper heat transfer relationships based on user defined inputs.

Alternate options to complete: ASEN 3402, CHEN 3210

EMP Cooling Coil for Thermal Management
electromechanicalproducts.com/thermal-management/

MCEN 3025: 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.

Prerequisites
MCEN 1025
MCEN 2024 or equivalent
MCEN 2063 or equivalent

Next Course in Sequence
MCEN 4045 Senior Design

How this fits into the big picture: MCEN 3025 places a heavy emphasis on the physics and fundamental engineering behind the mechanical components you will use to build future systems. This course familiarizes students with the best ways to select components such as bearings and threaded fasteners and assemble them in order to develop reliable solutions.

Example application: CeramicSpeed is well known for its work in the bike industry but is also a large supplier of mechanical components for many other applications. Its new hybrid bearings, pictured to the right, increase the strength and durability of production equipment, saving up to 60% of bearing related maintenance costs.

Insider insight/things that are good to know in advance: In this course, you will have the opportunity to build a drill powered vehicle to race at the end of the semester. This project is very hands-on and requires a large amount of manufacturing. You can save yourself a lot of time and stress by creating a manufacturing plan and working with the machine shop early on in the project.

Alternate options to complete: None

Ball bearing designed for cycling applications by Ceramic Speed
www.ceramicspeed.com/en/cycling

MCEN 3030: 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.

Prerequisites
APPM 2360 or equivalent
MCEN 1030 or equivalent

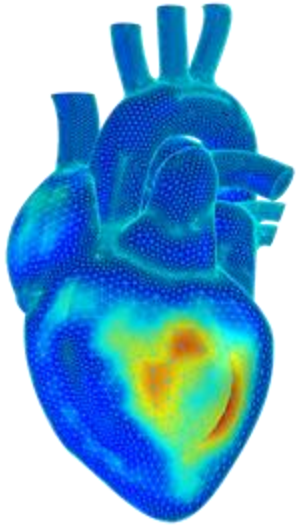
Next Course in Sequence
MCEN 3047 Data Analysis
MCEN 4043 System Dynamics
MCEN 4045 Senior Design

How this fits into the big picture: Without the application of computational methods, many of the engineering problems solved in today's world would be very time consuming and difficult to solve beyond simple cases. Utilizing the power of computers, complex systems can be broken down into equations that can be solved in rapid succession to model a dynamic system or find an optimal solution for a problem with many variables and constraints.

Example application: System Insight Engineering leverages the power of computational modeling to deliver industry leading results in fields such as energy-tissue interaction and tissue heating reactions.

Insider insight/things that are good to know in advance: MCEN 3030 is often heavy on MATLAB based work. If you have not worked with MATLAB much in the past it is important to practice coding in the environment before the class starts or at the beginning of the semester.

Alternate options to complete: ASEN 3502, APPM 4600, CSCI 3656



Simulation of the human heart displayed on System Insight Engineering's homepage
https://siesimulation.com/simulation-3/

MCEN 3032: 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.

Prerequisites
MCEN 3021 or equivalent
MCEN 3012 or equivalent
APPM 2360 or equivalent

Next Course in Sequence
None

How this fits into the big picture: As the name suggest, MCEN 3032 builds off many of the concepts introduced in MCEN 3012 Thermodynamics. Specifically, Thermo 2 focuses on power generation cycles, HVAC, and chemical reactions within processes such as combustion.

Example application: CU Boulder's Utility and Energy Services is responsible for the design, operation, maintenance, and repair of the campus's energy generation and distribution infrastructure for steam (heating), chilled water (cooling), and electricity. Manufacturing and building systems across industries rely on similar groups to design and maintain their heating, cooling and utility systems.

Insider insight/things that are good to know in advance:
A big portion of the class is a design project that you'll work on with a small team. There are a few options to choose from, but each of them provides an opportunity to design a system using the course material. This project provides great context for how engineering solutions can save or cost a company a lot of money.

Alternate options to complete: None

A medium-size steam generation boiler in the East District Energy Plant at CU Boulder

MCEN 3047: 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, and one- and two-factor ANOVA.

Prerequisites
APPM 2360 or equivalent
MCEN 2063 or equivalent
PHYS 1140 or equivalent

Corequisites
Writing Requirements
MCEN 3017 or equivalent
MCEN 3030 or equivalent

Next Course in Sequence:
MCEN 4045 Senior Design

How this fits into the big picture: Modeling and theoretical calculations only provide the answer to a problem sometimes. In many scenarios, experiments are needed to discover the behavior of materials, reactions, or systems. Those experiments are a valuable tool in research, development, and testing of new products.

Example application: The Laboratory for Atmospheric and Space Physics (LASP) is a research facility on the CU Boulder campus that designs, tests, and sends research instruments into space. They use many kinds of data analysis and experimental methods to ensure that the systems they design are ready for space.

