# BIOLOGICAL & ENVIRONMENTAL ENGINEERING (BEE)

**BEE 2000 - Perspectives on the Climate Change Challenge (1.5 Credits)**
Crosslisted with ENVS 2001
This university-wide seminar series provides critically important perspectives on the grand challenge of climate change. Speakers from Cornell University and other institutions will cover a range of topics including the science of climate change, implications for ecosystems, oceans, forests, agriculture and communities, the important ethical, philosophical and legal insights on the issue, and provide thoughts on societal responses through international mechanisms, economic drivers and communication tools. This seminar series counts towards the requirements of the climate change minor and the ESS minor and major.
**Forbidden Overlaps:** BEE 2000, BEE 2010
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

**BEE 2220 - Sustainable Engineering Thermodynamics (3 Credits)**
The laws of thermodynamics are elegant statements about the conservation, nature, and behavior of energy in the universe. They also provide a roadmap to designing and evaluating sustainable solutions to the world's most pressing challenges, from climate change to food insecurity to the energy crisis. This course examines how fundamental thermodynamic concepts characterize both natural and technological systems. We'll use the concept of exergy to benchmark forms of energy and their potential to do work, enabling us to evaluate the sustainability of energy and transportation sectors. Through exploring complex concepts like Gibbs Free Energy and Chemical Potential, we'll understand pollutant transport in environmental mixtures and analyze how human activities contribute to sea level rise. Students will connect thermodynamic theory to real-world sustainability challenges.
**Prerequisites:** MATH 2930; CHEM 2070 or 2090 or 2150; BEE 2510 or BEE 2600.
**Distribution Requirements:** (PSC-AG)
**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2022, Spring 2021
**Learning Outcomes:**

- Identify, formulate, and solve quantitative thermodynamic relationships for complex systems integrating knowledge from chemistry, physics, biology, mathematics, and prior mass & energy balance courses.
- Understand the complex, interdisciplinary nature of sustainable engineering problems, and the challenges faced by those who seek to address them.
- Propose and evaluate technical and non-technical aspects of sustainable engineering design solutions using thermodynamic and kinetic fundamentals.
- Identify needs for new information, define a process to find information, and develop the ability gauge the reliability of information.

Schedule of Classes

**BEE 2510 - Engineering Processes for Environmental Sustainability (3 Credits)**
Crosslisted with ENGRD 2510
Students will quantitatively understand and analyze environmental issues such as: the impact of industrial contaminants and excess nutrients on water quality; the global carbon cycle; improving global access to clean water. This course integrates principles from chemistry, biology, math and engineering to understand and solve real-world problems that impact three major environmental compartments: air, water, and soil. Students will solve mass and energy balances beginning with simple, closed systems, then progress through reactive, open systems to describe environmental fate and transport of pollutants, natural environmental cycles and remediation scenarios. Students will be exposed to technical and lay material from interdisciplinary sources to understand the environmental externalities - social, political, economic and cultural - that must be considered when proposing solutions to today's most pressing environmental issues. BE and EnvE students must complete either BEE 2510 or BEE 2600 according to their academic plan. Students who complete both BEE 2510 and BEE 2600 receive engineering credit toward their degree for only one of these courses.
**Prerequisites:** CHEM 2070 or CHEM 2090 or AP Chem. Prerequisite or corequisite: MATH 2930.
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 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 improve their ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions (ABET 6).
- 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

**BEE 2600 - Principles of Biological Engineering (3 Credits)**
Crosslisted with ENGRD 2600
Focuses on the integration of biological principles with engineering, math, and physical principles. Students learn how to formulate equations for biological systems in class and practice in homework sets. Topics range from molecular principles of reaction kinetics and molecular binding events to macroscopic applications such as energy and mass balances of bioprocessing and engineering design of implantable sensors. Students will also experience scientific literature searches as related to the biological engineering topics, and critical analysis and evaluation of relevant information sources. BEE students must complete either BEE 2510 or BEE 2600 according to their academic plan. BEE students who complete both BEE 2510 and BEE 2600 receive engineering credit for only one of these courses.
**Prerequisites:** Prerequisite or corequisite: MATH 2930, two semesters of core biology major classes (BIOMG 1350, BIOG 1440, BIOG 1445 or BIOEE 1610) plus BIOG 1500.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**

