MECHANICAL & AEROSPACE ENGINEERING (MAE)

MAE 1170 - Introduction to Mechanical Engineering (3 Credits)
Crosslisted with ENGRI 1170
Introduction to fundamentals of mechanical and aerospace engineering. Students learn and understand topics such as stress and strain, fluid mechanics, heat transfer, automotive engineering, and engineering design and product development. Emphasis is placed on critically examining problem solutions to begin developing engineering intuition. Key components of the class include in-class discussions, homework, laboratory experiments, and a group design project.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to gain a basic understanding of four major areas of the mechanical engineering curriculum: statics, mechanics of materials, fluid mechanics, and thermal sciences.
- Students will be able to identify a system and its interactions with surroundings; they will use this approach to solve problems in both mechanical and thermal/fluids systems.
- Students will gain experience with unit conversion, estimation, approximations, and critical thinking.
- Students will be able to design and build a device (e.g. a small battery-powered car), and perform and document laboratory experiments.
- Students will be able to become aware of current problems, issues, successes, entrepreneurship opportunities, design trade-offs, and failures in the mechanical and aerospace field.

Schedule of Classes (https://classes.cornell.edu/)

MAE 1270 - Introduction to Entrepreneurship for Engineers (3 Credits)
Crosslisted with ENGRI 1270
This course is intended for first-year students. A solid introduction to the entrepreneurial process to students in engineering. The main objective is to identify and to begin to develop skills in the engineering work that occurs in high-growth, high-tech ventures. Basic engineering management issues, including the entrepreneurial perspective, opportunity recognition and evaluation, and gathering and managing resources are covered. The fundamentals of supply and demand and other basic microeconomic terms are covered. Technical topics such as the engineering design process, product realization, and technology forecasting are discussed.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Learning Outcomes:

- Students will be able to explore a multi-disciplinary look at high-technology entrepreneurial businesses.
- Students will define terms and be familiar with the general attributes of various funding sources.
- Students will calculate simple financial numbers, such as gross margin, net income, and cost of goods sold.
- Students will demonstrate familiarity with the basics of intellectual property terminology and laws in the USA.
- Students will be familiar with the basics of microeconomics, such as supply and demand, externalities, and competition.

Schedule of Classes (https://classes.cornell.edu/)

MAE 1510 - Modeling and Simulation of Real-World Scientific Problems (3 Credits)
Crosslisted with ENGRI 1510, CHEM 1350, CHEME 1510
Last Four Terms Offered: Spring 2022, Spring 2020, Spring 2019, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MAE 1900 - First-Year Independent Study in Mechanical Engineering (1-4 Credits)
Individual research studies for students who want to pursue a particular analytical, computational, or experimental investigation outside of regular courses or for informal instruction supplementing that given in regular courses. An engineering report on the project is required of each student. Students must first make individual arrangements with a faculty sponsor and then submit an enrollment form, available online at https://www.mae.cornell.edu/mae/programs/undergraduate-programs/undergraduate-forms. Once approved, students will receive an enrollment pin to enroll in MAE 1900. Students are expected to spend 3-4 hours per week per credit hour working on the project. May not be used as a technical elective in the ME major.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MAE 2020 - Statics and Mechanics of Solids (4 Credits)
Crosslisted with ENGRD 2020
This course presents the methods for analyzing deformable structures in equilibrium. It is fundamental to mechanical analysis and design and is the basis for many advanced courses and professions in mechanical, civil, materials, biomedical and biological engineering.
Prerequisites: PHYS 1112. Corequisite: MATH 1920.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Learning Outcomes:

- Students will be able to draw complete and correct free body diagrams.
- Students will be able to apply the principle of equilibrium to calculate external and internal forces in simple, statically determinant mechanical systems, including simple shear and bending moment distributions.
- Students will be able to use key terminology related to stress, strain, deformation and elasticity along with analyzing the stress, strain and deformation in bars subject to axial, bending and torsional loads.
- Students will be able to use the principles of elasticity and equilibrium to solve for stresses in simple statically indeterminate systems.

Schedule of Classes (https://classes.cornell.edu/)

MAE 2030 - Dynamics (4 Credits)
Newtonian dynamics of a particle, systems of particles, rigid bodies, simple mechanisms and simple harmonic oscillators. Impulse, momentum, angular momentum, work and energy. Two-dimensional (planar) kinematics including motion relative to a moving reference frame. Three dimensional rigid-body dynamics are introduced at the instructor's option. Setting up the differential equations of motion and solving them both analytically and numerically with MATLAB. In-lecture laboratory demonstrations illustrate basic principles.
Prerequisites: ENGRD 2020 and MATH 2930. Corequisite: MATH 2940.
Last Four Terms Offered: Summer 2025, Spring 2025, Summer 2024, Spring 2024
Learning Outcomes:

- Students will be able to draw free-body diagrams and vectors for mechanics.
- Students will be able to describe particle motion in 1-D, 2-D and 3-D employing Cartesian, polar, and path coordinates, and rotating coordinate systems.
- Students will be able to apply Newton/Euler laws, momentum and work-energy principles to the motion of particles and rigid bodies to find equations of motion and conserved quantities.
- Students will be able to recognize simple harmonic motions for 1-degree-of-freedom mechanical systems.
- Students will be able to solve equations of motion numerically, and analytically in simple cases, and graphically show the resulting motion(s).
- Students will be able to understand measurement of displacement, velocity and acceleration - and use such data to characterize the kinematics of simple mechanisms and 1-degree-of-freedom mechanical systems.

Schedule of Classes (https://classes.cornell.edu/)

MAE 2210 - Thermodynamics (3 Credits)
Crosslisted with ENGRD 2210
Presents the definitions, concepts, and laws of thermodynamics. Topics include the first and second laws, thermodynamic property relationships, and applications to vapor and gas power systems, refrigeration, and heat pump systems. Examples and problems are related to contemporary aspects of energy and power generation and to broader environmental issues.
Prerequisites: MATH 1920 and PHYS 1112.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Summer 2025, Fall 2024, Summer 2024, Fall 2023
Learning Outcomes:

- Students will be able to choose an appropriate system and identify interactions between system and surroundings.
- Students will be able to obtain values of thermodynamic properties for a pure substance in a given state, using tables, relations for incompressible substances, and relations for gases.
- Students will be able to apply energy and entropy balances in the control mass (closed system) and control volume formulations to the analysis of devices and cycles.

Schedule of Classes (https://classes.cornell.edu/)

MAE 2250 - Introduction to Mechanical Design (4 Credits)
The majority of engineering courses focus on achieving quantitative outcomes using the proper applied formulas and metrics. This is not the case for MAE 2250, which focuses on applying a process and justifying decisions which lead to a (hopefully desired) outcome. You can expect to be challenged by the types of complex and open-ended problems regularly encountered in engineering practice and provided with a methodology to begin to navigate these challenges. Many of these challenges will be qualitative in nature, with no one correct answer. Your personal experiences and the experiences of your end user can - and should! - weigh into your final solutions.Our approach will follow the product development process, spanning stages of problem research through prototyping and evaluation. You will design mechanisms and devices to fulfill specific user needs and assess and iterate on various concepts that you develop and prototype. You will learn to create your own evaluation criteria and compare designs based on those criteria. These design experiences will simulate real-world engineering practices and include project management, team organization, version tracking, and oral communication. You will learn how to use computer aided design (CAD) tools effectively through projects.There will be one main group project (the open design project, or ODP) in this course and several individual assignments to support specific content. In the open design project, you will propose a problem that you will research and then spend time ideating, prototyping, and evaluating your solutions. Your group project will focus on combining mechanical constraints and requirements with an understanding of user needs and converging on a solution.
The individual projects will include CAD design, mechanism analysis, machine design, and design optimization. Each of these projects will be opportunities to apply specific skills from the course, while the group project will represent the larger design process.
Prerequisites: ENGRD 2020.
Enrollment Information: Enrollment limited to: Mechanical Engineering (M.E.) students and to students intending to affiliate in M.E.
Course Fee: Course Fee, $100. Materials fee.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to stimulate and practice original thinking and creativity.
- Students will be able to introduce the product design and development process.
- Students will be able to integrate engineering knowledge with individual experience in multi-disciplinary applications.
- Students will be able to foster an understanding of the unstructured nature of design.
- Students will be able to provide practice in problem definition and solution synthesis.
- Students will be able to provide training in graphical thinking and communication.
- Students will be able to introduce fabrication methods necessary for practical implementation of designs.

Schedule of Classes (https://classes.cornell.edu/)

MAE 2270 - Introduction to Entrepreneurship for Engineers (3 Credits)
Crosslisted with ENGRG 2270
This course is intended for first-year students. A solid introduction to the entrepreneurial process to students in engineering. The main objective is to identify and to begin to develop skills in the engineering work that occurs in high-growth, high-tech ventures. Basic engineering management issues, including the entrepreneurial perspective, opportunity recognition and evaluation, and gathering and managing resources are covered. The fundamentals of supply and demand and other basic microeconomic terms are covered. Technical topics such as the engineering design process, product realization, and technology forecasting are discussed.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Learning Outcomes:

- Students will be able to explore a multi-disciplinary look at high-technology entrepreneurial businesses.
- Students will define terms and be familiar with the general attributes of various funding sources.
- Students will calculate the rate of growth for a business, profit and loss, earnings per share, cost of goods sold, stock valuation, breakeven, and technology substitution rates.
- Students will demonstrate familiarity with the basics of intellectual property terminology and laws in the USA.
- Students will be familiar with the basics of microeconomics, such as supply and demand, externalities, and competition.

Schedule of Classes (https://classes.cornell.edu/)

MAE 3050 - Introduction to Aeronautics (4 Credits)
This course is an overview of the engineering science relevant to the design of aircraft. It is a course in applied aerodynamics, designed to develop the engineering background required to understand the principal aerodynamic constraints involved in the design of heavier-than-air, atmospheric flight vehicles. Basic concepts in fluid mechanics and aerodynamics are reviewed and described in the context of their relevance to the performance of aircraft and to the stability and controllability of flight vehicles. The fluid mechanical theory for lift and drag forces is developed, the characteristics of aircraft propulsive systems are explored, and the two are brought together to investigate the performance of typical aircraft.
Prerequisites: MAE 2030. Prerequisite or corequisite: ENGRD 2210 or BEE 2220, MAE 3230 or CHEME 3230 or BEE 3310 or CEE 3310.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to understand the basic elements of aerodynamic lift, drag, and moments forming the basis for flight.
- Students will be able to analyze the motion of aircraft to obtain performance, stability and control information.
- Students will be able to perform computer based solutions of problems related to aeronautics.

Schedule of Classes (https://classes.cornell.edu/)

MAE 3120 - Mechanical Properties of Materials, Processing, and Design (3 Credits)
Crosslisted with MSE 4020
Relationship between microscopic mechanisms and macroscopic mechanical behavior of engineering materials, how mechanical properties can be modified, and criteria for selection and use of materials in design. Stress, strain and elastic constants as tensor quantities, viscoelasticity and damping, plastic deformation, creep deformation, fracture, and fatigue.
Prerequisites: MAE 3270 or MSE 2610.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 3130 - Atomic and Molecular Structure of Matter (3 Credits)
Crosslisted with MSE 2060
This course covers the atomic and molecular structure of crystalline and noncrystalline materials as well as selected analytical techniques for structural interrogation. Selected topics include, basic elements of structure; order and disorder; crystals; semicrystalline materials; amorphous materials; molecular materials; x-ray diffraction; small angle x-ray scattering.
Prerequisites: Recommended prerequisite: MSE 2610.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 3230 - Introductory Fluid Mechanics (4 Credits)
Topics include physical properties of fluids, hydrostatics, conservation laws using control volume analysis and using differential analysis, Bernoulli's equation, potential flows, simple viscous flows (solved with Navier-Stokes equations), dimensional analysis, pipe flows, boundary layers. Introduction to compressible flow.
Prerequisites: ENGRD 2020, MAE 2030. Prerequisite or corequisite: ENGRD 2210.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Summer 2022
Learning Outcomes:

- Students will be able to use the fundamental principles and mathematical basis underlying the conservation equations.
- Students will be able to identify the guiding principles in a given fluid problem, to formulate the governing equations, and so to solve basic engineering problems.
- Students will be able to recognize solutions with and without vorticity, and understand the limitations of the solutions for real practical fluid flows. Understand the difference between a simple solution and a real practical problem.
- Students will be able to understand where their analysis might involve approximations and empirical approaches; for example, pipe flows and boundary layer flows.
- Students will be able to improve their ability to formulate an ordered approach to problem solving, using words of explanation in derivations, and algebra before substituting numerical values that allows neat analytical solutions and dimensional analysis.

Schedule of Classes (https://classes.cornell.edu/)

MAE 3240 - Heat Transfer (3 Credits)
This is the first course in heat transfer, with an emphasis on understanding the fundamental physics underlying different heat transfer processes, making proper approximations for analytical heat transfer calculations and numerical methods for engineering heat transfer analysis. Topics include: introduction to three modes of heat transfer, thermal resistance network analysis, steady-state conduction, transient conduction, numerical methods for heat conduction and convection using ANSYS, free convection, heat exchangers, radiation processes and properties.
Prerequisites: MAE 3230.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Summer 2022
Learning Outcomes:

- Students will be able to become proficient with energy balances to develop models of heat flow in various systems.
- Students will be able to learn terminology and principles of heat transfer.
- Students will be able to develop broad understanding of basic modes of heat transfer (conduction, convection, radiation) and become proficient at predicting heat transfer rates for these modes including computing the heat transfer coefficient for forced and natural convection.
- Students will be able to become proficient at computing radiative exchange between surfaces.
- Students will be able to apply basic heat exchange theory to predict heat exchanger performance for standard designs.

Schedule of Classes (https://classes.cornell.edu/)

MAE 3260 - System Dynamics (4 Credits)
Dynamic behavior of mechanical systems: modeling, analysis techniques, and applications; vibrations of single- and multidegree- of-freedom systems; feedback control systems. Computer simulation and experimental studies of vibration and control systems.
Prerequisites: MATH 2930, MATH 2940, and MAE 2030.
Enrollment Information: Enrollment limited to: juniors.
Last Four Terms Offered: Fall 2024, Fall 2023, Spring 2023, Spring 2022
Learning Outcomes:

- Student will be able to build an accurate dynamic model of a complex mechanical or electromechanical system by a divide-and-conquer approach that makes use of physics, constitutive laws, geometry, and whatever other information one may have about the system.
- Students will be able to use linear and nonlinear system simulation and analysis tools to study transient and frequency response of systems.
- Students will be able to use modern dynamics and control lab equipment to measure, record and analyze system response.
- Students will be able to choose appropriate values for model parameters to meet passive or open-loop performance specifications on dynamic response.
- Students will be able to design closed-loop feedback controllers to meet performance specifications on dynamic response.

Schedule of Classes (https://classes.cornell.edu/)

MAE 3270 - Mechanics of Engineering Materials (4 Credits)
This course will offer students opportunities to perform preliminary design and analysis of structures and mechanical components and to select materials to meet design objectives and constraints. To do so, students will extend their knowledge of and ability to apply solid and structural mechanics topics including general states of stress and strain, elasticity, coordinate transformations, energy methods, effects of combined loading and mechanical testing. The use of multipe failure criteria including yielding, brittle failure, fatigue and fracture as part of design calculations to meet stiffness, strength and other performace criteria is emphasized. Students are introduced to the structure, processing and mechanical properties of metals, polymers, ceramics and composites. A formal approach to mateirals selection is introduced and applied.
Prerequisites: ENGRD 2020, MATH 2940, CS 1112 or CS 1110.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Summer 2022
Learning Outcomes:

- Students will be able to perform preliminary design of simple structures and components considering strength, fatigue, fracture, stiffness and material suitability for a given purpose.
- Students will be able to break down problems into component parts and correctly perform calculations for stress, deflection, strength, fatigue life and fracture resistance.
- Students will be able to describe basic tests of mechanical properties of materials and to correctly define and use associated terms.
- Students will be able to describe the structure, processing, and properties of the basic classes of engineering materials: metals, polymers, ceramics, and composites.

Schedule of Classes (https://classes.cornell.edu/)

MAE 3780 - Mechatronics (4 Credits)
Mechatronics sits at the intersection of mechanical and electrical engineering. Many modern mechanical systems (e.g. vehicles) includes embedded electronics and microcontrollers. This course introduces students to mechatronic systems with a hands-on focus on circuits that interact with the world via sensors and actuators. Students will learn the underlying theory behind circuit behavior along with extensive circuit prototyping and debugging. The course will culminate in the design, fabrication, and programming of a mechatronic system such as a mobile robot or device for home/office automation.
Prerequisites: CS 1110/CS 1112 or equivalent programming experience, MATH 2930 and PHYS 2213.
Enrollment Information: Enrollment limited to: junior M.E. Majors and those officially taking the MechE Minor.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to analyze a given circuit using relevant physical laws to solve for parameters of interest in the circuit (e.g. voltages and currents).
- Students will be able to select from known circuit topologies to accomplish a desired task, and appropriately choose or size components for the circuit.
- Students will be able to prototype and debug electronic circuits and mechatronic systems while skillfully using relevant laboratory equipment (e.g. breadboards, multimeters, oscilloscopes).
- Students will be able to program a microcontroller to interface with circuits that include sensors and actuators.
- Students will be able to design, build, and program a mechatronic system to accomplish a desired task while taking constraints and requirements into account.