Insider insight/things that are good to know in advance: This class includes a combination of statistics and hands-on lab work. You'll learn how to use data acquisition systems, follow test protocols, and analyze the data you collect.

Alternate options to complete: GEEN 3853

Solar Radiation and Climate Experiment (SORCE) Satellite in a LASP clean room
lasp.colorado.edu/home/missions-projects/mission-history-all/

MCEN 4026: Manufacturing

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.

Prerequisites
MCEN 2024 or equivalent

Next Course in Sequence:
MCEN 4045 Senior Design

How this fits into the big picture: How does stuff get made? From raw materials to a finished product, imagine the supply chain, logistics, (statistical) quality control, economics, machines, and people involved at every stage of the process, across the world. Understanding different manufacturing processes and systems enables mechanical designers to make smart choices regarding materials selection, processing methods, and physical features.

Example application: Accu-Precision manufactures custom parts, sheet metal and assemblies for aerospace and industrial applications. They work with customers to provide engineering services and fabricate components using equipment including milling machines, lathes, grinders, punches, and presses.

Insider insight/things that are good to know in advance: In-person labs (including pouring your own molten Al) and watching YouTube videos about manufacturing are vital and fun parts of the course. Expect to disassemble and analyze everyday objects, and to learn from cool guest speakers too.

Alternate options to complete: None

Automated scrap metal disposal system designed by ME students for Accu-Precision
www.colorado.edu/mechanical/2022/04/12/mechanical-engineering-students-build-machine-automate-scrap-metal-disposal

MCEN 4043: 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 multi-domain systems.

Prerequisites
APPM 2360 or equivalent
MCEN 2043 or equivalent
MCEN 3017 or equivalent

Corequisites
MCEN 3030 or equivalent

Next Course in Sequence:
MCEN 4045 Senior Design

How this fits into the big picture: System Dynamics is all about putting an input into a system and anticipating what will come out the other side. It allows you to break down complex systems to figure out how they work and how they can be improved. It includes things like the impact of vibrations on a system and introductory control theory.

Example application: Vita Inclinata designs and builds load stabilization systems for helicopter rescues and for cranes used in the construction industry. Their technology uses control systems to sense and automatically adjust for conditions like wind speed and load weights.

Insider insight/things that are good to know in advance: This class involves a lot of complex math. It's probably going to be one of the hardest classes you take at CU, but it's worth it! Try to take MCEN 3030 before MCEN 4043 if you can, since they both tend to have a heavy workload.

Alternate options to complete: ECEN 3300/4138

Vita Inclinata's load stabilization technology in a rescue simulation
www.mgm-compro.com/news/vita-inclinata-life-rescue-system/

MCEN 4045/4085: Senior Design

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.

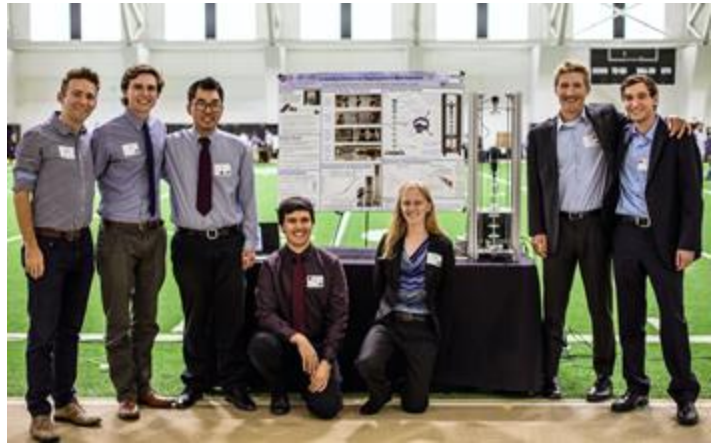
Prerequisites
See flowchart for details

How this fits into the big picture: Senior Design is set up to mirror processes and challenges you'll find in industry. You'll work with a team of 5-12 students on a year-long project and will go through the full design, analysis, fabrication, and testing cycle. Each team is assigned a faculty or industry director, who serves as their mentor throughout the year. Project deliverables are expected to be professional quality and will be showcased in a public expo.

Example application: You can find examples of past years' projects on the Senior Design website.

Insider insight/things that are good to know in advance: There are two sections of senior design. Teams in the *Industry* section work on projects sponsored by industry clients or on competition teams. Teams in the *Engineering for Social Innovation* section identify their own project to focus on and participate in the New Venture Challenge. Incoming seniors learn more about those options at the required Pre-Expo in April of their junior year.

Alternate options to complete: None



Senior Design teams and projects
www.colorado.edu/mechanical/senior-design