- Students will develop the ability to formulate differential equations for biological systems using basic principles of mass, momentum and energy conservation.
- Students will develop their abilities to think critically about biological engineering problems and solutions, including the ability to identify and develop alternatives
- Students will identify specific opportunities for integrating biology and engineering to address engineering problems.
- Students will use appropriate scientific literature searches, databases, source evaluation, information analysis and synthesis and presentation in written and oral formats.
- Students will demonstrate literature competency by the end of the course.

Schedule of Classes

**BEE 3280 - Systems and Synthetic Biology for Sustainable Energy (3 Credits)**
The world today is in a state of enormous transition. In the coming few decades, billions of people will leave poverty and enter the developed world. This unprecedented development will be one of the greatest opportunities ever presented to improve global public health and quality of life, but it will only be realized if it's done right. The challenge of sustainable energy is not just to provide energy without polluting the atmosphere with fossil carbon, but to do so at a global scale at a cost that everyone can afford. Thanks to capabilities ranging from room temperature and pressure catalysis to self-assembly, biology offers first draft solutions to problems in sustainable energy from the safe use of nuclear energy, the capture and storage of solar power, mining and purifying elements critical for sustainable energy technologies like rare earths and even in the construction of advanced materials. In each class we will discuss a set of scientific journal articles and use these discuss the advantages, disadvantages and potential of biology in applications in sustainable energy. Inthe past, we have used these discussions to write a scientific article with students as co-authors.
**Prerequisites:** BIOG 1440 or equivalent, BIOMG 3300 or equivalent, MATH 2930, and MATH 2940.
**Last Four Terms Offered:** Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**

- Find, evaluate, and integrate biochemical data on enzymatic reactions from multiple online sources.
- Combine integrated biochemical data, numerical models, and back of the envelope calculations to assess the feasibility of a chosen sustainability technology.
- Graduate students will learn how to lead a group writing project that describes mathematical assessment of the mathematical assessment of a chosen sustainability technology.

Schedule of Classes

**BEE 3299 - Sustainable Development (3 Credits)**
Sustainable development is a predominant environmental, economic, and social concern of the 21st century. This course seeks to introduce students from across Cornell's colleges to key concepts of sustainable development and how they are integrated into life cycle analysis (LCA) assessments of sustainability. Students seeking to expand their knowledge of sustainable development through readings, videos, written assignments, and interaction with their peers are welcome to take the course. Students learn to evaluate sustainability by carrying out a multi-phase LCA assessment from environmental, economic, and social perspectives throughout the semester for a system/product of their choice. Over the course of the semester, work is posted on an e-portfolio to enable peer sharing and commenting. Course is solely asynchronous and web-based. Additional course information can be found at our Sustainable Development page.
**Enrollment Information:** Enrollment limited to: sophomores and above.
**Distribution Requirements:** (DLG-AG, SCH-AG), (SCT-IL)
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

**BEE 3310 - Bio-Fluid Mechanics (4 Credits)**
Properties of Newtonian and non-Newtonian fluids; hydrostatic and dynamic forces; principles of continuity, conservations of mass, energy and momentum and their applications; laminar and turbulent flows, introduction to Navier Stokes; dimensional analysis and similarity; internal and external bio-fluid examples will be covered e.g., blood circulatory systems and animal locomotion.
**Prerequisites:** MATH 2930.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**

- Interpret fundamental equations of fluid mechanics.
- Apply fundamental equations of fluid mechanics to solve problems in biology.
- Apply dimensionless parameters in fluid mechanics to explain fluid phenomena.
- Compute and analyze fluid flow data.
- Review recent works in biofluid mechanics.

Schedule of Classes

**BEE 3400 - Design and Analysis of Biomaterials (3 Credits)**
Covers the analysis of different types of biomaterials, synthetic or bio-derived, their synthesis, characterization and applications. The fundamental understanding of biomaterials chemistry and physics at the molecular level is emphasized. Mathematical analysis towards rational design of biomaterials is used throughout the course. In addition, examples from forefront biomaterials research will be used for case studies.
**Prerequisites:** BEE 2220. Prerequisite or corequisite: BEE 3500.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
**Learning Outcomes:**

- 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 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 improve their 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 improve their capacity to integrate modern biology with engineering principles (ABET-BE).