Schedule of Classes (https://classes.cornell.edu/)

MAE 3783 - Mechatronics (4 Credits)
Mechatronics sits at the intersection of mechanical and electrical engineering. Many modern mechanical systems (e.g. vehicles) includes embedded electronics and microcontrollers. This course introduces students to mechatronic systems with a hands-on focus on circuits that interact with the world via sensors and actuators. Students will learn the underlying theory behind circuit behavior along with extensive circuit prototyping and debugging. The course will culminate in the design, fabrication, and programming of a mechatronic system such as a mobile robot or device for home/office automation.
Prerequisites: CS 1110/CS 1112 or equivalent programming experience, MATH 2930 and PHYS 2213.
Enrollment Information: Enrollment limited to: Non M.E. majors, and junior standing.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 3870 - Fundamentals of Electric-Drive Vehicle Engineering (3 Credits)
The course covers the engineering fundamentals and basic design of electric-drive vehicles by analyzing the relevant physics and applying the relevant equations and simple models. The course reviews transportation electrification history, electric vehicle architecture, powertrain components and their modeling and control.
Prerequisites: PHYS 2213, MAE 2030, and MATH 2930.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2024, Fall 2023
Learning Outcomes:

- Students will be able to explain the fundamental concepts of range and energy storage.
- Students will be able to perform calculations using efficiencies and loads to estimate range.
- Students will be able to perform calculations relating to the combination of cells to form battery packs, and the tradeoffs of voltage versus capacity.
- Students will be able to describe the key operating characteristics of induction electric motors.
- Students will be able calculate the mpge and other efficiency metrics for various drive cycles.
- Students will be able to perform modeling of some specific electric vehicle systems, using MATLAB and/or Python scripts.
- Students will be able to describe the performance and model the control systems of specialized low-speed electric vehicle systems such as wheelchairs, assistive scooters, and material handling equipment.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4020 - Wind Power (3 Credits)
Main features of energy conversion by wind turbines. Emphasis on characterization of the atmospheric boundary layer, aerodynamics of horizontal axis wind turbines, and performance prediction. Structural effects, power train considerations, siting and wind farm planning, offshore.
Prerequisites: MAE 3230 (or equivalent) or MAE 3050, MAE 3270.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Learning Outcomes:

- Students will be able to understand the need for carbon-free energy production and the functions of wind turbines.
- Students will be able to calculate mean wind fields.
- Students will be able to analyze the aerodynamics of wind turbine blades.
- Students will be able to predict efficiency of energy extraction.
- Students will be able to understand the basics of electrical generators and mechanical to electrical energy conversion.
- Students will be able to know how to choose sites for turbines and wind farms.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4021 - Wind Power (4 Credits)
Main features of energy conversion by wind turbines. Emphasis on characterization of the atmospheric boundary layer, aerodynamics of horizontal axis wind turbines, and performance prediction. Structural effects, power train considerations, siting and wind farm planning, offshore. Senior Design version of MAE 4020. Senior Design report required.
Prerequisites: MAE 3230 (or equivalent) or MAE 3050, MAE 3270.
Enrollment Information: Enrollment limited to: seniors.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Learning Outcomes:

- Students will be able to understand the need for carbon-free energy production and the functions of wind turbines.
- Students will be able to calculate mean wind fields.
- Students will be able to analyze the aerodynamics of wind turbine blades.
- Students will be able to predict efficiency of energy extraction.
- Students will be able to understand the basics of electrical generators and mechanical to electrical energy conversion.
- Students will be able to know how to choose sites for turbines and wind farms.
- Students will be able to demonstrate the ability to design a wind power system or component.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4060 - Introduction to Spaceflight Mechanics (3 Credits)
Introduction to spacecraft orbit mechanics, attitude dynamics, and the design and implementation of spaceflight maneuvers for satellites, probes, and rockets. Topics in celestial mechanics include orbital elements, types & uses of orbits, coordinate systems, Kepler's equation, the restricted three-body problem, interplanetary trajectories, the rocket equation and staging, Clohessy-Wiltshire equations and relative formation flight, drag and orbital decay, and propulsive maneuvers. Topics in attitude dynamics include kinematics, Euler's equations, stability of spinning spacecraft, attitude perturbations such as gravity-gradient and magnetic torques, equations of motion of rigid spacecraft with momentum actuators and thrusters, attitude maneuvers such as nutation control and reorientation, low-speed fluid behaviors, and elementary feedback control of linearized attitude and orbit dynamics. Principles of spacecraft propulsion technology and attitude-control technology are introduced along with the rocket equation and staging. The course includes discussions of current problems and trends in spacecraft operation and development.
Prerequisites: MATH 2930, MATH 2940, and MAE 2030.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to understand the fundamentals of spaceflight mechanics and how high-level mission requirements drive the design of orbits and attitude for contemporary spacecraft.
- Students will be able to understand the application of Kepler's laws for orbital motion, how to propagate an orbit, and calculate parameters associated with mission operations, including launch, insertion, and interplanetary transfers.
- Students will be able to understand the application of Euler's equations for rigid-body motion to spacecraft dynamics, attitude representations, attitude kinematics, how to predict and model spacecraft attitude motions, and how to achieve desirable attitude-dynamics behaviors.
- Students will be able to simulate a spacecraft in orbit using state of the art tools and identify and characterize the astrodynamics capabilities of a preliminary spacecraft design.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4070 - Dynamics of Flight Vehicles (3 Credits)
Introduction to stability and control of atmospheric-flight vehicles. At the end of the course, students will be able toderive from first principles the differential equations governing the motion of flight vehicles, formulate appropriate simplifying assumptions, solve for the aircraft motion through analytical or numerical means, analyze the static and dynamic stability properties of a given aircraft, and explain expected aircraft piloting behaviors through rigorous engineering reasoning.
Prerequisites: MAE 3050, and MAE 3230. Corequisite: MAE 3260.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Fall 2021
Learning Outcomes:
- Students will understand the nature of aerodynamic forces and moments (aerodynamic stability derivatives) in determining the motions of a flight vehicle.
- Students will understand the various terms in the equations of motion and the simplifications arising from assumptions of small disturbances from equilibrium flight and from the bi-lateral symmetry of most aircraft.
- Students will be able to identify, formulate and solve engineering problems in aircraft flight dynamics.
- Students will understand the principal constraints imposed on aircraft design by stability and controllability requirements.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4130 - Mechanics of Composite Structures (4 Credits)
Covers the fundamentals of mechanical analysis and material selection for composite materials. Topics include an overview of composite types, advantages, applications and fabrication; anisotropic elasticity; specific composite constitutive equations including plane stress and lamination theory; failure analysis; boundary value problems using composite materials; experimental methods and an introduction to micromechanics. Lectures cover essential background material and theoretical developments. Labs provide hands-on experiences for understanding composite materials properties and performance.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:
- Students will be able to understand the advantages, the potential applications associated with several classes of composite materials.
- Students will be able to conduct critical mechanical analyses associated with the deformation and failure of composites accounting specifically for stiffness and strength anisotropy.
- Students will be able to understand mechanical tests employed to measure composite elastic moduli and strength.
- Students will be able to properly select composite materials for mechanical designs.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4131 - Mechanics of Composite Structures (5 Credits)
Covers the fundamentals of mechanical analysis and material selection for composite materials. Topics include an overview of composite types, advantages, applications and fabrication; anisotropic elasticity; specific composite constitutive equations including plane stress and lamination theory; failure analysis; boundary value problems using composite materials; experimental methods and an introduction to micromechanics. Lectures cover essential background material and theoretical developments.
Prerequisites: MAE 3270.
Enrollment Information: Enrollment limited to: seniors or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:
- Students will be able to understand the advantages, the potential applications and the fabrication methods associated with several classes of composite materials.
- Students will be able to conduct critical mechanical analyses associated with the deformation and failure of composites accounting specifically for characteristic property anisotropy.
- Students will be able to approximate composite mechanical properties based on properties of constituent phases. Understand mechanical tests employed to measure composite properties.
- Students will be able to properly select composite materials for mechanical designs and to understand the advantages and liabilities of employing composites over monolithic materials.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4150 - GPS: Theory and Design (4 Credits)
Crosslisted with ECE 4150, EAS 4150
Analysis of GPS operating principles and engineering practice with a culminating design exercise. GPS satellite orbital dynamics, navigation data modeling, position/navigation/timing solution algorithm, receiver and antenna characteristics, analysis of error and accuracy, differential GPS.
Prerequisites: 3000-level engineering course with advanced math content (e.g., ECE 3030 or MAE 3260).
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2020, Spring 2018
Learning Outcomes:

- Students will be able to develop an understanding of orbital mechanics with non-Keplerian perturbations and reference frames adequate to calculate GPS satellite positions in absolute and local coordinates.
- Students will be able to use to use the GPS observables, their physical models, and the multi-variable version of Newton's nonlinear equation-solving method to calculate a navigation solution and a velocity solution.
- Students will be able to gain an understanding of the sources of ranging errors and how they map to navigation errors.
- Students will be able to collect raw GPS data in a laboratory environment, to analyze its properties, including its noise properties, and to use it to derive useful position, navigation, timing, and velocity information.
- Students will be able to implement an advanced analysis or design solution to a GPS problem, test it experimentally, and effectively communicate the results in a final report.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4160 - Spacecraft Technology and Systems Architecture (3 Credits)
This course is a survey of contemporary space technology from subsystems through launch and mission operations, all in the context of spacecraft and mission design. It focuses on the classical subsystems of robotic and human-rated spacecraft, planetary rovers, and other space vehicles, as well as on contemporary engineering practice. Topics covered include subsystem technologies and the systems-engineering principles that tie them together into a spacecraft architecture. Subsystem technologies discussed include communications, thermal subsystems, structure, spacecraft power, payloads (remote sensing, in-situ sensing, human life support), entry/descent/landing, surface mobility, and flight-computer hardware and software.
Prerequisites: MAE 3260 and MAE 4060.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to understand, at a higher systems level, space missions and systems, and how the space environment and mission requirements drive spacecraft design.
- Students will be able to understand the basic fundamentals of spacecraft subsystems, including propulsion, attitude determination and control, power, structures, thermal, communications, and command and data handling.
- Students will be able to understand typical practices for designing space systems in a contemporary context of US commercial space and government agencies.
- Students will be able to simulate a spacecraft in operation using state of the art tools, and identify and characterize subsystems for a preliminary spacecraft design.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4161 - Spacecraft Technology and Systems Architecture (4 Credits)
This course is a survey of contemporary space technology from subsystems through launch and mission operations, all in the context of spacecraft and mission design. It focuses on the classical subsystems of robotic and human-rated spacecraft, planetary rovers, and other space vehicles, as well as on contemporary engineering practice. Topics covered include subsystem technologies and the systems-engineering principles that tie them together into a spacecraft architecture. Subsystem technologies discussed include communications, thermal subsystems, structure, spacecraft power, payloads (remote sensing, in-situ sensing, human life support), entry/descent/landing, surface mobility, and flight-computer hardware and software.
Prerequisites: MAE 3260 and MAE 4060.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to understand, at a higher systems level, space missions and systems, and how the space environment and mission requirements drive spacecraft design.
- Students will be able to understand the basic fundamentals of spacecraft subsystems, including propulsion, attitude determination and control, power, structures, thermal, communications, and command and data handling.
- Students will be able to understand typical practices for designing space systems in a contemporary context of US commercial space and government agencies.
- Students will be able to simulate a spacecraft in operation using state of the art tools, and identify and characterize subsystems for a preliminary spacecraft design.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4180 - Autonomous Mobile Robots (3 Credits)
Crosslisted with CS 4758, ECE 4180
Creating robots capable of performing complex tasks autonomously requires one to address a variety of different challenges such as sensing, perception, control, planning, mechanical design, and interaction with humans. In recent years many advances have been made toward creating such systems, both in the research community (different robot challenges and competitions) and in industry (industrial, military, and domestic robots). This course gives an overview of the challenges and techniques used for creating autonomous mobile robots. Topics include sensing, localization, mapping, path planning, motion planning, obstacle and collision avoidance, and multi-robot control.
Prerequisites: MATLAB programming experience.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022, Spring 2021
Learning Outcomes:

- Students will be able to understand and implement localization and mapping algorithms using different sensor modalities.
- Students will be able to generate a path and the motion for a robot moving around an area with obstacles.
- Students will be able to understand and implement the concepts of different approaches for motion planning such as roadmaps, feedback control, and sampling based methods.
- Students will be able to apply the tools learned in the class to physical robots.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4190 - Fast Robots (4 Credits)
Crosslisted with ECE 4160
The course focus is on systems level design and implementation of fast and dynamic autonomous robots. With the recent DIY movement, design of kinematic robots is largely becoming a software challenge. In dynamic robots, however, any latency or noise can be detrimental. We will design a fast autonomous car, explore dynamic behaviors, acting forces, sensors, and reactive control on an embedded processor, as well as the benefit of partial off-board computation. Students will learn how to derive design specifications from abstract problem descriptions and gain familiarity with rapid prototyping techniques, system debugging, system evaluation, and online dissemination of work.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Students will learn how to robustly integrate systems consisting of electronics, software, and mechanics operating in the real world.
- Students will learn how to translate probabilistic control and planning methods to practical robots with hardware and processing constraints.
- Students will learn how to disseminate their work to their peers and an engineering audience.
- Students will learn how to predict the likely social and environmental effects of their design.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4220 - Introduction to Internet of Things - Technology and Engagement (3 Credits)
This interdisciplinary design course aims to provide a holistic introduction to Internet of Things (IoT) and train students on the core technological and communication skills through community engagement and working on real-world applications. IoT has become an enabler for new economic activities and provides potentially cost-effective solutions to a wide range of societal challenges. Students team up with community partners throughout a semester to tackle a real-world problem using IoT technology. The project topics include, but are not limited to, energy, environmental, civic infrastructure monitoring. The project teams will apply engineering design principles and critically examine sensor selection, sensor deployment, wireless communication, data quality, security, and privacy as well as value proposition for IoT-based solutions. The key learning outcome of this course is that students will grasp how to develop IoT-based technological solutions and become competent in communicating how to use the IoT technology responsibly to create positive societal impact.
Prerequisites: MAE 3780 or ECE 3400.
Exploratory Studies: (CU-CEL, CU-SBY)

Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:
- Students will be able to develop IoT-based solutions to address community partners' specified needs.
- Students will be able to apply the principles of data security and data privacy in IoT designs.
- Students will be able to engage with community partners in designing the IoT-based solutions and communicate the designs effectively with community partners and peers in both verbal and written forms.
- Students will be able to evaluate the feasibility of the IoT-based solutions and articulate the potential improvement.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4221 - Introduction to Internet of Things - Technology and Engagement (4 Credits)
This interdisciplinary design course aims to provide a holistic introduction to Internet of Things (IoT) and train students on the core technological and communication skills through community engagement and working on real-world applications. IoT has become an enabler for new economic activities and provides potentially cost-effective solutions to a wide range of societal challenges. Students team up with community partners throughout a semester to tackle a real-world problem using IoT technology. The project topics include, but are not limited to, energy, environmental, civic infrastructure monitoring. The project teams will apply engineering design principles and critically examine sensor selection, sensor deployment, wireless communication, data quality, security and privacy as well as value proposition for IoT-based solutions. The key learning outcome of this course is that students will grasp how to develop IoT-based technological solutions and become competent in communicating how to use the IoT technology responsibly to create positive societal impact.
Prerequisites: MAE 3780 or ECE 3400.
Exploratory Studies: (CU-CEL, CU-SBY)

Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:
- Students will be able to develop IoT-based solutions to address community partners' specified needs.
- Students will be able to apply the principles of data security and data privacy in IoT designs.
- Students will be able to engage with community partners in designing the IoT-based solutions and communicate the designs effectively with community partners and peers in both verbal and written forms.
- Students will be able to evaluate the feasibility of the IoT-based solutions and articulate the potential improvement.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4230 - Intermediate Fluid Dynamics (3 Credits)
This course builds on the foundation of MAE 3230. The lectures emphasize on the physics and mathematical analysis of the subject. Topics include incompressible flows, compressible flows, and computational fluid dynamics. As an integral part of the course, you will learn numerical method and how to use ANSYS/Fluent to solve flow problems. The students will develop problem-solving skills, through which to cultivate an appreciation for the rich and complex structure of fluids, and appreciation for fundamental ideas in fluid dynamics.
Prerequisites: MAE 3230 or CEE 3310/BEE 3310, CHEME 3230.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to understand the derivation and physical meaning of the conservation equations.
- Students will be able to derive analytical solutions to simplified problems.
- Students will be able to understand the underlying models in ANSYS/FLUENT.
- Students will be able to apply ANSYS/FLUENT to solve a range of problems.
- Students will be able to understand numerical methods and the limitations of CFD.
- Students will be able to demonstrate the ability to design a component using CFD analysis in ANSYS/FLUENT.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4231 - Intermediate Fluid Dynamics (4 Credits)
This course builds on the foundation of MAE 3230. The lectures emphasize on the physics and mathematical analysis of the subject. Topics include incompressible flows, compressible flows, and computational fluid dynamics. As an integral part of the course, you will learn numerical method and how to use ANSYS/Fluent to solve flow problems. The students will develop problem-solving skills, through which to cultivate an appreciation for the rich and complex structure of fluids, and appreciation for fundamental ideas in fluid dynamics.
Prerequisites: MAE 3230 or CEE 3310/BEE 3310, CHEME 3230. Prerequisite or corequisite MAE 4300.
Enrollment Information: Enrollment limited to: seniors.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to understand the derivation and physical meaning of the conservation equations.
- Students will be able to derive analytical solutions to simplified problems.
- Students will be able to understand the underlying models in ANSYS/FLUENT.
- Students will be able to apply ANSYS/FLUENT to solve a range of problems.
- Students will be able to understand numerical methods and the limitations of CFD.
- Students will be able to demonstrate the ability to design a component using CFD analysis in ANSYS/FLUENT.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4240 - Materials Processing and Manufacturing (3 Credits)
Crosslisted with MSE 4510
How a material is made into its final form has great importance to its structure and therefore to its properties and performance. This course is aimed at giving students an understanding of the state-of-the-art material processing and manufacturing technologies as well as how these processes influence materials' microstructure and properties. With a unified approach this course will introduce the fundamentals of materials processing applied to metals, ceramics, and polymers. Different material processing routes from melt-based and powder-based processes to shape forming, joining, surface engineering and additive manufacturing will be discussed. Emphasis will be placed on the physics of the process as well as on how the processes will influence the properties of emerging materials and applications.
Prerequisites: ENGRD 2020 or ENGRD 2610.
Enrollment Information: Enrollment limited to: junior and senior students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Describe the physics of materials processes and manufacturing technologies.
- Identify and explain process-microstructure-property relationships for different materials processes.
- Design processing routes and justify process selection for a desired performance.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4272 - Fluids and Heat Transfer Laboratory (3 Credits)
Laboratory exercises in fluid mechanics and the thermal sciences. Measurements of flame temperature, pressure, heat transfer, viscosity, lift and drag, fluid-flow rate, effects of turbulence, airfoil stall, flow visualization, and spark ignition engine performance. Instrumentation, techniques and analysis, and interpretation of results. Biweekly written assignments with extensive feedback.
Prerequisites: MAE 3230, MAE 3240.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to experience in performing diverse experiments in fluid mechanics and the thermal sciences; extensive analysis of data.
- Students will be able to become familiar with instrumentation for fluids and thermal science experiments.
- Students will be able to experience in applying concepts from junior-year fluid mechanics and heat transfer classes.
- Students will be able to analyze experimental results and their uncertainties, and interpret them; and also to communicate these interpretations effectively.
- Students will be able to use graphics and words to present and discuss experimental results effectively.
- Students will be able to practice and feedback on Engineering Communication.
- Students will be able to experience working on a team to collect experimental data.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4291 - Supervised Senior Design Experience (3-4 Credits)
Substantial design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints. Sections of this course satisfy the BS ME senior design requirement. Sections are directed by a faculty member as an individual or a team design exercise. Students must first make individual arrangements with a faculty sponsor and then submit an enrollment form, available online at https://www.mae.cornell.edu/mae/programs/undergraduate-programs/undergraduate-forms. Once approved, students will receive an enrollment pin to enroll in MAE 4291.
Prerequisites: Prerequisite or corequisite: MAE 4300.
Enrollment Information: Enrollment limited to: seniors.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MAE 4300 - Engineers and Society (2 Credits)
This course aims to give students a broad grasp of the roles and responsibilities of engineers in contributing to societal well-being by integrating perspectives from sociocultural and humanistic studies with science and technology. The course will explore how the process of applying engineering principles can impact society, including environmental sustainability, diversity and equity, and ethics. Students will be familiarized with concepts related to engineering standards and regulations, sustainable development goals, sustainability reporting, community engagement, and the ethics and the governance of artificial intelligence. These concepts will then be used to explore the larger context of how social factors interact with engineering science and technology.
Prerequisites: Prerequisite or corequisite: M.E. Senior Design.
Enrollment Information: Enrollment limited to: seniors in MAE.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will identify how engineering principles and practices are interwoven with societal impact.
- Students will identify ways to foster scientific innovation that enhance positive social outcomes.
- Students will demonstrate competency in the fundamentals of community-engaged engineering and ethical reasoning.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4320 - Integrated Micro Sensors and Actuators: Bridging the Physical and Digital Worlds (4 Credits)
Crosslisted with ECE 4320
Introduction to micro and nano devices that allow the digital world to both sense and actuate in the physical world. Design and analysis of modern MEMS/NEMS (Micro/Nano Electromechanical Systems) touch, accelerometers, gyroscopes, pressure, microphones, neural probe sensors. Design and analysis of electrostatic, piezoelectric, thermal, and magnetic actuators for frequency control and micro robotic applications. This is an interdisciplinary course drawing from mechanics, materials, solid state devices, CMOS electronics, and micro and nano fabrication. The students design, fabricate, and test a microsensor chip to implement class concepts.
Prerequisites: ECE 2100 or equivalent, or permission of instructor.
Last Four Terms Offered: Fall 2024, Spring 2023, Spring 2022, Spring 2021
Learning Outcomes:

- Be able to design and model a digital app-based electronic interface to integrated sensors.
- Be able to model spring-mass equivalent models of micro/nano fabricated structures, using analysis and finite-element analysis software.
- Be able to use individual fabrication steps into a device fabrication process flow.
- Be able to design and model electromechanical models of planar surface micromachined accelerometers and gyroscopes.
- Be able to design membrane based sensors and actuators such as pressure monitors and microphones.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4341 - Innovative Product Design via Digital Manufacturing (4 Credits)
This hands-on/project-based course instructs students on methods to identify product concepts for machine designs with commercial potential. It combines lectures and field/lab activities on the new product development cycle: iterative design based on ethnographic fieldwork, team brainstorming, prototyping, testing/consumer feedback, and limitations set by mass manufacturing. Students -coming from diverse backgrounds and industry experience, and some currently working in different companies -will be teamed together to develop the new products.They will be given a common design challenge, and after observingand engagingwith real users, they will identify specific needs; then based on those needs each team will end up with a different problem definition and a different product. Industry advisersfrom real world companies will provide constant feedback throughout the semester.
Enrollment Information: Enrollment limited to: M.E. seniors.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to experience the major impact of a human-centered design approach.
- Students will be able to understand the logic of the product development cycle in the context of both a startup company and an established firm.
- Students will be able to appreciate the limitations of early-stage prototypes and the importance of staged development into more realistic prototypes.
- Students will be able to identify product platforms for mechanical design with commercial potential.
- Students will be able to appreciate Intellectual Property in terms of design and utility.
- The student will be able to acquire familiarity with basic tools of design and manufacturing, such as CAD and digital manufacturing tools.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4351 - Interdisciplinary Design Concepts (4 Credits)
This course emphasizes entrepreneurial driven technology designs (forward engineering) by integrating mechanical, chemical, and materials engineering through the understanding of early stage product development complexities. These complexities include staging invention and innovation via the critical selection of materials, assessing product mechanics and processes for final product function, performance, reliability, cost and technical marketability. Students will attend lectures, participate in establishing a Tech Startup integrated into the Johnson School MBA mentoring program, attend startup design reviews, give a series of individual/group presentations, and write a startup issue paper.
Enrollment Information: Enrollment limited to: seniors in MSE, CBE, or MAE.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 4360 - Design and Simulation of Multiphase Flow Systems (3 Credits)
This course will introduce fundamental concepts of multiphase flow physics and explain their relevance in natural and engineered systems of societal importance. In this course, multiphase refers both to a carrier fluid laden with particles or two immiscible phases like water and air. State-of-the-art scientific computing strategies for modeling multiphase flows are presented and deployed in a series of case studies in which students will use, manipulate, and modify advanced algorithms in order to quantitatively predict the complex, highly non-linear behavior of these flows.
Prerequisites: MAE 3230, knowledge in vector calculus, ordinary differential equations, partial differential equations, and proficiency in Matlab, Python or other scientific computing language.
Last Four Terms Offered: Spring 2024
Learning Outcomes:

- Students will be able to identify important non-dimensional numbers and physical processes in multiphase flows.
- Students will be able to formulate mathematical models for multiphase flows.
- Students will be able to select methods for computational modeling.
- Students will be able to develop solutions and interpret them in physical terms.
- Students will be able to explain what was learned in written and oral form.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4440 - Spacecraft Thermal Management (3 Credits)
This course will overview the physical princples governing existing spacecraft thermal management technologies, including conductive and radiative heat transfer, passive and active fluid transport, and ablation. One focus of the class is on thermal protection, which consists of materials and systems designed to protect spacecraft from extreme temperatures, particularly during atmospheric entry. Additionally, we discuss thermal control systems, which maintain all vehicle surfaces and compnents within an appropriate temperature range throughout all mission phases. Integral to the class is the reading and discussion of scientific research articles on the topics of spacecraft thermal control and protection.
Prerequisites: MAE 3230 and MAE 3240.
Last Four Terms Offered: Fall 2023
Learning Outcomes:

- Students will be able to identify flight paths and operating conditions corresponding to insulative versus ablative heat shields in thermal protection systems.
- Students will be able to identify the mechanisms (e.g., radiation, capillary forces, etc.) governing existing thermal control technologies.
- Students will be able to participate in reading and discussion of scientific research articles.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4441 - Spacecraft Thermal Management (4 Credits)
This course will overview the physical princples governing existing spacecraft thermal management technologies, including conductive and radiative heat transfer, passive and active fluid transport, and ablation. One focus of the class is on thermal protection, which consists of materials and systems designed to protect spacecraft from extreme temperatures, particularly during atmospheric entry. Additionally, we discuss thermal control systems, which maintain all vehicle surfaces and compnents within an appropriate temperature range throughout all mission phases. Integral to the class is the reading and discussion of scientific research articles on the topics of spacecraft thermal control and protection.
Prerequisites: MAE 3230 and MAE 3240.
Enrollment Information: Enrollment limited to: M.E. seniors or permission of instructor.
Last Four Terms Offered: Fall 2023
Learning Outcomes:

- Students will be able to identify flight paths and operating conditions corresponding to insulative versus ablative heat shields in thermal protection systems.
- Students will be able to identify the mechanisms (e.g., radiation, capillary forces, etc.) governing existing thermal control technologies.
- Students will be able to participate in reading and discussion of scientific research articles.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4450 - Additive Manufacturing: Process Physics, Materials, Properties and Post Processing (3 Credits)
In this course, we'll start by covering the fundamentals of additive manufacturing (AM), introducing you to various techniques like extrusion, powder bed fusion, photopolymerization, material jetting, binder jetting, direct energy deposition, and laminated object manufacturing. You will also explore the crucial post-processing steps that enhance the quality and functionality of 3D printed objects. We'll also dive into the compatibility of materials with each AM process, enabling you to make informed material choices for your specific projects. Throughout the course, you'll develop the expertise to select the most suitable AM technique for various design challenges and manufacturing problems, optimizing efficiency and cost-effectiveness. Real-world case studies from diverse industries will provide practical insights, helping you analyze project strengths and weaknesses and apply this knowledge to future applications. This course offers an accessible gateway to the exciting world of additive manufacturing.
Prerequisites: MAE 2250, MAE 3230, MAE 3270. Corequisite: MAE 3240.
Last Four Terms Offered: Spring 2024
Learning Outcomes:

- The student will describe the fundamentals of extrusion, powder bed fusion, photopolymerization, material jetting, binder jetting, direct energy deposition, and laminated object manufacturing.
- The student will examine the mechanical properties of 3D printed components and investigate the underlying factors contributing to disparities when compared to identical materials manufactured using traditional production methods.
- The student will identify post processing steps for each additive manufacturing process.
- The student will identify materials that are compatible with each additive manufacturing process.
- The student will select the appropriate additive manufacturing technique for a specific design or manufacturing problem.
- The student will analyze case studies of real-world additive manufacturing projects and identify their strengths and weaknesses.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4480 - Biomechanics Laboratory (3 Credits)
Crosslisted with BME 4490
This course focuses on mastering experimental techniques related to measuring the mechanical behavior of biomedical materials and biological tissues. Students will learn techniques for measuring mechanical properties of cardiovascular and musculoskeletal tissues in tension, compression, shear, and bending. Students will learn to apply non-linear models to describe the behavior of elastic, viscoelastic, poroelastic, and hyperelastic materials.
Prerequisites: BME 3410 or BME 3210 or permission of instructor.
Enrollment Information: Enrollment preference given to: Biomedical Engineering majors.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 4510 - Propulsion of Aircraft and Rockets (3 Credits)
Introduction to air and rocket propulsion. Emphasis on air-breathing gas-turbines. Chemical rocket propulsion. Brief discussion of of ramjets and of propellers. Application of thermodynamic and fluid-mechanical principles to analysis of performance and design, including fuel efficiency and environmental impacts.
Prerequisites: ENGRD 2210/MAE 2210 and MAE 3230 or equivalents. Recommended prerequisite: MAE 3050.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to describe and interpret the types, characteristics, and performance measures of combustion engines used in propulsion.
- Students will be able to apply thermodynamic and fluid mechanical principles to quantitatively describe engine operation.
- Students will be able to predict how their performance depends on design parameters and operating conditions.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4530 - Computer-Aided Engineering: Applications to Biological Processes (3 Credits)
Crosslisted with BEE 4530
Introduction to simulation-based design as an alternative to prototype-based design; modeling and optimization of complex real-life processes for design and research, using industry-standard physics-based computational software. Emphasis is on problem formulation, starting from a real process and developing its computer model. Modeling application (project) can be biomedical (thermal therapy and drug delivery) or broader biological and bioenvironmental applications that involve heat transfer, mass transfer, and fluid flow. Computational topics introduce the finite-element method, model validation, pre- and post-processing, and pitfalls of using computational software. Students choose their own semester-long project, which is a major part of the course (no final exam).
Prerequisites: BEE 3500 or MAE 3240 or CHEME 3240 or equivalent.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will improve their ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (ABET 1).
- Students will demonstrate improved ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as relevant global, cultural, social, environmental and economic factors (ABET 2).
- Students will display an ability to communicate effectively with a range of audiences (ABET 3).
- Students will demonstrate an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements which consider the impact of engineering solutions in global, economic, environmental, and societal contexts (ABET 4).
- Students will demonstrate an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives (ABET 5).
- Students will demonstrate the ability to acquire and apply new knowledge as needed, using appropriate learning strategies (ABET 7).
- Students will improve their capacity to integrate modern biology with engineering principles (ABET-BE).

Schedule of Classes (https://classes.cornell.edu/)

MAE 4540 - Propulsion of Spacecraft (3 Credits)
This course provides the contextual and physical framework to understand and design space propulsion devices for orbiting spacecraft and satellite systems. An introduction to the basic principles of propulsion and performance metrics in the context of space missions are presented. Key physics underlying the operation of propulsion devices are covered. Specifically, the design and performance of ion engines, Hall thrusters, electrospray thrusters, and emerging propulsion concepts are covered.
Prerequisites: Prerequisite or corequisite: undergraduate-level coursework in thermodynamics, electromagnetism, and orbital mechanics.
Last Four Terms Offered: Fall 2024, Fall 2023, Spring 2023, Fall 2021
Learning Outcomes:

- Students will be conversant across the range of propulsion options for space missions.
- Students will be able to describe the physics underlying their operation and performance limits.
- Students will be able to use their knowledge of propulsion physics and mission context to create or evaluate new designs.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4580 - Introduction to Nuclear Science and Engineering (3 Credits)
Crosslisted with ECE 4130, CHEME 4130, AEP 4130
Introduces the fundamental concepts of nuclear science and engineering, including nuclear structure, radioactivity, nuclear reactions and the interaction of neutrons, charged particles, x-rays and gamma-rays with matter. Discusses the neutron chain reaction and its control in the core of a fission reactor. Different reactor designs are introduced and discussed along with their safety features. Other topics include radiation shielding and aspects of the nuclear fuel cycle, including isotope separation, fuel reprocessing, waste disposal and sustainability
Prerequisites: PHYS 2214 and MATH 2940.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2020, Fall 2019
Learning Outcomes:

- Demonstrate basic conceptual understanding of atomic and nuclear physics, quantum mechanics and electrostatics relevant to the interaction of radiation with matter, and especially neutron interactions.
- Demonstrate a basic understanding o the fission process and neutron chain reactions.
- Know and understand the advantages and disadvantages of various combinations of fuel and other materials (moderator, coolant, structure) for safety and sustainability.
- Understand the design and operation of a nuclear reactor core as a critical or near critical mass of fissile and other materials in steady state and in times of slowly changing power.
- Demonstrate the ability to calculate the amount of fuel needed by a power reactor per year as well as the amount of nuclear waste that will be produced and its decay rate.
- Know and understand the interaction of radiation with biological systems and the consequences thereof, and methods of shielding to reduce radiation effects.
- Understand case histories of nuclear reactor accidents.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4590 - Introduction to Controlled Fusion: Principles and Technology (3 Credits)
Crosslisted with ECE 4840, AEP 4840
Introduction to the physical principles and various engineering aspects underlying power generation by controlled fusion. Topics include: fuels and conditions required for fusion power and basic fusion-reactor concepts, fundamental aspects of plasma physics relevant to fusion plasmas and basic engineering problems for a fusion reactor, and an engineering analysis of proposed magnetic and/or inertial confinement fusion-reactor designs.
Enrollment Information: Recommended prerequisite: one of the following: PHYS 1112, PHYS 2213, PHYS 2214, or equivalent background in electricity and magnetism and mechanics.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Understand the scientific basis for controlled fusion by both magnetic confinement and inertial confinement approaches, as well as the technological requirements for practical electric power generation by the controlled fusion process.
- Be able determine the energy release of any nuclear reaction or reaction chain using the mass-energy relationship, and be able to solve well-posed engineering problems in plasma physics as applied to controlled fusion using Maxwell's equations and the equations of motion of charged particles in electric and magnetic fields.
- Be able to solve well-posed engineering problems in energy generation by controlled fusion having to do with the properties of materials in the presence of neutron irradiation and other relevant processes.
- Understand the fundamental role played by energy in our society and in the developing world, the potential role fusion can play, and the reasons that it is potentially more attractive than fission-based electric power generation.
- Be able to determine the state-of-the-art of different aspects of fusion reactor design by independent study using books, journals, conference proceedings, reports on the web and personal communication with experts.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4610 - Entrepreneurship for Engineers (3 Credits)
Crosslisted with ORIE 4152, ENGRG 4610
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 4630 - Advanced Product Design (3 Credits)
This hands-on course instructs on strategies to invent - make - and disseminate products that solve an identified need. These products can be consumer, enterprise, research, for profit or non-profit. The lectures will primarily be discussion based on assigned readings and tasks, and guest lectures from domain experts. This course combines lectures and field/lab activities on the new product development cycle: invention based on bioinspiration, iterative design based on customer discovery, team brainstorming, prototyping, testing/consumer feedback, and manufacturing innovation.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2021
Learning Outcomes:

- Students will be able to experience the major impact of a human-centered design approach.
- Students will be able to understand the importance of managing interfaces between subsystems in prototype development.
- Students will be able to identify product platforms for mechanical design with commercial potential.
- Students will be able to gain appreciation of Intellectual Property in terms of design and utility.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4631 - Advanced Product Design (4 Credits)
This hands-on course instructs on strategies to invent - make - and disseminate products that solve an identified need. These products can be consumer, enterprise, research, for profit or non-profit. The lectures will primarily be discussion based on assigned readings and tasks, and guest lectures from domain experts. The course combines lectures and field/lab activities on the new product development cycle: invention based on bioinspiration, iterative design based on customer discovery, team brainstorming, prototyping, testing/consumer feedback, and manufacturing innovation.
Enrollment Information: Enrollment limited to: MAE seniors.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2021
Learning Outcomes:

- Students will be able to experience the major impact of a human-centered design approach.
- Students will be able to understand the importance of managing interfaces between subsystems in prototype development.
- Students will be able to identify product platforms for mechanical design with commercial potential.
- Students will be able to appreciation of Intellectual Property in terms of design and utility.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4640 - Orthopaedic Tissue Mechanics (3 Credits)
Crosslisted with BME 4640
Application of mechanics and materials principles to orthopaedic tissues. Physiology of bone, cartilage, ligament, and tendon and the relationship of these properties to their mechanical function. Mechanical behavior of skeletal tissues. Functional adaptation of these tissues to their mechanical environment. Tissue engineering of replacement structures.
Prerequisites: ENGRD 2020 and MAE 3270.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2021, Spring 2019
Learning Outcomes:

- Students will be able to know and understand the function and physiology of bone, cartilage, tendon and ligament as organs and tissue.
- Students will be able to apply strength of materials concepts to the mechanical behavior of musculoskeletal tissues and organs.
- Students will be able to understand the unique adaptive capacity of musculoskeletal tissues to their mechanical environment.
- Students will be able to integrate and interpret biological data and mechanical engineering concepts.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4641 - Orthopaedic Tissue Mechanics (4 Credits)
Application of mechanics and materials principles to orthopaedic tissues. Physiology of bone, cartilage, ligament, and tendon and the relationship of these properties to their mechanical function. Mechanical behavior of skeletal tissues. Functional adaptation of these tissues to their mechanical environment. Tissue engineering of replacement structures. Senior design report required.
Prerequisites: ENGRD 2020 and MAE 3270. Prerequisite or corequisite: MAE 4300.
Enrollment Information: Enrollment limited to: seniors.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2021, Spring 2019
Learning Outcomes:

- Students will be able to know and understand the function and physiology of bone, cartilage, tendon and ligament as organs and tissues.
- Students will be able to apply strength of materials concepts to the mechanical behavior of musculoskeletal tissues and organs.
- Students will be able to understand the unique adaptive capacity of musculoskeletal tissues to their mechanical environment.
- Students will be able to integrate and interpret biological data and mechanical engineering concepts.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4650 - Biofluid Mechanics (3 Credits)
Crosslisted with BME 4410
Prerequisites: ENGRD 2020 and ENGRD 2202 or MAE 3230 or equivalents, or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2022, Fall 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

MAE 4660 - Biomedical Engineering Analysis of Metabolic and Structural Systems (3 Credits)
Crosslisted with BME 4010
This course focuses on applying techniques of engineering analysis to quantify function and dysfunction of human physiologic systems. Thematic areas include the cardiovascular, respiratory, musculoskeletal, and renal systems. Emphasis will be placed on developing mathematical models to understand function and dysfunction across tissue scales, and implementing these with experimental data to make biomedical engineering judgments.
Prerequisites: ENGRD 2020, MATH 2930, BIOMG 1350 and BME 2010 or BIOG 1440.
Enrollment Information: Enrollment preference given to: Biomedical Engineering majors.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 4670 - Polymer Mechanics (3 Credits)
This course will provide foundations of polymer mechanics building from the basics of mechanics of materials. The focus will be split between experimental methods/data interpretation and modeling approaches. Topics will include hyper-elasticity, viscoelasticity, glass transition temperature, and plasticity with applications to both synthetic and biological materials. There will also be a scientific literature reading component through which students will be able to pick their own focus areas in the latter part of the semester.
Prerequisites: ENGRD 2020 and MAE 3270, or MSE 2610.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- The student will be able to classify polymers into different regimes of behavior and explain their microstructural origin.
- The student will be able to analyze and interpret data from key experimental methods for polymer thermo-mechanical properties.
- The student will be able to describe, computationally implement, and find parameters for models that describe key aspects of polymer and gel mechanical behavior.
- The student will be able to explain how the thermo-mechanical properties of natural and synthetic polymers are central to applications of interest to the student.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4671 - Polymer Mechanics (4 Credits)
This course will provide foundations of polymer mechanics building from the basics of mechanics of materials. The focus will be split between experimental methods/data interpretation and modeling approaches. Topics will include hyper-elasticity, viscoelasticity, glass transition temperature, and plasticity with applications to both synthetic and biological materials. There will also be a scientific literature reading component through which students will be able to pick their own focus areas in the latter part of the semester.
Prerequisites: ENGRD 2020 and MAE 3270, or MSE 2610.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- The student will be able to classify polymers into different regimes of behavior and explain their microstructural origin.
- The student will be able to analyze and interpret data from key experimental methods for polymer thermo-mechanical properties.
- The student will be able to describe, computationally implement, and find parameters for models that describe key aspects of polymer and gel mechanical behavior.
- The student will be able to explain how the thermo-mechanical properties of natural and synthetic polymers are central to applications of interest to the student.