Schedule of Classes

**BEE 3500 - Heat and Mass Transfer in Biological Engineering (4 Credits)**
Focuses on understanding the principles of heat and mass transfer in the context of biological (biomedical/bioprocessing/bioenvironmental) systems. Emphasizes physical understanding of transport processes with application examples from plant, animal and human biology, the bioenvironment (soil/water/air), and industrial processing of food and biomaterials.
**Prerequisites:** Prerequisite or corequisite: MATH 2930 and BEE 3310 or equivalent.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**

- Develop problem formulation and solution ability following a step-by-step approach, applying to heat and mass transfer in biological systems
- Describe the various modes of heat and mass transfer: conduction, convection, radiation, mass diffusion, dispersion and mass convection
- Apply mass and energy conservation to develop governing equations for heat and mass transfer
- Formulate appropriate types and number of boundary conditions to solve the governing equations for a particular situation
- Identify the ranges of biomaterial properties affecting the heat and mass transfer processes
- Build conceptual knowledge of temperatures/concentrations and heat/mass fluxes in biological systems and calculate the same: I. Under steady and unsteady conduction and diffusion II. In conduction and diffusion in presence of flow III. In radiative and combined radiative-convective situations IV. In systems undergoing phase change (freezing and thawing).

Schedule of Classes

**BEE 3600 - Molecular and Cellular Bioengineering (3 Credits)**
In this class you'll learn about mathematical models of biology that you can use to build engineered organisms. We will cover how to make back of the envelope calculations about biological systems, study the mathematics of metabolic networks for producing commodity chemicals and pharmaceuticals, learn how to approach building a new mathematical model of a biological system, and study mathematical models of gene regulation.
**Prerequisites:** BEE 2600, BIOMG 3300 or equivalent, MATH 2930 and MATH 2940, or permission of instructor.
**Last Four Terms Offered:** Fall 2025, Spring 2024, Spring 2023, Spring 2022
**Learning Outcomes:**

- After this class students should be able to weigh the ethical arguments for and against developing a biotechnology.
- After this class students should be able to search biological databases and condense the results into a mathematical representation.
- After this class students should be able to Install python code using the Unix command line and make calculations using condensed biological data.
- After this class students should be able to present the results of computer calculation and interpret them.
- After this class students should be able to use computer models to understand modes of gene regulation.

Schedule of Classes

**BEE 3710 - Physical Hydrology for Ecosystems (3 Credits)**
Introduction to physical hydrology with an emphasis on roles and interactions between hydrological processes and ecological, biogeochemical, and human systems.
**Prerequisites:** MATH 1920.
**Exploratory Studies:** (CU-SBY); (LAAREA)

**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2021
**Learning Outcomes:**

- Explain the components of the hydrological cycle and calculate the major fluxes.
- Create a simple watershed model.
- Manipulate and analyze basic hydrologic data.
- Connect hydrologic processes with ecological and chemical processes in the landscape.
- Assess impacts and risk to water resources due to climate change & human-activities.
- Make basic hydrologic field measurements such as snow-water equivalent, stream discharge, and infiltration (weather depending).

Schedule of Classes

**BEE 3801 - Introduction to Nanobiotechnology (1 Credit)**
This course is offered as part of the CALS Signature Semester: Toward a Sustainable Future and Emerging Technologies in China on site in Shanghai, China. Nanobiotechnology strides at the interface between nanotechnology and biotechnology. This introductory course teaches the nano concept related to nanotechnology and biotechnology. The course further covers nanoscale building blocks of life, in particular nucleic acids (including DNA, RNA, TNA, PNA, etc.). Students also learn the concepts of polymers, biosensing, hierarchy assemblies and self-assemblies in the context of sustainability. A variety of related techniques are examined along with demonstrations of real-world applications at different scales, from nano to eco.
**Prerequisites:** basic (first-year and sophomore-level) mathematics, physics, chemistry and biology.
**Exploratory Studies:** (CU-ITL)