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MAE 4700 - Finite Element Analysis for Mechanical and Aerospace Design (4 Credits)
Introduction to linear finite element static analysis for discrete and distributed mechanical and aerospace structures. Prediction of load, deflection, stress, strain, and temperature distributions. Major emphasis on underlying mechanics and mathematical formulation. Introduction to computational aspects via educational and commercial software (such as MATLAB and ANSYS). Selected mechanical and aerospace applications in the areas of trusses, beams, frames, heat transfer, and elasticity. A selection of advanced topics such as dynamic modal analysis, transient heat transfer, or design optimization techniques may also be covered, time permitting.
Enrollment Information: Enrollment limited to: seniors.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to recall, identify, and analyze the mathematical and physical principles underlying the FEM as applied to solid mechanics, thermal analysis and select aspects of fluid mechanics.
- Students will be able to develop their own FEM computer programs, for mathematically simple but physically challenging problems, in MATLAB.
- Students will be able to compare FEM results obtained with MATLAB with those obtained from ANSYS. Analyze more complex problems (in solid mechanics or thermal analysis) using the commercial FEM code ANSYS.
- Students will be able to demonstrate the ability to design a component using FEM analysis (both MATLAB AND ANSYS).
- Students will be able to make clear and effective technical presentations, both in terms of form as well as content, of his/her work and write clear technical reports describing his/her work.

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MAE 4721 - Advanced Applications of Finite Element Analysis Using Ansys (3 Credits)
This course prepares students to solve industry-relevant problems in structural mechanics and dynamics using Ansys simulation software. This is a problem-based course where students will learn finite-element applications by solving practical problems involving realistic 3D CAD geometries. Applications considered include pressure vessel stress analysis, wind turbine blade buckling, turbine disk vibration, electronics enclosure dynamics and robot arm motion. The focus will be on developing a strong conceptual understanding of what's inside the simulation blackbox so as to move beyond garbage-in, garbage-out. Verification and validation of simulation results is emphasized throughout. Rigid-body dynamics applications will also be covered. Concepts, solution approaches and best practices learned will be applicable to the use of other industry-standard simulation software. Suitable for both on-campus and distance learning students.
Prerequisites: MAE 4700, MAE 4701, and MAE 5700.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Create reliable static and dynamic simulations of structures using Ansys software for a range of industrial-level problems.
- Explain the mathematical model underlying each simulation including governing equations, boundary conditions, physical principles and assumptions.
- Explain the numerical solution strategy used to solve the mathematical model and how to reduce the numerical errors introduced.
- Defend simulation results by undertaking a verification and validation procedure.

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MAE 4730 - Intermediate Dynamics (3 Credits)
The course emphasizes the classical dynamics of single- and multi-degree-of-freedom systems made up of particles, rigid-objects in 2 and 3 special dimensions. Three approaches are used: the Newton-Euler and Lagrangian approach, both using minimal coordinates, and also a 'maximal coordinate' approach using differential algebraic equations (DAEs). The course emphasizes finding equations of motion, solving them analytically (if possible) and numerically; and graphical presentation of solutions, including animations.
Prerequisites: MATH 2940 or equivalent.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- The student will be able to locate the governing equations of motion for a variety of dynamic mechanical systems consisting of particles and rigid objects that might interact with various standard connections (e.g., strings, springs, hinges, rolling, surface sliding) and forces (e.g., gravity, friction, fluid drag).
- The student will be able to solve the simple cases by hand, solve the more complex cases with numerical integration (Matlab), graphically represent the results, including animations.
- The student will be able to check the reasonableness of the results using extreme cases and Laws of Conservation (momentum, angular momentum and energy).
- The student will be able to use principles of Lagrangian mechanics to develop the same governing equations as above for simple conservative systems.
- The student will be able to formulate, setup, numerically solve, and interpret the equations and solutions of a 3D rigid object rotating in space.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4750 - Special Intersession Elective (1-4 Credits)
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MAE 4760 - Foundations of Robotics (4 Credits)
Crosslisted with CS 4750, ECE 4770
Robotics is interdisciplinary and draws inspiration from many different fields towards solving a variety of tasks in real-world environments using physical systems. This course is a challenging introduction to basic computational concepts used broadly in robotics. By the end of this course, students should have a fundamental understanding of how the different sub-fields of robotics such as kinematics, state-estimation, motion planning, and controls come together to develop intelligent behaviors in physical robotic systems. The mathematical basis of each area will be emphasized, and concepts will be motivated using common robotics applications. Students will be evaluated using a mixture of theoretical and programming exercises throughout the semester.
Prerequisites: CS 1112, CS 2110, CS 2800, MATH 1920, MATH 2940 or their equivalents.
Distribution Requirements: (SMR-AS)
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
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MAE 4770 - Engineering Vibrations (3 Credits)
The course covers the free and forced response of vibrating mechanical systems modeled as having one, two and several degrees of freedom, as well as models of continuous structures such as beams.
Prerequisites: MAE 3260.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to be proficient at modeling vibrating mechanical systems.
- Students will be able to perform analysis such as systems characterization and modeling of SDOF and MDOF systems.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4780 - Feedback Control Systems (4 Credits)
This course covers the analysis and design of linear feedback systems in both the frequency and time domains. The course includes a laboratory that examines modeling and control of representative dynamic processes. The frequency domain aspects are analyzed via Laplace transforms, transfer functions, root locus, and frequency response methods. The time domain aspects are analyzed via state space models, stability, controllability, observability, state feedback, and observers.
Prerequisites: CHEME 3720 or MAE 3260.
Last Four Terms Offered: Spring 2025, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to obtain the linearization of a non-linear system about an operating point.
- Students will be able to construct a transfer function representation of a linear dynamical system.
- Students will be able to manipulate block diagrams and transfer functions.
- Students will be able to understand the relationship between a linear system and its frequency response, and know how to construct a Bode plot.
- Students will be able to know how to design traditional controllers such as Proportional, Integral, Derivate (PID), and Lead-Lag.
- Students will be able to understand the concepts of stability, including gain and phase margins and Nyquist stability condition.
- Students will be able to design control systems in the frequency domain using state space and Bode/Nyquist techniques.
- Students will be able to design control systems in the time domain using state space and Root Locus techniques.
- Students will be able to analyze control systems using Root Locus techniques.
- Students will be able to apply the tools learned in the class to physical problems.

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MAE 4810 - Robot Perception (3 Credits)
Crosslisted with ECE 4240
An introductory course to robot perception techniques for modeling and planning heterogeneous and dynamic sensor measurements, and for processing the sensor feedback in the context of robot motions and environments. Methods for intelligent sensor fusion and robot perception in motion will be covered in detail in this course. Topics in artificial vision, acoustic propagation, and filtering will be discussed along with related algorithms inspired by neural networks, Bayesian networks, and information theory. Sensing problems and performance will be investigated in regard to benchmark problems, such as coverage, target search, target tracking, and treasure hunting, will be covered in-depth and demonstrated through applications drawn from environmental monitoring, sensing-and-pursuit games, surveillance, and human-robot interactions.
Prerequisites: ENGRD 2112, MATH 2940, and MATH 4710 (or ENGRD 2700 or ENGRD 2720); or graduate standing in a technical field.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2021
Learning Outcomes:

- Students will be able to use methods for sensor fusion to inform robot perception.
- Students will be able to implement artificial vision, acoustic propagation, and filtering along with neural networks, Bayesian algorithms, and information theory to identify robot states.
- Students will be able to analyze benchmark problems such as coverage, target search, target tracking, and treasure hunting.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4850 - Special Technical Elective (1-4 Credits)
Special offering providing technical depth and/or breadth beyond the required engineering common curriculum, in an applications area or discipline with connections to engineering. This course number is used for courses that are not a permanent part of the curriculum.
Enrollment Information: Enrollment limited to: Engineering sophomores, juniors, and seniors.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 4860 - Automotive Engineering (3 Credits)
Selected topics in the analysis and design of vehicle components and vehicle systems. Emphasis on automobiles. Engines, transmissions, suspension, brakes, and aerodynamics are discussed. The course uses first principles and applies them to specific systems. The course is highly quantitative, using empirical and analytical approaches.
Prerequisites: MAE 2030 and ENGRD 2210.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to explain the fundamental concepts of intake air flow and valves for internal combustion spark ignition engines.
- Students will be able to perform calculations using efficiencies and fuel flow to estimate power and torque developed by IC engines.
- Students will be able to perform calculations estimating the power developed with turbochargers and superchargers
- Students will be able to calculate the engine power and torque required to operate a vehicle under various loads.
- Students will be able to estimate braking performance given the parameters of the vehicle.
- Students will be able to calculate the stability and performance of vehicles with specified suspension geometries.
- Students will be able to calculate steering and ride performance, given vehicle parameters.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4861 - Automotive Engineering (4 Credits)
Selected topics in the analysis and design of vehicle components and vehicle systems. Emphasis on automobiles. Engines, transmissions, suspension, brakes, and aerodynamics are discussed. The course uses first principles and applies them to specific systems. The course is highly quantitative, using empirical and analytical approaches. Senior Design report required.
Prerequisites: MAE 2030 and ENGRD 2210. Prerequisite or corequisite: MAE 4300.
Enrollment Information: Enrollment limited to: seniors.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to explain the fundamental concepts of intake air flow and valves for internal combustion spark ignition engines.
- Students will be able to perform calculations using efficiencies and fuel flow to estimate power and torque developed by IC engines.
- Students will be able to perform calculations estimating the power developed with turbochargers and superchargers.
- Students will be able to calculate the engine power and torque required to operate a vehicle under various loads.
- Students will be able to estimate braking performance given the parameters of the vehicle.
- Students will be able to calculate the stability and performance of vehicles with specified suspension geometries.
- Students will be able to calculate steering and ride performance, given vehicle parameters.

Schedule of Classes (https://classes.cornell.edu/)

MAE 4900 - Individual and Group Projects in Mechanical Engineering (1-4 Credits)
Individual or group study or project for students who want to pursue a particular analytical, computational, or experimental investigation outside of regular courses or for informal instruction supplementing that given in regular courses. An engineering report on the project is required of each student. Students are expected to spend 3-4 hours per week per credit hour working on the project. Students must first make individual arrangements with a faculty sponsor and then submit an enrollment form, available online at https://www.mae.cornell.edu/mae/programs/undergraduate-programs/undergraduate-forms. Once approved, students will receive an enrollment pin to enroll in MAE 4900.
Enrollment Information: Enrollment limited to: sophomores, juniors, or seniors.
Exploratory Studies: (CU-UG)

Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MAE 4950 - Special Major-Approved Elective (3-4 Credits)
Special offering providing depth and/or breadth beyond the required mechanical engineering curriculum, in an applications area or discipline with connections to mechanical engineering. This course number is used for courses that are not a permanent part of the curriculum.
Enrollment Information: Enrollment limited to: Engineering sophomores, juniors, and seniors.
Last Four Terms Offered: Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 4980 - Teaching Experience in Mechanical Engineering (1-3 Credits)
Students serve as teaching assistants in Cornell Mechanical Engineering classes or in local middle school technology classes.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MAE 4998 - International Research Internship (1-12 Credits)
Off-campus internship in which students gain experience in mechanical and/or aerospace engineering.
Last Four Terms Offered: Fall 2023, Summer 2023, Spring 2023, Fall 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 5010 - Future Energy Systems (3 Credits)
Critically examines the technology of energy systems that will be acceptable in a world faced with global climate change, local pollution, and declining supplies of oil. The focus is on renewable energy sources (wind, solar, biomass), but other non-carbon-emitting sources (nuclear) and lowered-carbon sources (co-generative gas turbine plants, fuel cells) also are studied. Both the devices and the overall systems are analyzed. The course explains calculations to support capacity, efficiency, and productivity of renewable energy. Cost and economics of renewables are explored as well, along with the connection to U.S. and global climate and energy policy.
Prerequisites: ENGRD 2210 or equivalent. Recommended prerequisite: MAE 3230, MAE 3240, or equivalents.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021
Learning Outcomes:

- Students will be proficient in engineering calculations of the performance and rudimentary design of various energy conversion systems.
- Students will be able to become familiar with the physics of the environmental issues, including the greenhouse effect and global climate change.
- Students will be adept in the comparative analysis of various energy conversion systems. The comparisons will include cost, social acceptability as well as environmental consequences.

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MAE 5020 - Wind Power (3 Credits)
Main features of energy conversion by wind turbines. Emphasis on characterization of the atmospheric boundary layer, aerodynamics of horizontal axis wind turbines, and performance prediction. Structural effects, power train considerations, siting and wind farm planning, offshore.
Prerequisites: MAE 3230 (or equivalent) or MAE 3050, MAE 3270.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Learning Outcomes:

- Students will be able to understand the need for carbon-free energy production and the functions of wind turbines.
- Students will be able to calculate mean wind fields.
- Students will be able to analyze the aerodynamics of wind turbine blades.
- Students will be able to predict efficiency of energy extraction.
- Students will be able to understand the basics of electrical generators and mechanical to electrical energy conversion.
- Students will be able to know how to choose sites for turbines and wind farms.

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MAE 5065 - Introduction to Spaceflight Mechanics (3 Credits)
Introduction to spacecraft orbit mechanics, attitude dynamics, and the design and implementation of spaceflight maneuvers for satellites, probes, and rockets. Topics in celestial mechanics include orbital elements, types & uses of orbits, coordinate systems, Kepler's equation, the restricted three-body problem, interplanetary trajectories, the rocket equation and staging, Clohessy-Wiltshire equations and relative formation flight, drag and orbital decay, and propulsive maneuvers. Topics in attitude dynamics include kinematics, Euler's equations, stability of spinning spacecraft, attitude perturbations such as gravity-gradient and magnetic torques, equations of motion of rigid spacecraft with momentum actuators and thrusters, attitude maneuvers such as nutation control and reorientation, low-speed fluid behaviors, and elementary feedback control of linearized attitude and orbit dynamics. Principles of spacecraft propulsion technology and attitude-control technology are introduced along with the rocket equation and staging. The course includes discussions of current problems and trends in spacecraft operation and development.
Prerequisites: MATH 2930, MATH 2940, and MAE 2030.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to understand the fundamentals of spaceflight mechanics and how high-level mission requirements drive the design of orbits and attitude for contemporary spacecraft.
- Students will be able to understand the application of Kepler's laws for orbital motion, how to propagate an orbit, and calculate parameters associated with mission operations, including launch, insertion, and interplanetary transfers.
- Students will be able to understand the application of Euler's equations for rigid-body motion to spacecraft dynamics, attitude representations, attitude kinematics, how to predict and model spacecraft attitude motions, and how to achieve desirable attitude-dynamics behaviors.
- Students will be able to simulate a spacecraft in orbit using state of the art tools and identify and characterize the astrodynamics capabilities of a preliminary spacecraft design.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5070 - Dynamics of Flight Vehicles (3 Credits)
Introduction to stability and control of atmospheric-flight vehicles. At the end of the course, students will be able toderive from first principles the differential equations governing the motion of flight vehicles, formulate appropriate simplifying assumptions, solve for the aircraft motion through analytical or numerical means, analyze the static and dynamic stability properties of a given aircraft, and explain expected aircraft piloting behaviors through rigorous engineering reasoning.
Prerequisites: MAE 3050, MAE 3230. Corequisite: MAE 3260.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Fall 2021
Learning Outcomes:
- Students will understand the nature of aerodynamic forces and moments (aerodynamic stability derivatives) in determining the motions of a flight vehicle.
- Students will understand the various terms in the equations of motion and the simplifications arising from assumptions of small disturbances from equilibrium flight and from the bi-lateral symmetry of most aircraft.
- Students will be able to identify, formulate and solve engineering problems in aircraft flight dynamics.
- Students will understand the principal constraints imposed on aircraft design by stability and controllability requirements.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5130 - Mechanical Properties of Thin Films (3 Credits)
Crosslisted with MSE 5120
Last Four Terms Offered: Spring 2021, Spring 2019, Spring 2017, Spring 2015
Schedule of Classes (https://classes.cornell.edu/)

MAE 5135 - Mechanics of Composite Structures (4 Credits)
Covers the fundamentals of mechanical analysis and material selection for composite materials. Topics include an overview of composite types, advantages, applications and fabrication; anisotropic elasticity; specific composite constitutive equations including plane stress and lamination theory; failure analysis; boundary value problems using composite materials; experimental methods and an introduction to micromechanics. Lectures cover essential background material and theoretical developments. Labs provide hands-on experiences for understanding composite materials properties and performance.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:
- Students will be able to understand the advantages, the potential applications associated with several classes of composite materials.
- Students will be able to conduct critical mechanical analyses associated with the deformation and failure of composites accounting specifically for stiffness and strength anisotropy.
- Students will be able to understand mechanical tests employed to measure composite elastic moduli and strength.
- Students will be able to properly select composite materials for mechanical designs.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5150 - GPS: Theory and Design (4 Credits)
Analysis of GPS operating principles and engineering practice with a culminating design exercise. GPS satellite orbital dynamics, navigation data modeling, position/navigation/timing solution algorithm, receiver and antenna characteristics, analysis of error and accuracy, differential GPS.
Prerequisites: 3000-level engineering course with advanced math content (e.g. ECE 3030 or MAE 3260).
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2020, Spring 2018
Learning Outcomes:
- Students will be able to develop an understanding of orbital mechanics with non-Keplerian perturbations and reference frames adequate to calculate GPS satellite positions in absolute and local coordinates.
- Students will be able to use to use the GPS observables, their physical models, and the multi-variable version of Newton's nonlinear equation-solving method to calculate a navigation solution and a velocity solution.
- Students will be able to gain an understanding of the sources of ranging errors and how they map to navigation errors.
- Students will be able to collect raw GPS data in a laboratory environment, to analyze its properties, including its noise properties, and to use it to derive useful position, navigation, timing, and velocity information.
- Students will be able to implement an advanced analysis or design solution to a GPS problem, test it experimentally, and effectively communicate the results in a final report.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5160 - Spacecraft Technology and Systems Architecture (4 Credits)
This course is a survey of contemporary space technology from subsystems through launch and mission operations, all in the context of spacecraft and mission design. It focuses on the classical subsystems of robotic and human-rated spacecraft, planetary rovers, and other space vehicles, as well as on contemporary engineering practice. This course includes an in-depth design activity suitable for MEng students. Topics covered include subsystem technologies and the systems-engineering principles that tie them together into a spacecraft architecture. Subsystem technologies discussed include communications, thermal subsystems, structure, spacecraft power, payloads (remote sensing, in-situ sensing, human life support), entry/descent/landing, surface mobility, and flight-computer hardware and software. The final project consists of architecting a complete spacecraft system with appropriate subsystems, with designs supported by parametric analysis and simulation.
Prerequisites: MAE 3260 and MAE 4060.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to understand, at a higher systems level, space missions and systems, and how the space environment and mission requirements drive spacecraft design.
- Students will be able to understand the basic fundamentals of spacecraft subsystems, including propulsion, attitude determination and control, power, structures, thermal, communications, and command and data handling.
- Students will be able to understand typical practices for designing space systems in a contemporary context of US commercial space and government agencies.
- Students will be able to simulate a spacecraft in operation at the level of a Preliminary Design Review (PDR) using state of the art tools, and identify and characterize subsystems for a preliminary spacecraft design.

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MAE 5180 - Autonomous Mobile Robots (4 Credits)
Crosslisted with ECE 5772, CS 5758
Creating robots capable of performing complex tasks autonomously requires one to address a variety of different challenges such as sensing, perception, control, planning, mechanical design, and interaction with humans. In recent years many advances have been made toward creating such systems, both in the research community (different robot challenges and competitions) and in industry (industrial, military, and domestic robots). This course gives an overview of the challenges and techniques used for creating autonomous mobile robots. Topics include sensing, localization, mapping, path planning, motion planning, obstacle and collision avoidance, and multi-robot control.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2022, Spring 2021
Learning Outcomes:

- Students will be able to understand and implement localization and mapping algorithms using different sensor modalities.
- Students will be able to generate a path and the motion for a robot moving around an area with obstacles.
- Students will be able to understand and implement the concepts of different approaches for motion planning such as roadmaps, feedback control, and sampling based methods.
- Students will be able to apply the tools learned in the class to physical robots.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5190 - Fast Robots (4 Credits)
Crosslisted with ECE 5160
The course focus is on systems level design and implementation of fast and dynamic autonomous robots. With the recent DIY movement, design of kinematic robots is largely becoming a software challenge. In dynamic robots, however, any latency or noise can be detrimental. We will design a fast autonomous car, explore dynamic behaviors, acting forces, sensors, and reactive control on an embedded processor, as well as the benefit of partial off-board computation. Students will learn how to derive design specifications from abstract problem descriptions and gain familiarity with rapid prototyping techniques, system debugging, system evaluation, and online dissemination of work.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Students will learn how to robustly integrate systems consisting of electronics, software, and mechanics operating in the real world.
- Students will learn how to translate probabilistic control and planning methods to practical robots with hardware and processing constraints.
- Students will learn how to disseminate their work to their peers and an engineering audience.
- Students will learn how to predict the likely social and environmental effects of their design.

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MAE 5210 - Dimensional Tolerancing in Mechanical Design (1 Credit)
Designers use dimensional tolerances to limit spatial variations in mechanical parts and assemblies; the goals are interchangeability in assembly, performance, and cost. This course covers traditional limit tolerances briefly, but focuses mainly on modern geometric tolerances and their role in assembly control. Students learn how to represent assemblies in terms of mating and relational constraints, and how to design tolerances for relatively simple parts and assemblies.
Prerequisites: MAE 2250 or equivalent CAD-based design course, plus 2.5 years of engineering mathematics through probability and statistics.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:
- The student will be able to identify limitations of traditional limit tolerancing.
- The student will be able to read and interpret the symbols, dimensions, and tolerances on mechanical drawings.
- The student will be able to understand design intent based on mechanical design.
- The student will be able to understand the basics of tolerance stack-up analyses.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5220 - Introduction to Internet of Things - Technology and Engagement (4 Credits)
This interdisciplinary design course aims to provide a holistic introduction to Internet of Things (IoT) and train students on the core technological and communication skills through community engagement and working on real-world applications. IoT has become an enabler for new economic activities and provides potentially cost-effective solutions to a wide range of societal challenges. Students team up with community partners throughout a semester to tackle a real-world problem using IoT technology. The project topics include, but are not limited to, energy, environmental, civic infrastructure monitoring. The project teams will apply engineering design principles and critically examine sensor selection, sensor deployment, wireless communication, data quality, security and privacy as well as value proposition for IoT-based solutions. The key learning outcome of this course is that students will grasp how to develop IoT-based technological solutions and become competent in communicating how to use the IoT technology responsibly to create positive societal impact.
Prerequisites: MAE 3780, ECE 3400.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:
- Develop IoT-based solutions to address community partners' specified needs.
- Apply the principles of data security and data privacy in IoT designs.
- Engaging community partners in designing the IoT-based solutions and communicate the designs effectively with community partners and peers in both verbal and written forms.
- Evaluate the feasibility of the IoT-based solutions and articulate the potential improvement.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5230 - Intermediate Fluid Dynamics with CFD (4 Credits)
Builds on the foundation of MAE 3230. The lectures emphasize on the physics and mathematical analysis of the subject. Topics include incompressible flows, compressible flows, and computational fluid dynamics. As an integral part of the course, you will learn numerical method and how to use ANSYS/Fluent to solve flow problems. The students will develop problem-solving skills, through which to cultivate an appreciation for the rich and complex structure of fluids, and appreciation for fundamental ideas in fluid dynamics.
Enrollment Information: Enrollment limited to: graduate students. Intended for: M.Eng. students who wish to take a fluid dynamics course including implementation of commercial computational fluid dynamics packages.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:
- Students will be able to apply knowledge of mathematics, science, and engineering.
- Students will be able to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- Students will be able to identify, formulate, and solve engineering problems.
- Students will be able to understand the impact of engineering solutions in a global, economic, environmental, and social context.
- Students will be able to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5240 - Materials Processing and Manufacturing (3 Credits)
Crosslisted with MSE 5510
Schedule of Classes (https://classes.cornell.edu/)

MAE 5250 - Computer-Aided Manufacture (1 Credit)
Covers the fundamentals of computer-aided manufacture (CAM) and computer numerical control (CNC) programming. The course is a hands-on series on CAM and provides practical applications for the use of Gcode and solid modeling software, CNC mill and/or lathe setup, tool selection, and operation. An additional non-credit lab is required only for students wishing to obtain Emerson Lab machine certification. Certification is required for students wishing to use the CNC equipment in the Emerson Manufacturing Teaching Lab for team or research projects. The lab follows completion of the regular course and prepares students for the Emerson CNC Blue Apron test.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:
- The student will be able to describe the role of machine tools in history and current industry.
- The student will be able to list and describe the capabilities and limitations of machine tool technology.
- The student will be able to perform CNC programming both manually and in AutoDesk Fusion 360.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5260 - Design for Manufacture and Assembly (1 Credit)
Successful component and system design is dependent on the ability to specify products that balance cost, performance, and component robustness. This course will consider methods for design optimization that are driven by an attention to manufacturing and assembly processes while maintaining consideration for functional sensitivities.
Prerequisites: equivalent CAD-based design course plus 2.5 years of engineering mathematics, including probability and statistics.
Enrollment Information: Enrollment limited to: M.Eng. or graduate students in MAE or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- The student will be able to better understand the role of design engineers as related to industry.
- The student will be able to understand DFMA (Design for Manufacturing and Assembly) as it applied to design of mechanical systems.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5270 - Design Failure Modes and Effects Analysis (DFMEA) (1 Credit)
In industry, engineers are often tasked with the mitigation of technical and functional risks associated with the development and launch of new products. A Design Failure Modes and Effects Analysis (DFMEA) is a controlled process by which a product concept, a customer specification, and other system functional requirements are transformed into a fully validated (robust) product design whose product risks can be recorded, minimized, and communicated to the greater organization prior to product launch. This course will explore the realization of validated designs through the utilization of the DFMEA process.
Prerequisites: equivalent CAD-based design course plus 2.5 years of engineering mathematics, including probability and statistics.
Enrollment Information: Enrollment limited to: M.Eng. or graduate students in MAE.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to better understand the role of design engineers as related to industry.
- Students will be able to understand Design Failure Modes and Effects Analysis (DFMEA) as it applied to design of mechanical systems.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5280 - Adaptive and Learning Systems (3 Credits)
Crosslisted with SYSEN 5280, MAE 6280
This course focuses on the design and development of self-awareness and learning models to understand and predict the dynamic behavior of systems. In particular considerable emphasis will be placed on the development of critical thinking skills in the analysis of time-varying systems in response to system data. Students will be provided prototype computer code to help them build realistic models from first principles in MATLAB/SIMULINK without commercial software packages. The goal is for students to leave the course with the independent ability to utilize learning systems to analyze and predict behavior of systems without the aid of any tailored commercial software package.
Prerequisites: knowledge of linear regression and matrix operations.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Learning Outcomes:

- Identify variation of systems from data.
- Analyze system variation from data.
- Demonstrate application of system learning for decision and control.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5310 - Advanced Thermodynamics of Multiphase Systems (4 Credits)
This course will provide a more advanced treatment of classical thermodynamics than is typically found in a first course on the subject. The emphasis will be on phase transitions of fluid systems. Topics include the following: stability of superheated liquids and supersaturated gases; second law limits of allowable fluid states; energetics and kinetics of nano-scale bubble formation in the bulk of a liquid and at a solid surface; transport equations for melting, solidification, bubble growth and droplet burning. Applications will include industrial considerations related to rapid evaporation relevant to vapor explosions, burning of fuel droplets, ink-jet printing, liquid natural gas spills, and nuclear reactor safety. Transport of two-phase flows will be summarized from a simplified perspective.
Prerequisites: ENGRD 2210 and MAE 3240.
Last Four Terms Offered: Fall 2024, Spring 2022
Learning Outcomes:

- Students will be able to identify the terminologies associated with the laws, postulates, corollaries and systems of thermodynamics.
- Students will be able to predict the thermodynamic and kinetic limits of superheat of a fluid with application to selected industrial problems.
- Students will be able to develop models for melting and freezing of fluids including problem formulation with boundary conditions.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5340 - Innovative Product Design via Digital Manufacturing (4 Credits)
This hands-on/project-based course instructs students on methods to identify product concepts for machine designs with commercial potential. It combines lectures and field/lab activities on the new product development cycle: iterative design based on ethnographic fieldwork, team brainstorming, prototyping, testing/consumer feedback, and limitations set by mass manufacturing. Students -coming from diverse backgrounds and industry experience, and some currently working in different companies -will be teamed together to develop the new products. They will be given a common design challenge, and after observing and engaging with real users, they will identify specific needs; then based on those needs each team will end up with a different problem definition and a different product. Industry advisers from real world companies will provide constant feedback throughout the semester.Graduate students will be required to expand and/or focus on some aspects of the process/products.
Enrollment Information: Enrollment limited to: M.E. seniors and other MEng./graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to experience the major impact of a human-centered design approach.
- Students will be able to understand the logic of the product development cycle in the context of both a startup company and an established firm.
- Students will be able to appreciate the limitations of early-stage prototypes and the importance of staged development into more realistic prototypes.
- Students will be able to identify product platforms for mechanical design with commercial potential.
- Students will be able to appreciate Intellectual Property in terms of design and utility.
- The student will be able to acquire familiarity with basic tools of design and manufacturing, such as CAD and digital manufacturing tools.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5350 - Multidisciplinary Design Optimization (4 Credits)
Crosslisted with SYSEN 5350
This course presents a rigorous, quantitative multidisciplinary design methodology that incorporates the creative side of the design process. Through a topic of your choice, learn how to use multidisciplinary design optimization (MDO) to create advanced and complex engineering systems that must be competitive in performance and life-cycle value. Multidisciplinary design aspects appear frequently during the conceptual and preliminary design of complex new systems and products, where different disciplines (e.g. structures, aerodynamics, controls, optics, costing, manufacturing, environmental science, marketing, etc.) have to be tightly coupled in order to arrive at a competitive solution. This course is designed to be fundamentally different from most traditional university optimization courses which focus mainly on the mathematics and algorithms for search. Focus will be equally strong on all three aspects of the problem: (i) the multidisciplinary character of engineering systems, (ii) design of these complex systems, and (iii) tools for optimization. Students will demonstrate mastery of the subject by working in small teams on a term project to apply the multidisciplinary design optimization principles to design and optimize an engineering system of their choice.
Prerequisites: undergraduate linear algebra and knowledge of MATLAB, Python or R.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Fall 2021
Learning Outcomes:

- Subdivide a complex system into smaller disciplinary models, manage their interfaces and reintegrate them into an overall system model.
- Identify the most suitable optimization algorithm between gradient-based numerical optimization algorithms (i.e. sequential quadratic programming (SQP)) and various modern heuristic optimization techniques (i.e. simulated annealing (SA) or genetic algorithms (GA)) for their design problem and use it to find the optimal design for a single objective of their choice.
- Critically evaluate and interpret analysis and optimization results, including sensitivity analysis and exploration of performance, cost and risk tradeoffs.
- Utilize basic concepts of multi-objective optimization, including the conditions for optimality and Pareto front computation techniques, to optimize their design with respect to two objectives of their choice.
- Work as a team to formulate a realistic engineering design problem, optimize the design for a single objective and multiple competing objectives, and present the results in a final oral presentation and written report.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5360 - Design and Simulation of Multiphase Flow Systems (3 Credits)
This course will introduce fundamental concepts of multiphase flow physics and explain their relevance in natural and engineered systems of societal importance. In this course, multiphase refers both to a carrier fluid laden with particles or two immiscible phases like water and air. State-of-the-art scientific computing strategies for modeling multiphase flows are presented and deployed in a series of case studies in which students will use, manipulate, and modify advanced algorithms in order to quantitatively predict the complex, highly non-linear behavior of these flows.
Prerequisites: MAE 3230, knowledge in vector calculus, ordinary differential equations, partial differential equations, and proficiency in Matlab, Python or other scientific computing language.
Last Four Terms Offered: Spring 2024
Learning Outcomes:

- Students will be able to identify important non-dimensional numbers and physical processes in multiphase flows.
- Students will be able to formulate mathematical models for multiphase flows.
- Students will be able to select methods for computational modeling.
- Students will be able to develop solutions and interpret them in physical terms.
- Students will be able to explain what was learned in written and oral form.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5390 - Cybersecurity for Cyber-Physical and Aerospace Systems (3 Credits)
Crosslisted with SYSEN 5390
The goal is to identify and analyze the unique cybersecurity challenges faced by cyber-physical systems, particularly within the constraints of assets like space systems and their infrastructure. The course will then focus on applying practical mitigation techniques to enhance the security of such critical infrastructure operations.
Prerequisites: SYSEN 5100 and MAE 5160.
Last Four Terms Offered: Spring 2025
Learning Outcomes:

- Engineer an attack against a cyber-physical system using methods and frameworks discussed in class.
- Explain the motivations of attackers, the unique security challenges of cyber-physical systems and the expansive surface areas that attackers are interested in as both targets and vectors.
- Identify opportunities to infuse practical, implementable low-hanging fruit security practices into space system development processes.
- Articulate future cyber-physical system capabilities and propose how these assets and their services will need to be secured.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5430 - Combustion Processes (3 Credits)
Combustion is an interdisciplinary field that combines chemistry, fluid mechanics, thermodynamics and heat transfer. This course is an introduction to combustion science, beginning with a review of thermodynamics, its application to combustion system analysis, and concepts of chemical kinetics. We will then discuss the nonequilibrium diffusive transport of heat, mass and momentum and introduce the general conservation equations for chemically reacting flows. The transport laws and governing equations are then applied to several flame configurations. Finally, the basic structure of premixed and non-premixed flames are analyzed, and practical applications of these principles in transportation, propulsion, power generation, and industrial processes are discussed.
Enrollment Information: Enrollment limited to: Graduate students.
Last Four Terms Offered: Fall 2024, Spring 2024, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to identify basic flame structure in existing practical combustion systems (gas turbine engine, internal combustion engines, etc.).
- Students will be able to identify regimes of subsonic and supersonic flame propagation in premixtures.
- Students will be able to compare and apply different models for predicting thermochemical data.
- Students will be able to distinguish reaction mechanisms corresponding to different fuels.
- Students will be able to calculate reaction rates.
- Students will be able to calculate analytically and numerically (using open-source software Cantera) the energy released during combustion and the thermodynamic state of the combustion products.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5440 - Spacecraft Thermal Management (3 Credits)
This course will overview the physical princples governing existing spacecraft thermal management technologies, including conductive and radiative heat transfer, passive and active fluid transport, and ablation. One focus of the class is on thermal protection, which consists of materials and systems designed to protect spacecraft from extreme temperatures, particularly during atmospheric entry. Additionally, we discuss thermal control systems, which maintain all vehicle surfaces and compnents within an appropriate temperature range throughout all mission phases. Integral to the class is the reading and discussion of scientific research articles on the topics of spacecraft thermal control and protection.
Prerequisites: MAE 3230 and MAE 3240.
Enrollment Information: Enrollment limited to: M.E. seniors and other MEng./graduate students.
Last Four Terms Offered: Fall 2023
Learning Outcomes:

- Students will be able to identify flight paths and operating conditions corresponding to insulative versus ablative heat shields in thermal protection systems.
- Students will be able to identify the mechanisms (e.g., radiation, capillary forces, etc.) governing existing thermal control technologies.
- Students will be able to participate in reading and discussion of scientific research articles.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5450 - Additive Manufacturing: Process Physics, Materials, Properties and Post Processing (3 Credits)
In this course, we'll start by covering the fundamentals of additive manufacturing (AM), introducing you to various techniques like extrusion, powder bed fusion, photopolymerization, material jetting, binder jetting, direct energy deposition, and laminated object manufacturing. You will also explore the crucial post-processing steps that enhance the quality and functionality of 3D printed objects. We'll also dive into the compatibility of materials with each AM process, enabling you to make informed material choices for your specific projects. Throughout the course, you'll develop the expertise to select the most suitable AM technique for various design challenges and manufacturing problems, optimizing efficiency and cost-effectiveness. Real-world case studies from diverse industries will provide practical insights, helping you analyze project strengths and weaknesses and apply this knowledge to future applications. This course offers an accessible gateway to the exciting world of additive manufacturing.
Prerequisites: MAE 2250, MAE 3230, MAE 3270. Corequisite: MAE 3240.
Last Four Terms Offered: Spring 2024
Learning Outcomes:

- The student will describe the fundamentals of extrusion, powder bed fusion, photopolymerization, material jetting, binder jetting, direct energy deposition, and laminated object manufacturing.
- The student will examine the mechanical properties of 3D printed components and investigate the underlying factors contributing to disparities when compared to identical materials manufactured using traditional production methods.
- The student will identify post processing steps for each additive manufacturing process.
- The student will identify materials that are compatible with each additive manufacturing process.
- The student will select the appropriate additive manufacturing technique for a specific design or manufacturing problem.
- The student will analyze case studies of real-world additive manufacturing projects and identify their strengths and weaknesses.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5459 - Energy Seminar I (1 Credit)
Crosslisted with ECE 5870, CHEME 5870, BEE 5459
Energy Seminars will explore energy-related topics of emerging, contemporary and historical interest. An abbreviated list of subjects explored in the seminars includes: global energy resources, energy generation technologies (present and future), energy storage options, environmental impacts and climate change mitigation, energy policy, and energy delivery economics and systems. Seminar speakers will be distinguished practicing engineers and executives from industry and government as well as faculty members from several departments at Cornell, and other academic institutions. Students from any department in Engineering or the Physical Sciences should find these talks informative.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 5469 - Energy Seminar II (1 Credit)
Crosslisted with ECE 5880, CHEME 5880, BEE 5469
Energy Seminars will continue to explore energy-related topics of emerging, contemporary and historical interest. An abbreviated list of subjects explored in the seminars includes: global energy resources, energy generation technologies (present and future), energy storage options, environmental impacts and climate change mitigation, energy policy, and energy delivery economics and systems. Seminar speakers will be distinguished practicing engineers and executives from industry and government as well as faculty members from several departments at Cornell, and other academic institutions.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 5510 - Propulsion of Aircraft and Rockets (4 Credits)
Introduction to air and rocket propulsion. Emphasis on air-breathing gas-turbines. Chemical rocket propulsion. Brief discussion of of ramjets and of propellers. Application of thermodynamic and fluid-mechanical principles to analysis of performance and design, including fuel efficiency and environmental impacts.
Prerequisites: ENGRD 2210/MAE 2210 and MAE 3230 or equivalents. Recommended prerequisite: MAE 3050.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to describe and interpret the types, characteristics, and performance measures of combustion engines used in propulsion, power generation, and road vehicles.
- Students will be able to apply thermodynamic and fluid mechanical principles to quantitatively describe engine operation.
- Students will be able to predict how their performance depends on design parameters and operating conditions.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5530 - Computer-Aided Engineering: Applications to Biological Processes (3 Credits)
Crosslisted with BEE 5530
Introduction to simulation-based design as an alternative to prototype-based design; modeling and optimization of complex real-life processes for design and research, using industry-standard physics-based computational software. Emphasis is on problem formulation, starting from a real process and developing its computer model. Modeling application (project) can be biomedical (thermal therapy and drug delivery) or broader biological and bioenvironmental applications that involve heat transfer, mass transfer, and fluid flow. Computational topics introduce the finite-element method, model validation, pre- and post-processing, and pitfalls of using computational software. Students choose their own semester-long project, which is a major part of the course (no final exam).Students in BEE 5530 will expand the developed model as an individual effort separate from the group effort and include this as an individual report that is an extension of the group report. Such an extension of the mathematical model can include additional and substantial computational work approved by the instructor in any (but not all) of the areas-physics, geometry, properties, and validation.
Prerequisites: BEE 3500 or MAE 3240 or CHEME 3240 or equivalent.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 5540 - Propulsion of Spacecraft (3 Credits)
This course provides the contextual and physical framework to understand and design space propulsion devices for orbiting spacecraft and satellite systems. An introduction to the basic principles of propulsion and performance metrics in the context of space missions are presented. Key physics underlying the operation of propulsion devices are covered. Specifically, the design and performance of ion engines, Hall thrusters, electrospray thrusters, and emerging propulsion concepts are covered.
Prerequisites: Prerequisite or corequisite: undergraduate-level coursework in thermodynamics, electromagnetism, and orbital mechanics.
Last Four Terms Offered: Fall 2024, Fall 2023, Spring 2023, Fall 2021
Learning Outcomes:

- Students will be conversant across the range of propulsion options for space missions.
- Students will be able to describe the physics underlying their operation and performance limits.
- Students will be able to use their knowledge of propulsion physics and mission context to create or evaluate new designs.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5630 - Advanced Product Design (4 Credits)
This hands-on course instructs on strategies to invent - make - and disseminate products that solve an identified need. These products can be consumer, enterprise, research, for profit or non-profit. The lectures will primarily be discussion based on assigned readings and tasks, and guest lectures from domain experts. The course combines lectures and field/lab activities on the new product development cycle: invention based on bioinspiration, iterative design based on customer discovery, team brainstorming, prototyping, testing/consumer feedback, and manufacturing innovation.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2021
Learning Outcomes:

- Students will be able to experience the major impact of a human-centered design approach.
- Students will be able to understand the importance of managing interfaces between subsystems in prototype development.
- Students will be able to identify product platforms for mechanical design with commercial potential.
- Students will be able to appreciation of Intellectual Property in terms of design and utility.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5640 - Orthopaedic Tissue Mechanics (3 Credits)
Application of mechanics and materials principles to orthopaedic tissues. Physiology of bone, cartilage, ligament, and tendon and the relationship of these properties to their mechanical function. Mechanical behavior of skeletal tissues. Functional adaptation of these tissues to their mechanical environment. Tissue engineering of replacement structures.
Prerequisites: ENGRD 2020 and MAE 3270.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2021, Spring 2019
Learning Outcomes:

- Students will be able to know and understand the function and physiology of bone, cartilage, tendon and ligament as organs and tissue.
- Students will be able to apply strength of materials concepts to the mechanical behavior of musculoskeletal tissues and organs.
- Students will be able to understand the unique adaptive capacity of musculoskeletal tissues to their mechanical environment.
- Students will be able to integrate and interpret biological data and mechanical engineering concepts.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5650 - Biofluid Mechanics (4 Credits)
Crosslisted with BME 5410
Prerequisites: ENGRD 2020 and ENGRD 2202 or MAE 3230 or equivalents, or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2022, Fall 2021, Spring 2020
Schedule of Classes (https://classes.cornell.edu/)

MAE 5670 - Polymer Mechanics (3 Credits)
This course will provide foundations of polymer mechanics building from the basics of mechanics of materials. The focus will be split between experimental methods/data interpretation and modeling approaches. Topics will include: hyper-elasticity, viscoelasticity, glass transition temperature, and plasticity with applications to both synthetic and biological materials. There will also be a scientific literature reading component through which students will be able to pick their own focus areas in the latter part of the semester.
Prerequisites: ENGRD 2020 and MAE 3270, or MSE 2610.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- The student will be able to classify polymers into different regimes of behavior and explain their microstructural origin.
- The student will be able to analyze and interpret data from key experimental methods for polymer thermo-mechanical properties.
- The student will be able to describe, computationally implement, and find parameters for models that describe key aspects of polymer and gel mechanical behavior.
- The student will be able to explain how the thermo-mechanical properties of natural and synthetic polymers are central to applications of interest to the student.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5680 - Soft Tissue Biomechanics (3 Credits)
Crosslisted with BME 5810
Introduces concepts of biomechanics applied to understanding the material behavior of soft tissues. Topics include finite strain, nonlinearities, constitutive frameworks, and experimental methodologies. Tissues to be modeled include tendons, blood vessels, heart valves, cartilage, and engineered tissues.
Prerequisites: ENGRD 2020, BME 3410 or MAE 3270.
Enrollment Information: Enrollment limited to: graduate students; seniors by permission of instructor.
Last Four Terms Offered: Spring 2024, Fall 2019, Fall 2017, Fall 2016
Schedule of Classes (https://classes.cornell.edu/)

MAE 5700 - Finite Element Analysis for Mechanical and Aerospace Design (4 Credits)
Introduction to linear finite element static analysis for discrete and distributed mechanical and aerospace structures. Prediction of load, deflection, stress, strain, and temperature distributions. Major emphasis on underlying mechanics and mathematical formulation. Introduction to computational aspects via educational and commercial software (such as MATLAB and ANSYS). Selected mechanical and aerospace applications in the areas of trusses, beams, frames, heat transfer and elasticity. A selection of advanced topics such as dynamic modal analysis, transient heat transfer, or design optimization techniques may also be covered, time permitting.
Enrollment Information: Enrollment limited to: graduate students in Engineering.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to recall, identify, and analyze the mathematical and physical principles underlying the FEM as applied to solid mechanics, thermal analysis and select aspects of fluid mechanics.
- Students will be able to develop their own FEM computer programs, for mathematically simple but physically challenging problems, in MATLAB.
- Students will be able to compare FEM results obtained with MATLAB with those obtained from ANSYS. Analyze more complex problems (in solid mechanics or thermal analysis) using the commercial FEM code ANSYS.
- Students will be able to demonstrate the ability to design a component using FEM analysis (both MATLAB AND ANSYS).
- Students will be able to make clear and effective technical presentations, both in terms of form as well as content, of his/her work and write clear technical reports describing his/her work.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5720 - Advanced Applications of Finite Element Analysis Using Ansys (2-3 Credits)
This course prepares students to solve industry-relevant problems in structural mechanics and dynamics using Ansys simulation software. This is a problem-based course where students will learn finite-element applications by solving practical problems involving realistic 3D CAD geometries. Applications considered include pressure vessel stress analysis, wind turbine blade buckling, turbine disk vibration, electronics enclosure dynamics and robot arm motion. The focus will be on developing a strong conceptual understanding of what's inside the simulation blackbox so as to move beyond garbage-in, garbage-out. Verification and validation of simulation results is emphasized throughout. Rigid-body dynamics applications will also be covered. Concepts, solution approaches and best practices learned will be applicable to the use of other industry-standard simulation software. Suitable for both on-campus and distance learning students.
Prerequisites: MAE 4700, MAE 4701, and MAE 5700.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Create reliable static and dynamic simulations of structures using Ansys software for a range of industrial-level problems.
- Explain the mathematical model underlying each simulation including governing equations, boundary conditions, physical principles and assumptions.
- Explain the numerical solution strategy used to solve the mathematical model and how to reduce the numerical errors introduced.
- Defend simulation results by undertaking a verification and validation procedure.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5730 - Intermediate Dynamics (3 Credits)
The course emphasizes the classical dynamics of single- and multi-degree-of-freedom systems made up of particles, rigid-objects in 2 and 3 spatial dimensions. Three approaches are used: the Newton-Euler and Lagrangian approach, both using minimal coordinates, and also a 'maximal coordinate' approach using differential algebraic equations (DAEs). The course emphasizes finding equations of motion, solving them analytically (if possible) and numerically; and graphical presentation of solutions, including animations.
Prerequisites: MATH 2940 or equivalent.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- The student will be able to locate the governing equations of motion for a variety of dynamic mechanical systems consisting of particles and rigid objects that might interact with various standard connections (e.g., strings, springs, hinges, rolling, surface sliding) and forces (e.g., gravity, friction, fluid drag).
- The student will be able to solve the simple cases by hand, solve the more complex cases with numerical integration (Matlab), graphically represent the results, including animations.
- The student will be able to check the reasonableness of the results using extreme cases and Laws of Conservation (momentum, angular momentum and energy).
- The student will be able to use principles of Lagrangian mechanics to develop the same governing equations as above for simple conservative systems.
- The student will be able to formulate, setup, numerically solve, and interpret the equations and solutions of a 3D rigid object rotating in space.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5770 - Engineering Vibrations (3 Credits)
This course covers the free and forced response of vibrating mechanical systems modeled as having one, two and several degrees of freedom, as well as models of continuous structures such as beams.
Prerequisites: MAE 3260.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to be proficient at modeling vibrating mechanical systems.
- Students will be able to perform analysis such as systems characterization and modeling of SDOF and MDOF systems.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5780 - Feedback Control Systems (3-4 Credits)
This course covers the analysis and design of linear feedback systems in both the frequency and time domains. The course includes a laboratory that examines modeling and control of representative dynamic processes. The frequency domain aspects are analyzed via Laplace transforms, transfer functions, root locus, and frequency response methods. The time domain aspects are analyzed via state space models, stability, controllability, observability, state feedback, and observers.
Prerequisites: CHEME 3720 or MAE 3260.
Last Four Terms Offered: Spring 2025, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to obtain the linearization of a non-linear system about an operating point.
- Students will be able to construct a transfer function representation of a linear dynamical system.
- Students will be able to manipulate block diagrams and transfer functions.
- Students will be able to understand the relationship between a linear system and its frequency response, and know how to construct a Bode plot.
- Students will be able to know how to design traditional controllers such as Proportional, Integral, Derivate (PID), and Lead-Lag.
- Students will be able to understand the concepts of stability, including gain and phase margins and Nyquist stability condition.
- Students will be able to design control systems in the frequency domain using Bode plots and the Nyquist stability condition.
- Students will be able to analyze control systems using Root Locus techniques.
- Students will be able to apply the tools learned in the class to physical problems.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5790 - Nonlinear Dynamics and Chaos (3 Credits)
Introduction to nonlinear dynamics, with applications to physics, engineering, biology, and chemistry. Emphasizes analytical methods, concrete examples, and geometric thinking. Topics include one-dimensional systems; bifurcations; phase plane; nonlinear oscillators; and Lorenz equations, chaos, strange attractors, fractals, iterated mappings, period doubling, renormalization.
Prerequisites: high level of performance in a semester of linear algebra (MATH 2210, MATH 2230, MATH 2310, or MATH 2940) and a semester of multivariable calculus (MATH 2220, MATH 2240, or MATH 1920), or equivalent.
Forbidden Overlaps: MAE 5790, MATH 4200, MATH 4210, MATH 5200
Last Four Terms Offered: Fall 2024, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 5810 - Robot Perception (3 Credits)
Crosslisted with ECE 5240
An introductory course to robot perception techniques for modeling and planning heterogeneous and dynamic sensor measurements, and for processing the sensor feedback in the context of robot motions and environments. Methods for intelligent sensor fusion and robot perception in motion will be covered in detail in this course. Topics in artificial vision, acoustic propagation, and filtering will be discussed along with related algorithms inspired by neural networks, Bayesian networks, and information theory. Sensing problems and performance will be investigated in regard to benchmark problems, such as coverage, target search, target tracking, and treasure hunting, will be covered in-depth and demonstrated through applications drawn from environmental monitoring, sensing-and-pursuit games, surveillance, and human-robot interactions.
Prerequisites: ENGRD 2112, MATH 2940, and MATH 4710 (or ENGRD 2700 or ENGRD 2720); or graduate standing in a technical field.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2021
Learning Outcomes:

- Students will be able to use methods for sensor fusion to inform robot perception.
- Students will be able to implement artificial vision, acoustic propagation, and filtering along with neural networks, Bayesian algorithms, and information theory to identify robot states.
- Students will be able to analyze benchmark problems such as coverage, target search, target tracking, and treasure hunting.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5830 - Astronautic Optimization (3 Credits)
Crosslisted with SYSEN 5830
This course provides a brief review of several topics in sufficient detail to amplify student success: estimation, allocation, and control; classical feedback; sensor noise; and Monte Carlo analysis. The review leads to application of the methods of Pontryagin applied to examples including single-gimballed rocket engines, guidance, and control problems including least squares estimation, and the famous Brachistochrone problem as a motivating example illustrating the minimum time solution is not necessarily the minimum path-length solution, particularly in a gravity field. After taking this course, students will be able to apply their expertise to actual systems in advanced courses or in laboratory settings leveraging analytic (non-numerical) nonlinear programming and real-time optimal control. Graduates will understand the application of constrained (smooth constrained, box constrained, with brief introduction to inequality constrained) and unconstrained optimization; linear-quadratic programming; and Bellman's principle of optimality.
Prerequisites: undergraduate-level coursework in dynamics, calculus (understanding of extrema), and classical feedback control or system dynamics. Recommended prerequisite: coursework or understanding of spacecraft attitude control or rotational mechanics.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- The student will be able to apply their expertise to actual systems in space in advanced courses or in spacecraft attitude control laboratory settings leveraging nonlinear programming and real time optimal control.
- The student will be able to understand the application of constrained (smooth constrained, box constrained, inequality constrained) and unconstrained optimization.
- The student will be able to understand the application of linear-quadratic programming; and Bellman's principle of optimality; all strictly applied to the problem of spacecraft attitude control.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5860 - Automotive Engineering (3 Credits)
Selected topics in the analysis and design of vehicle components and vehicle systems. Emphasis on automobiles. Engines, transmissions, suspension, brakes, and aerodynamics are discussed. The course uses first principles and applies them to specific systems. The course is highly quantitative, using empirical and analytical approaches.
Prerequisites: MAE 2030 and ENGRD 2210.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to explain the fundamental concepts of intake air flow and valves for internal combustion spark ignition engines.
- Students will be able to perform calculations using efficiencies and fuel flow to estimate power and torque developed by IC engines.
- Students will be able to perform calculations estimating the power developed with turbochargers and superchargers.
- Students will be able to calculate the engine power and torque required to operate a vehicle under various loads.
- Students will be able to estimate braking performance given the parameters of the vehicle.
- Students will be able to calculate the stability and performance of vehicles with specified suspension geometries.
- Students will be able to calculate steering and ride performance, given vehicle parameters.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5910 - Model Based Systems Engineering (4 Credits)
Crosslisted with SYSEN 5100, CEE 5240, ECE 5120, ORIE 5140
Fundamental ideas of systems engineering, and their application to design and development of various types of engineered systems. Defining system requirements, creating effective project teams, mathematical tools for system analysis and control, testing and evaluation, economic considerations, and the system life cycle.Content utilizes model-based systems engineering, which is the integration of systems modeling tools, such as SysML, with tools for systems analysis, such as Matlab and Modelica. The vision for this integration is the ability to create and analyze complete parametric representations of complex products and systems. These systems make it possible to investigate the impact of changing one aspect of a design on all other aspects of design and performance. This course will familiarize students with these modeling languages. Off-campus students must provide their own Windows 7, internet-connected, computer with administrator access in order to install the commercial software used in this course.
Prerequisites: Prerequisite or corequisite: enrollment in group-based project with strong system design component approved by course instructor.
Enrollment Information: Enrollment limited to: seniors or graduate students in an engineering field.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 5920 - Systems Analysis Behavior and Optimization (3 Credits)
Crosslisted with SYSEN 5200, CEE 5252, ORIE 5142, ECE 5130
This is an advanced course in the application of analytical methodologies and tools to the analysis and optimization of complex systems. On completion of this course, students should be able to use probability and statistics as a modeling and analysis tool for systems exhibiting uncertainty; be able to use algorithms and dynamic programming to model and optimize systems with a recursive structure; be able to use optimization tools to optimize complex systems and tune parameters.
Prerequisites: ENGRD 2700, calculus skills, and familiarity with basic programming in a language such as python, C++, java, matlab, etc.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 5930 - Systems Engineering and Six Sigma for the Design and Operation of Reliable Systems (3-4 Credits)
Crosslisted with SYSEN 5300
Develops skills in the design, operation and control of systems for reliable performance. Focuses on four key themes; risk analysis (with a particular emphasis on risk assessment and risk characterization), modeling system reliability (including the development of statistical models based on accelerated life testing), quality control techniques and the optimization of system design for reliability. Six Sigma Green or Blackbelt can be earned through activities associated with course. Students in distance-learning programs enroll in SYSEN 5100.
Prerequisites: ENGRD 2700 or CEE 3040, SYSEN 5100, or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 5940 - Professional Development for Master of Engineering in MAE (1 Credit)
Covers tools needed to build skills for career development and the job search. Also covers a process to organize, complete and present the Master of Engineering Project.
Enrollment Information: Enrollment limited to: M.Eng. students.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Learning Outcomes:

- Students will be able to describe career and job goals in writing and orally.
- Students will be able to understand how to start a project and plan for its successful completion.
- Students will be able to present work in a formal presentation and a poster.

Schedule of Classes (https://classes.cornell.edu/)

MAE 5949 - Enterprise Engineering Colloquium (1 Credit)
Crosslisted with ORIE 5920
Weekly meeting for master of engineering students. Discussion with industry speakers and faculty members on the uses of engineering in the effective and efficient design, manufacturing, marketing, distribution, sustainment, and retirement of goods and services.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 5950 - Theory and Practice of Systems Architecture (3 Credits)
Crosslisted with SYSEN 5400
Every system has an architecture (its essence, or DNA), i.e., a high-level abstraction of its design that provides a unifying concept for detailed design and commits most of the system's performance and lifecycle cost. This course presents the frameworks, methods, and tools required to analyze and synthesize system architectures. The course has a theory part that emphasizes synergies between humans and computers in the architecture process, and a practical part based on a long project and guest lectures by real system architects. The theory part covers topics such as architecture views, layers and projections, stakeholder networks, dealing with fuzziness, automatic concept generation, architecture space exploration, patterns and styles, heuristics, and knowledge engineering. The practice part focuses on special topics such as commonality, platforming, reuse, upstream and downstream influences, and software architecture.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 6010 - Foundations of Fluid Mechanics I (4 Credits)
Crosslisted with PHYS 7601
Foundations of fluid mechanics from an advanced viewpoint, including formulation of continuum fluid dynamics; kinematic descriptions of fluid flow, derivation of the Navier-Stokes equations and energy equation for compressible fluids; and sound waves, viscous flows, boundary layers, and potential flows.
Prerequisites: MAE 3230 or higher, in addition to basic knowledge in vector calculus, ordinary differential equations, partial differential equations, and complex variable analysis.
Enrollment Information: Enrollment limited to: Graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to identify important fluid properties and physical processes in fluid flows.
- Students will be able to formulate mathematical models for fluid flows.
- Students will be able to select methods of analysis and computation.
- Students will be able to develop solutions and interpret them in physical terms.
- Students will be able to explain what was learned in written and oral form.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6030 - Space Structures (3 Credits)
The Space Structures class introduces students to mechanical concepts used in the realization of lightweight structures, their application to space systems, and the scientific methods employed to assess their performance. The class provides the analytical foundations to analyze modern structures that fold, deploy, and undergo large deformations, as well as a methodology to design them.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024
Learning Outcomes:

- The student will be able to derive equivalent homogenized properties for structures made of multiple members or components.
- The student will learn how to assess the performance of these structures given requirements on mass and stiffness.
- The student will be able to identify suitable structural concepts given a practical problem, and design specific structures using the analytical methods covered in the class.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6040 - Tribology and Surface Engineering (3 Credits)
This two-part course is aimed at giving students a knowledgebase to (i) fundamentally understand contact, friction, and wear mechanisms and (ii) design surface engineering processes for a desired tribological performance. The first part of the course covers fundamental science relevant to surfaces. Mechanics of contact at different length-scales, the origin of the frictional force, the use of lubrication to reduce friction, and different wear mechanisms, from adhesive to abrasive and erosive, will be discussed in the first part. The second part of the course will cover an overview of different surface modification processes and coating technologies with an emphasis on the physics of the process.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2023, Spring 2022, Spring 2021
Learning Outcomes:

- Students will be able to analyze contact mechanics problems.
- Students will be able to evaluate state of surfaces under friction and wear.
- Students will be able to design surface engineering processes.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6050 - Mechanical Metallurgy (3 Credits)
This course delves into the metallurgical fundamentals of the mechanical behavior of metals, alloys, and metals matrix composites. Students will engage in an in-depth study of the mechanisms of deformation and failure in these materials from a microscopic and/or atomistic point of view. The key role of dislocations in plastic deformation of metallic materials as well as their strengthening mechanisms will be discussed in depth. Deformation mechanisms under extreme conditions such as at high temperatures and high strain rates will be discussed. Students will also learn about the deformation mechanisms in non-conventional alloys including nanocrystalline alloys, complex concentrated alloys (high entropy alloys), and metallic glasses. Through theoretical discussions and case studies, students will gain expertise in designing structural materials for real-world applications.
Last Four Terms Offered: Spring 2024
Learning Outcomes:

- The student will understand deformation and failure mechanisms in metallic materials.
- The student will learn how to describe mechanical behavior of metallic materials at extreme conditions.
- The student will understand mechanical behavior of high entropy alloys, nanocrystalline alloys, and metallic glasses.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6060 - Spacecraft Attitude Dynamics, Estimation, and Control (3 Credits)
The focus is on spacecraft attitude dynamics and its application in core space-systems areas: mission design, operations, and autonomy. Also introduces the problem of attitude estimation and treats aspects of guidance, navigation, and control unique to the context of space mission design. Readings and lectures include examples based on flight data.
Prerequisites: MATH 2940 and MAE 4730/MAE 5730, some experience with MATLAB is expected.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2022, Fall 2021, Fall 2020
Learning Outcomes:

- Students will be able to analyze and simulate problems in spacecraft dynamics, control, and estimation.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6110 - Foundations of Solid Mechanics I (3 Credits)
An in-depth introduction to the fundamentals of kinematics of deformation, traction and stress, and balance of momentum. Constitutive theory for linear and nonlinear elastic bodies, including isotropic and orthotropic behaviors, restrictions from symmetry and strain energy, and length scale limitations stemming from a material's physical structure. Boundary conditions, requirements for well-posed problems, and uniqueness. Basic theorems and principles for elastostatics, with emphasis on virtual work, upper and lower bounds, and superposition.
Prerequisites: competence in MATLAB, C or Fortran.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 6130 - Foundations and Frontiers of Engineered Living Materials (3 Credits)
This course will provide foundational knowledge to work in the interdisciplinary field of engineered living materials. Topics will include structure-funtion relationships in different organisms; culturing techniques; genetic engineering and sequencing techniques; mechanical, electrochemical, and optical characterization methods; and biological system modeling.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023
Learning Outcomes:

- Students will be able to analyze literature in the engineered living materials field.
- Students will be able to demonstrate the ability to orally communicate technical concepts in their field of expertise to scientists and engineers from different fields.
- Students will be able to demonstrate knowledge of tools and techniques for attacking specific challenges in the engineered living materials field.
- Students will be able to identify research gaps and opportunities.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6140 - State Variable Modeling (3 Credits)
This course will present an introduction to the state variable modeling framework, which is used for the representation of a broad range of material behaviors and material systems, including metals, polymers, and composites; anisotropy and rate and temperature dependent plasticity. Implicit in the state variable method is the representation of processes at small size scales within the constitutive response at the macroscale. Experimental quantification of state variables will also be explored.
Prerequisites: MAE 6110 or equivalent.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2022, Fall 2021, Fall 2018, Spring 2017
Learning Outcomes:

- Students will be able to assess thermodynamic consistency of a constitutive model.
- Students will be able to understand the process for creating a constitutive model.
- Students will be able to computationally implement existing constitutive models.
- Students will be able to understand the relationship between material structure and macroscopic properties.
- Students will be able to differentiate between microstructurally based models and phenomenological models.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6230 - Computational Fluid Dynamics (4 Credits)
Intended as a first graduate-level course on Computational Fluid Dynamics (CFD), with focus on flows for which compressibility effects can be neglected. Includes topics ranging from discretization techniques to solution methods for linear and non-linear, steady and unsteady problems. Advanced concepts such as multigrid methods, verification and validation, and reactive flows simulations will be introduced. Builds upon a required fluid mechanics background, providing a more detailed discussion of governing equations and presenting computational methods for generating approximate solutions. In this project-based course, students will build a CFD code during the course of the semester, integrating various techniques as they are discussed in class.
Prerequisites: MAE 6010 or equivalent.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2023, Spring 2022, Spring 2020, Spring 2018
Learning Outcomes:
- Students will be able to identify a technique suited to a problem at hand.
- Students will be able to obtain the discretized form of the governing equations.
- Students will be able to adopt an appropriate numerical method for solving the discretized equations.
- Students will be able to implement the entire framework and build a CFD code for simple settings.
- Students will be able to assess the accuracy, stability, convergence, efficiency, and conservative properties of the developed framework.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6260 - Multiscale Computational Mechanics (3 Credits)
This course will provide the foundations for applied multiscale computational mechanics through a hands-on approach. The focus will be primarily on particle-based methods that emphasize practical usages of open-source software in a Linux environment, such as Python, ORCA, Quantum Espresso, LAMMPS, and NAMD. Topics will include introductory levels of python programming, quantum mechanics, density functional theory, statistical mechanics, molecular dynamics, and multiscale coupling methods with broad applications in characterizing the structural, mechanical, and thermal properties for both organic and inorganic materials.
Prerequisites: familiarity with a programming language is essential. Knowledge of Python scripting an advantage.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:
- Students will be able to understand the mathematical and physical principles underlying various particle-based methods.
- Students will be able to identify the appropriate computational method to be used for a given spatiotemporal scale.
- Students will be able to demonstrate competency in using scripts to run software in a Linux-based environment.
- Students will be able to apply the correct techniques to analyze the relevant mechanics and properties of a given material.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6270 - Experimental Methods in Fluid Dynamics (4 Credits)
Crosslisted with CEE 6370
Introduction to experimental techniques, data collection, and data analysis, in particular as they pertain to fluid flows. Introduces theory and use of analog transducers, acoustic Doppler velocimetry (ADV), full-field (2-D) quantitative imaging techniques such as particle image velocimetry (PIV) and laser induced fluorescence (LIF). Additional topics include computer-based experimental control, analog and digital data acquisition, discrete sampling theory, digital signal processing, and uncertainty analysis. The canonical flows of the turbulent flat plate boundary layer and the neutrally buoyant turbulent round jet are introduced theoretically and the subject of three major laboratory experiments using ADV, PIV and LIF. There is a final group project on a flow of the students choosing.
Prerequisites: Prerequisite or corequisite: CEE 3310 and CEE 3040, or equivalents and ENGRD 3200.
Last Four Terms Offered: Spring 2024, Fall 2021, Spring 2020, Spring 2017
Schedule of Classes (https://classes.cornell.edu/)

MAE 6280 - Adaptive and Learning Systems (3 Credits)
Crosslisted with SYSEN 5280, MAE 5280
This course focuses on the design and development of self-awareness and learning models to understand and predict the dynamic behavior of systems. In particular considerable emphasis will be placed on the development of critical thinking skills in the analysis of time-varying systems in response to system data. Students will be provided prototype computer code to help them build realistic models from first principles in MATLAB/SIMULINK without commercial software packages. The goal is for students to leave the course with the independent ability to utilize learning systems to analyze and predict behavior of systems without the aid of any tailored commercial software package.
Prerequisites: knowledge of linear regression and matrix operations.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020
Learning Outcomes:
- Identify variation of systems from data.
- Analyze system variation from data.
- Demonstrate application of system learning for decision and control.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6310 - Turbulence and Turbulent Flows (3 Credits)
Topics include the nature of turbulence and its physical manifestations, statistical description and scales of turbulent motion, turbulent free shear flows and wall bounded flows, Reynolds-averaged Navier-Stokes equations and closure models, introduction to large-eddy simulation, and mixing and reaction in turbulent flows.
Prerequisites: MAE 6010.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021
Learning Outcomes:
- Students will ne able to describe hydrodynamic instability.
- Students will be able to describe the turbulence energy cascade and the inertial range.
- Students will be able to describe scaling and self-similarity.
- Students will be able to describe intermittency in dissipation and in the inertial range.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6340 - Advanced Optical Metrology for Sustainability (3 Credits)
Schedule of Classes (https://classes.cornell.edu/)

MAE 6350 - Wave Interactions with Offshore Systems (4 Credits)
Wave energy converters, offshore wind turbines, liquified natural gas (LNG) vessels, and autonomous underwater vehicles are some examples of offshore systems that are affected by ocean waves. This course presents the analytical framework to analyze the interactions these types of systems and ambient ocean waves. We begin by discussing surface wave theory and properties of regular surface waves and random ocean waves. We then discuss the linearized theory of floating body dynamics along with kinematic and dynamic free surface conditions and body boundary conditions that arise in the ocean setting. We consider simple harmonic motions and both diffraction and radiation problems of waves. We derive key hydrodynamic coefficients of offshore systems such as added mass, damping, and stiffness. Finally, we discuss ship seakeeping in regular and random waves. Throughout the course, examples and homework problems are drawn from real-world applications such as offshore wind turbines.
Prerequisites: at least one of the following courses or their equivalents: MAE 3230, CEE 3310, or AEP 4340.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2022
Learning Outcomes:

- Students will be able to analyze the wave forces on an ocean system using linear potential flow theory.
- Students will be able to examine the dynamic response of an ocean system to wave forces using linear potential flow theory.
- Students will be able to evaluate the hydrodynamic stability of a body subject to ocean waves.
- Students will be able to assess various control schemes for wave energy converters.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6430 - Computational Combustion (3 Credits)
Last Four Terms Offered: Spring 2021, Spring 2016, Spring 2014
Schedule of Classes (https://classes.cornell.edu/)

MAE 6450 - Advanced Topics in Metal Additive Manufacturing (3 Credits)
Crosslisted with MSE 5520
This course delves into three distinct categories of metal additive manufacturing processes, each governed by unique principles: solidification-based techniques, sintering-dependent methods, and solid-state bonding processes. Students will explore the intricacies of powder bed fusion and direct energy deposition, where solidification mechanisms play a pivotal role in controlling microstructure formation. The course will provide a comprehensive understanding of how factors such as heat transfer, cooling rates, and alloy composition influence solidification behavior in these processes. Additionally, students will examine indirect metal printing methods, including extrusion, stereolithography, and binder jetting, which rely on sintering to fuse metal powders together. Detailed discussions will cover the sintering process, its underlying mechanisms, and its impact on the final properties of printed parts. Furthermore, the course will delve into metal additive manufacturing processes based on solid-state bonding, such as cold spray and sheet lamination. Students will explore the principles of solid-state bonding, including diffusion bonding and mechanical interlocking, and understand how these processes are applied to join metal powders/sheets without melting. Throughout the course, major alloys commonly used in metal additive manufacturing, such as Ni-based alloys, titanium alloys, steels, and aluminum alloys, will be discussed. Common defects encountered in metal printing technologies, post-processing steps for defect removal, and in situ monitoring techniques for defect mitigation will also be covered, ensuring students gain a comprehensive understanding of quality assurance in metal AM.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to learn the fundamentals of additive manufacturing (AM) of polymers, metals, and ceramics.
- Students will be able to understand the operating principles, capabilities, and limitations of state-of-the-art AM methods, including fused deposition modeling, photopolymerization, laser melting/sintering, and material/binder jetting.
- Students will be able to understand properties of AM parts.
- Students will be able to realize industrial applications of AM.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6510 - Advanced Heat Transfer (4 Credits)
An advanced treatment of conduction and convection from a theoretical perspective. Topics include: conservation of linear momentum in integral and differential forms; steady state and transient conduction; boundary layer flows with emphasis on laminar conditions; scale analysis; forced and natural convection; internal and external flows; fundamentals of radiative exchange between surfaces and relationship to problems of environmental importance (e.g., global climate change); numerical simulation to solve conduction and convection problems.
Enrollment Information: Open to: graduate students at all levels and senior-level undergraduates.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2025, Fall 2022, Fall 2021, Spring 2021
Learning Outcomes:

- Students will be able to develop a capability to theoretically analyze problems in conduction, convection and radiation from a more advanced perspective than an undergraduate course.
- Students will be able to reduce a physical thermal problem to a set of differential equations based on the laws of thermodynamics: predict heat transfer rates for various conduction, convection and radiation configurations.
- Students will be able to become familiar with a commercial code (ANSYS-FLUENT) for solving problems in conduction and convection.
- Students will be able to use scale analysis to 'solve' complex problems in convection.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6530 - Space Exploration Engineering (3 Credits)
A graduate-level survey course on the engineering problems associated with the remote and in-situ exploration of space, with a particular focus on current and near-future practices and tools. Topics covered include science-driven robotic and human exploration of the solar system, astrophysical observatories, and exoplanet detection and characterization.
Prerequisites: coursework in space mechanics and spacecraft engineering, covering topics from the MAE 4060/MAE 4160 sequence.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2023, Spring 2021, Spring 2019
Learning Outcomes:

- Students will be able to understand the space mission formulation requirements setting process for a broad range of space mission classes.
- Students will be able to be aware of the range of remote and in-situ sensing methodologies and available technologies and how they enable space missions of exploration.
- Students will be able to have gained experience in the preparation of oral and written technical presentations and documents, including independent literature review and peer review.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6540 - Plasmas for Propulsion (3 Credits)
This course covers the physics, thermodynamics, and mechanics of ionized fluids for propulsion applications. This course begins by introducing principles of statistical thermodynamics to derive distribution functions for the fluid description of charged particles. Electrohydrodynamic and magnetohydrodynamic continuum models are introduced and applied to equilibrium problems ranging from the transport of a multi-species charged liquid in a propellant reservoir to the acceleration of a supersonic plasma flow. Both continuum and kinetic approaches are applied to understand the key principles and non-linear phenomena pertinent to the design and operation ion engines, Hall thrusters, and generic ion plumes.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Fall 2020
Learning Outcomes:

- Students will be able to calculate and describe basic plasma properties and principles.
- Students will be able to calculate and describe energy transfer mechanisms in plasmas.
- Students will be able to build simulations of charged particle motion in relevant conditions.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6560 - Nanoscale Energy Transport and Conversion (3 Credits)
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2020, Spring 2014
Schedule of Classes (https://classes.cornell.edu/)

MAE 6630 - Immuno-engineering (3 Credits)
Crosslisted with VETMI 6630
Schedule of Classes (https://classes.cornell.edu/)

MAE 6650 - Principles of Tissue Engineering (3 Credits)
Crosslisted with BME 6650, MSE 6650
Covers introductory concepts in tissue engineering, including polymeric biomaterials used for scaffolds, mechanisms of cellbiomaterial interaction, biocompatibility and foreign body response, cell engineering, and tissue biomechanics. This knowledge is applied to engineering of several bodysystems, including the musculoskeletal system, cardiovascular tissues, the nervous system, and artificial organs. These topics are discussed in the context of scale-up, manufacturing, and regulatory issues.
Enrollment Information: Enrollment limited to: graduate students or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2023, Spring 2017, Spring 2015
Schedule of Classes (https://classes.cornell.edu/)

MAE 6670 - Soft Tissue Biomechanics II: Viscoelasticity and Phasic Theory (3 Credits)
Application of mechanics and materials principles to orthopaedic soft tissues. Mechanical properties of cartilage, tendon, and ligaments; applied viscoelasticity theory for cartilage, tendon, and ligament; cartilage, tendon, and ligament biology; tendon and ligament wound healing; osteoarthritis.
Prerequisites: ENGRD 2020.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Spring 2023, Spring 2022, Spring 2021
Learning Outcomes:

- Students will be able to know and understand the function and physiology of orthopaedic soft tissues that lead to effective joint function.
- Students will be able to develop a basic understanding of viscoelasticity theory and its application to orthopaedic tissues.
- Students will be able to apply linear viscoelasticity, quasilinear viscoelasticity, and biphasic theory to tendon, ligament, cartilage, and fibrocartilage.
- Students will be able to understand the rationale for using these theories to characterize the mechanical behavior of orthopaedic tissues.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6680 - Cancer for Engineers and Physicists (3 Credits)
Crosslisted with BME 6680
Introduction to clinical and biological aspects of cancer, organized primarily for a physical science and engineering audience that is interested in the topic but not necessarily steeped in biological training. Stress on description of current understanding and current clinical practice but not the history and process that has led to that understanding. In addition to the biological and medical aspects of cancer, engineering/chemistry/physics aspects of the process e.g., transport, reaction rates, tumor growth models will be discussed at a quantitative level when relevant to system-level understanding of cancer. Topics: Nature and hallmarks of cancer. Introductory human cell biology and modes of dysregulation by carcinogenesis. Cell cycle, aberrant mitogens, dysregulation of checkpoints. Framework and notation for describing reaction networks. Genetic foundations of cancer phenotype--germline and somatic. Tumorigenesis and metastasis. Clinical staging and medical management of the most common human cancers, including breast, prostate, lung, pancreas, colon, leukemia, lymphoma. Information on the course is summarized at blogs.cornell.edu/cancerforengineers.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2020, Spring 2018, Spring 2017, Spring 2015
Schedule of Classes (https://classes.cornell.edu/)

MAE 6700 - Advanced Dynamics (3 Credits)
This course offers an in-depth look at several contemporary approaches to classical mechanics, i.e. the kinematics and kinetics of systems of particles and bodies that may be rigid or elastic. Frames of reference, coordinate systems, vector kinematics, and concepts of energy and momentum are considered in the most general terms. Analytical methods include Kane's formulation, Hamilton's equations, and the Udwadia-Kalaba method. Holonomic and non-holonomic systems are considered in this context. The course introduces concepts in differential geometry as well as the stability and control of such systems.
Prerequisites: MAE 5730.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2021, Spring 2019, Spring 2017, Spring 2016
Learning Outcomes:

- Students will be able to analyze multibody dynamics problems involving 3D motion, contact, and flexible components using multiple contemporary techniques, such as Kane's method and the Udwadia-Kalaba method.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6710 - Human-Robot Interaction: Algorithms and Experiments (3 Credits)
Crosslisted with CS 6754
As robots move from factory floors and battlefields into homes, offices, schools, and hospitals, how can we build robotic systems made for human interaction? Course will cover core engineering, computational, and experimental techniques in human-robot interaction (HRI). Lectures will cover key algorithms in Probabilistic Robotics, including Bayesian Networks, Markov Models, HMMs, Kalman and Particle Filters, MDP and POMPD, Supervised Learning, and Reinforcement Learning. Seminal and recent papers in HRI will be discussed, including topics such as: generating intentional action, reasoning about humans, social navigation, teamwork and collaboration, machine learning with humans in the loop, and human-robot dialog. Students will learn methods for designing and analyzing HRI experiments. Presentation of papers in class, and an HRI-related research project in teams will be required. Intended for M.Eng to PhD students from multiple disciplines including MAE, CS, ECE and IS.
Prerequisites: Python programming experience.
Enrollment Information: Enrollment limited to: graduate students or seniors with permission of instructor.
Last Four Terms Offered: Spring 2025, Fall 2023, Spring 2021, Spring 2020
Learning Outcomes:

- Students will be able to find, read, and comprehend a technical HRI Research Paper.
- Students will be familiar with the main probabilistic algorithms driving computational HRI.
- Students will be able to implement a HRI system in ROS.
- Students will be able to know how to plan and execute a human-subject study and analyze the results of a study using inferential statistics.
- Students will be proficient at presenting a research paper in a 20-minute conference-style presentation.
- Students will be able to know how to critically review a paper and comment on its advantages and shortcomings.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6720 - Advanced Astrodynamics (3 Credits)
Crosslisted with ASTRO 6579
A graduate level course in astrodynamics and trajectory design. Course topics include a brief review of the two body problem, impulsive transfers, and perturbations; orbit determination and one-way ranging; algebraic and symplectic mappings and surfaces of section; the circular and elliptical 3-body problem, invariant manifolds and 3-body orbit design; secular and resonant perturbations; finite and continuous thrust modeling and transfer design. The course will emphasize numerical methods and building deep understanding of modern approaches to orbital design problems. Familiarity with basic orbital mechanics (at the level of MAE 4060 or equivalent) and numerical integration of dynamical systems will be assumed.
Prerequisites: advanced undergraduate course in dynamics.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Spring 2022, Spring 2020, Spring 2018
Learning Outcomes:

- Students will be able to understand the evolution of orbits of spacecraft and natural bodies in response to various forces.
- Students will be able to simulate and fit natural orbits and spacecraft trajectories using a variety of computational tools.
- Students will be able to understand the inner workings of modern orbit design and analysis tools.
- Students will be able to understand the dynamical behavior of planetary systems.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6730 - Robot Manipulation (3 Credits)
Crosslisted with CS 6751
Robot manipulation is the ability for a robot to interact physically with objects in the world and manipulate them towards completing a task. It is one of the greatest technical challenges in robotics, due primarily to the interplay of uncertainty about the world and clutter within it. As robots become integrated into complex human environments, robot manipulation is increasingly necessary to assist humans in these unstructured environments. Robotic manipulation will enable applications like personal assistant robots in the home and factory worker robots in advanced manufacturing. This course is a mixture of lectures and paper presentations and covers the fundamental theory, concepts, and systems of robot manipulation, including both software and hardware. Topics we will cover this semester include perception, state estimation, robot arm kinematics and dynamics, task and motion planning, machine learning, controls, human-robot interaction towards various robot manipulation tasks. The course features a semester-long group project in which students propose, formalize, and execute a working robotic manipulation system towards a real-world task. The scope of possible components is quite broad and extends beyond traditional robotics issues into other aspects of CS. This course is offered to prepare a student for Ph.D. research in robot manipulation.
Prerequisites: Proficiency in C++ or Python, and familiarity with ROS.
Enrollment Information: Primarily for: graduate students, or permission of the instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MAE 6755 - Finite Element Method: Theory and Applications in Mechanics and Multiphysics (3 Credits)
Crosslisted with CEE 6755, EAS 6755
This class is an intermediate-level course on the linear Finite Element Method (FEM) for graduate engineering students. The students will learn to: set up the strong formulation of mechanical, hydraulic, thermal, and coupled problems, write the variational formulation, discretize the weak form in space and time, choose a resolution algorithm, write an input file for a FEM software, and interpret numerical results. Applications will focus on climate change and energy. First, one-dimensional problems will be solved for one dependent variable, e.g., elongation, fluid flow, heat transfer. Second, hydro-mechanical equations for two-phase porous media will be introduced and applied to consolidation problems. Next, 2D space discretization and numerical integration will be explained and applied through simulation and analysis of problems of plane elasticity and seepage. The course will conclude with the modeling unsaturated porous media with applications to geological storage, evapo-transpiration, and subsidence.
Last Four Terms Offered: Spring 2025
Learning Outcomes:

- Approximate the solution of partial differential equations by using a variational method.
- Design Finite Element models for time-dependent hydro-mechanical problems.
- Analyze Finite Element results, numerical errors, and convergence issues.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6760 - Model-Based Estimation (4 Credits)
Course covers a variety of ways in which models and experimental data can be used to estimate model quantities that are not directly measured. Covers methods for solving the class of inverse problems that take the following form: given partial information about a system, what is the behavior of the whole system? Main estimation methods presented are batch least-squares-type estimation for general problems and Kalman filtering for dynamic system problems. Course deals with the issue of observability, which amounts to a consideration of whether a given inverse problem has a unique solution, and briefly covers the concept of statistical hypothesis testing. Techniques for linear and nonlinear models are taught. Both theory and application are presented.
Prerequisites: Knowledge of undergraduate-level probability, linear algebra/linear systems, differential equations, or permission from the instructor.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2022, Fall 2021
Learning Outcomes:

- Students will be able to create, run, interpret and analyze model based estimators such as the Kalman Filter, Extended Kalman Filter, Sigma Point Filter, Information Filter, Particle Filter, and Gauss Sum Filter.
- Students will be able to understand the strengths, weaknesses and best problems/applications for each filter.
- Students will be able to assess the accuracy of filters via statistical hypothesis tests.
- Students will be able to create a square root formulation of a filter for real time implementation.
- Students will be able to develop and analyze a model based filter for a self-selected problem/application.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6770 - Formal Methods for Robotics (3 Credits)
Crosslisted with CS 6752
How can we guarantee robots will never cause harm? How can we prove that complicated mechanical systems, controlled by computers and programmed by people, will always behave as expected under changing conditions and in a variety of uncertain environments? How do we formalize what such behaviors are? Guaranteeing safety, predictability and reliability of robots is crucial for the assimilation of such systems into society, be it at home or in the workplace. While every robotics researcher working with or on a robot is aware of safety issues, only recently the robotics community has begun looking at ways to either formally prove or grarantee by design different behavioral properties such as safety and correctness. This class will present recent results on the topic of formal methods for robotics and automation that combine and extend ideas from control theory, dynamical systems, automata theory, logic, model checking, synthesis, and hybrid systems.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2024, Fall 2021, Fall 2019, Fall 2017
Learning Outcomes:

- The student will be able to define specifications using different formalisms such as temporal logics and sets.
- The student will be able to will explain different verification algorithms.
- The student will be able to explain the different approaches to control synthesis.
- The student will be able to present a state-of-the-art research paper in a way that conveys the main contribution of the paper.
- The student will be able to apply the tools learned in the class to their individually chosen project.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6780 - Multivariable Control Theory (4 Credits)
Crosslisted with ECE 6780
Introduction to multivariable feedback control theory in both time and frequency domain. Topics include model-based control, performance limitations, Linear Quadratic and H-infinity optimal control, control synthesis vis convex optimization, and model predictive control. Additional topics at the discretion of the instructor.
Prerequisites: MAE 4780 or MAE 5780, ECE 6210, plus a strong background in classical control, linear algebra, and state space models.
Last Four Terms Offered: Spring 2024, Spring 2022, Spring 2021, Spring 2020
Learning Outcomes:

- Students will be able to learn how to model dynamical systems for multivariable control by case studies.
- Students will be able to know state-space representation, transfer function matrix and transition matrix approaches.
- Students will be able to understand optimal control theory via case studies in linear quadratic regulator (LQR) and implicit model following (IMF).
- Students will be able to learn robust control theory including H-infinity control design.
- Students will be able to know adaptive control approaches including gain scheduling and model-reference adaptive systems (MRAS).
- Students will be able to gain a further understanding of modern control approaches including model predictive control (MPC), mu-synthesis, sliding mode control and feedback linearization in an independent project.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6790 - Intelligent Sensor Planning and Control (3 Credits)
An introductory course on learning and intelligent-systems techniques for the modeling, planning, and control of dynamic sensors. Methods for intelligent sensor fusion, sensor management, and mobile sensor navigation and control. Topics include neural networks, Bayesian networks, genetic algorithms as they apply to problems drawn from intelligent sensor placement for environmental monitoring, sensor path planning, sensing-and-pursuit games, target classification, and search-and-communications in heterogeneous sensor networks.
Prerequisites: MAE 4780 or MAE 5780 and ECE 6210.
Last Four Terms Offered: Fall 2020, Fall 2019, Fall 2017, Fall 2016
Schedule of Classes (https://classes.cornell.edu/)

MAE 6800 - Design and Control of Haptic Systems (3 Credits)
Study of the design and control of haptic systems, which provide touch feedback to human users interacting with virtual environments and teleoperated robots. Focus is on device modeling (kinematics and dynamics), synthesis and analysis of control systems, design and implementation, and human interaction with haptic systems. Coursework includes homework/laboratory assignments, a research paper presentation, and a hands-on project. Directed toward graduate students in engineering and computer science. Prerequisites: dynamic systems, feedback controls, and MATLAB programming.
Prerequisites: MAE 3260, MAE 3780, CS 1109, CS 1110, or equivalent(s).
Last Four Terms Offered: Fall 2024
Learning Outcomes:

- Students will be able to identify the primary mechanisms of human haptic sensing.
- Students will be able to describe and implement basic telemanipulation controllers.
- Students will be able to design psychophysical and perceptual tests.
- Students will be able to develop a new haptic device or application of a haptic device.
- Students will be able to read, evaluate, and critique research papers.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6810 - Methods of Applied Mathematics I (3 Credits)
Course covers: Cartesian tensors, linear algebra and complex variables.
Enrollment Information: Enrollment limited to: beginning graduate students in engineering and science. Open to exceptional undergraduates by permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 6830 - Astronautic Optimization (3 Credits)
Crosslisted with SYSEN 6830
This course provides a brief review of several topics in sufficient detail to amplify student success: estimation, allocation, and control, classical feedback, sensor noise, and Monte Carlo analysis. The review leads to application of the methods of Pontryagin applied to examples including single-gimballed rocket engines, guidance, and control problems including least squares estimation, and the famous Brachistochrone problem as a motivating example illustrating the minimum time solution is not necessarily the minimum path-length solution, particularly in a gravity field. After taking this course, students will be able to apply their expertise to actual systems in advanced courses or in laboratory settings leveraging analytic (non-numerical) nonlinear programming and real-time optimal control. Graduates will understand the application of constrained (smooth constrained, box constrained, with brief introduction to inequality constrained) and unconstrained optimization; linear-quadratic programming; and Bellman's principle of optimality.
Prerequisites: undergraduate-level coursework in dynamics, calculus (understanding of extrema), and classical feedback control or system dynamics. Recommended prerequisite: coursework or understanding of spacecraft attitude control or rotational mechanics.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- After taking this course, students will be able to apply their expertise to actual systems in space in advanced courses or in spacecraft attitude control laboratory settings leveraging nonlinear programming and real-time optimal control.
- Graduates will understand the application of constrained (smooth constrained, box constrained, inequality constrained) and unconstrained optimization.
- Graduates will understand the application of linear-quadratic programming; and Bellman's principle of optimality; all strictly applied to the problem of spacecraft attitude control.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6870 - Engineering Collective Intelligence: Methods in Multi-Agent Coordination (3 Credits)
Decentralized, self-organizing systems are the future of autonomous technology. Large numbers of self driving cars, ground robots, delivery drones, and mobile sensors are being rapidly deployed into the open world. It is imperative that these systems are capable of proactive collaboration to operate safely and cohesively in dynamic environments. This course will provide an overview of state-of-the-art methods for the design of decentralized coordination in groups of communicating agents, with a focus on mathematical fundamentals and code implementation. A particular emphasis will be placed on nonlinear methods grounded in biological and cognitive principles that give rise to collectively intelligent behaviors in nature. Possible topics covered include collective decision-making, synchronization, and task allocation, with applications to collaborative navigation and collision avoidance.
Schedule of Classes (https://classes.cornell.edu/)

MAE 6900 - Special Investigations in Mechanical and Aerospace Engineering (1-8 Credits)
The Master of Engineering Project adds real world, applied experience to an MEng Program. Projects are the centerpiece of the program, leveraging new and learned subject matter to highlight engineering skills in ways that mirror employment after school. Projects are done in a focus area, under an advisor's direction, usually a faculty member, but also corporate partners. Projects are applied, utilizing engineering tools to complete a a design, an apparatus, a process, or an analysis.
Enrollment Information: Enrollment limited to: candidates for M.Eng. degree in mechanical or aerospace engineering or approval of faculty member offering project.
Last Four Terms Offered: Summer 2025, Spring 2025, Fall 2024, Summer 2024
Learning Outcomes:

- Students will be able to determine feasibility of design or concept; document design issues, challenges, and constraints.
- Students will be able to create detailed and appropriate plana; monitor and assess project progress as related to plan.
- Students will be able to use engineering tools (concepts, modeling, simulations, testing, evaluation) to determine accuracy or success of project.
- Students will be able to apply critical approach to work; how to seek and incorporate feedback; demonstrate sound decision making.
- Students will be able to show written and oral communication, both formally and informally: progress report, email, phone, online.
- Students will be able to demonstrate the use of weekly report, logging, creating a final report and/or presentation.

Schedule of Classes (https://classes.cornell.edu/)

MAE 6910 - M.Eng. Independent Study (1-4 Credits)
This course is designed to allow students to pursue individual learning or topics not covered by existing curriculum that relate to a focus area. Students are required to have a faculty advisor or supervisor for the course. Each course is individualized based on a plan of study negotiated between the student and faculty. Students work independently, and faculty provide guidance and supervision. An independent study must be approved by the Master of Engineering Director. A maximum of four credits will the allowed.
Enrollment Information: Enrollment limited to: candidates for M.Eng. degree in mechanical or aerospace engineering or approval of faculty member offering courses.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MAE 6949 - Seminar for M.S. and First-Year MAE Ph.D. Students (1 Credit)
Mandatory course for all M.S. and first-year Ph.D. students in the Sibley School of Mechanical and Aerospace Engineering. An ongoing orientation and mentoring seminar for M.S. and first-year Ph.D. students that includes research presentations by faculty and students as well as discussions and assignments on such topics as academic ethics, writing technical papers, and publishing.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes (https://classes.cornell.edu/)

MAE 6950 - Special Topics (1-4 Credits)
Special offering providing depth and/or breadth beyond the required mechanical engineering curriculum, in an applications area or discipline with connections to mechanical engineering. This course number is used for courses that are not a permanent part of the curriculum.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2024, Fall 2023, Spring 2023, Spring 2022
Schedule of Classes (https://classes.cornell.edu/)

MAE 6998 - Graduate Research Internship for International Students (1-12 Credits)
Off-campus internship in which graduate students gain experience in mechanical and/or aerospace engineering.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)

MAE 7400 - Finite Element Method for Fluid-Structure Interaction (3 Credits)
Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2022, Fall 2020
Schedule of Classes (https://classes.cornell.edu/)

MAE 7750 - Introductory Nonlinear Finite Element Analysis for Solids (3 Credits)
Crosslisted with CEE 7750
The focus of this course is the development of the fundamentals of nonlinear finite element analysis for continuum solids, spanning topics from finite element formulations, functional analysis, numerical solution techniques to aspects of practical implementation. Most natural phenomena are nonlinear, so the main aim of this course is the development of an adequate framework to model nonlinear phenomena in solids and obtain approximate solutions. We will focus on several problems for solid mechanics, including material nonlinearities, geometric nonlinearities, contact mechanics, and multiphysics problems. All assignments will include coding.
Prerequisites: MAE 5700 or equivalent.
Last Four Terms Offered: Spring 2023, Spring 2021, Spring 2015, Spring 2013
Learning Outcomes:

- Students will be able to develop nonlinear finite element formulations for problems in solid mechanics.
- Students will be able to learn about nonlinear solution techniques.
- Students will be able to learn practical finite element implementation details for nonlinear problems in solid mechanics.

Schedule of Classes (https://classes.cornell.edu/)

MAE 7760 - Applied Dynamical Systems (3 Credits)
Crosslisted with MATH 6270
Topics include review of planar (single-degree-of-freedom) systems; local and global analysis; structural stability and bifurcations in planar systems; center manifolds and normal forms; the averaging theorem and perturbation methods; Melnikov's method; discrete dynamical systems, maps and difference equations, homoclinic and heteroclinic motions, the Smale Horseshoe and other complex invariant sets; global bifurcations, strange attractors, and chaos in free and forced oscillator equations; and applications to problems in solid and fluid mechanics.
Prerequisites: MAE 6750, MATH 6260, or equivalent.
Last Four Terms Offered: Spring 2023, Spring 2021, Spring 2020, Spring 2018
Schedule of Classes (https://classes.cornell.edu/)

MAE 7880 - Continuum Mechanics and Thermodynamics (3 Credits)
Crosslisted with CEE 7780
Continuum mechanics is the basis for a vast array of problems in modern and classical engineering. The focus of this course is the development of the fundamentals of continuum mechanics and thermodynamics which will allow for description of complex phenomena in solids, fluids, and mixtures (solid-fluid) and quickly take us to modern and exciting topics of coupled problems in multiphysics problems in solids as well mechanics of soft and biological materials. Most natural phenomena are nonlinear, so the main aim of this course is the development of an adequate framework to model nonlinear phenomena in solids. The models that will be developed to capture physcial phenomena, can be solved analytically or numerically; towards the latter, a connection of the proposed modeling with the Finite Element Method in the context of multiphysical modeling will be covered.
Prerequisites: MAE 6810, MAE 6110 and MAE 6120 or equivalents.
Last Four Terms Offered: Spring 2024, Spring 2022, Spring 2019, Spring 2017
Schedule of Classes (https://classes.cornell.edu/)

MAE 7999 - Mechanical and Aerospace Engineering Colloquium (1 Credit)
MAE 7999 is a weekly seminar series featuring invited speakers both internal and external. Topics range the areas in Mechanical and Aerospace Engineering. The purpose of MAE 7999 is twofold: (a) to expose students to current research activities, challenges, and opportunities on the frontiers of Mechanical and Aerospace engineering, and (b) to improve student presentation skills by attending and critiquing presentations.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Learning Outcomes:

- Students will be able to be exposed to current research areas.
- Students will be able to learn about current problem solving techniques.
- Students will be able to critique a formal research presentation.
- Students will be able to critique presentation methods.

Schedule of Classes (https://classes.cornell.edu/)

MAE 8900 - Research in Mechanical and Aerospace Engineering (1-15 Credits)
Independent research in an area of mechanical and aerospace engineering under the guidance of a member of the faculty.
Enrollment Information: Enrollment limited to: MS students in Mechanical or Aerospace Engineering or approval from director.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes (https://classes.cornell.edu/)