**Last Four Terms Offered:** Spring 2023, Spring 2022, Spring 2021, Spring 2019
**Learning Outcomes:**

- The students from China (SJTU) and from Cornell University (CALS) will interact and learn from each other intellectually and culturally.
- Examine the importance of sizes when down to the nanoscale; different sets of physical rules start to govern the behavior of objects.
- Grasp the concept of movement at the nanoscale related to diffusion and energy.
- Define the concept that DNA is not only a genetic biomaterial but also a generic nanomaterial.
- Assess several fundamental tools related to nanobiotechnology.

Schedule of Classes

**BEE 3900 - Bio-Robotics (3 Credits)**
Introduction to bio-inspired and bio-enabled robotics across scales by an interdisciplinary approach, by gradually integrating knowledge in mechanical engineering and bioengineering. The concept and basic principles of biorobotics are discussed through macroscale robots in various fields including agriculture such as fruit picking robots. Homework includes programming, literature searches, and design studies of their own biorobots.
**Prerequisites:** MATH 2930 or permission of instructor.
**Exploratory Studies:** (CU-SBY)

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

- Identify, formulate, and solve complex engineering robotic components by applying principles of engineering, science and mathematics.
- Apply robotic design to produce solutions that meet specified needs with consideration of agricultural health and safety.
- Integrate/synthesize your knowledge of biology, physics, chemistry, and/or engineering analysis to create a robot.

Schedule of Classes

**BEE 3910 - Advanced Bio-Robotics (3 Credits)**
**Last Four Terms Offered:** Spring 2023
Schedule of Classes

**BEE 4270 - Water Measurement and Analysis Methods (3 Credits)**
Managing soil and water resources requires monitoring. In this field-based lab course, you learn techniques to quantify water flow in surface and subsurface environments and monitor water quality in lakes, rivers, and groundwater. Soil health considerations, measurement accuracy, and water sampling quality assurance are discussed. The final project involves designing a water quality monitoring plan for a research or industrial site.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**

- Students will display an ability to communicate effectively with a range of audiences (ABET 3).
- Students will improve their ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions (ABET 6).

Schedule of Classes

**BEE 4310 - Environmental Statistics and Learning (4 Credits)**
This course introduces statistical and machine learning techniques for analyzing complex datasets in the environmental sciences and engineering. It focuses on supervised learning methods, such as regression, decision trees, and neural networks, applied to real environmental data, with emphasis on both prediction and inference. Designed for students with basic statistics knowledge, the course provides a practical foundation in applied statistics and machine learning. It includes review of key mathematical and coding concepts needed to implement these tools. The goal is to build a toolbox of methods not covered in introductory courses and to help students understand when and why to use each method. Learning is hands-on, with in-class programming exercises that translate theory into application using real-world datasets.
**Prerequisites:** CEE 3040 or ENGRD 2700 or BTRY 3010.
**Enrollment Information:** Preferred prerequisite of MATH 2940.
**Distribution Requirements:** (DLS-AG)
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Fall 2025, Fall 2024, Spring 2022, Spring 2021
**Learning Outcomes:**

- Apply statistical and machine learning techniques in modern programming languages.
- Interpret and communicate analyses of data to support scientific discovery and advance engineering solutions in environmental fields.
- Appropriately use generative AI to assist and enhance data analysis skills to support higher-order synthesis, thinking, and learning.

Schedule of Classes

**BEE 4500 - Bioinstrumentation (3-4 Credits)**
Bioinstrumentation applications are emphasized in this laboratory-based course. Electronic instruments from sensor to computer are considered. Static and dynamic characteristics of components and systems are examined theoretically and empirically. General analog and digital signal condition circuits are designed, constructed, and tested. A variety of biological applications of instrumentation are discussed. Lecture and lab only for 3 credits; lecture, lab and design project for 4 credits. The 3 credit class ends after week 10. The 4 credit class includes a design project and continues for the full semester.
**Prerequisites:** MATH 2940, CS 1112, PHYS 1112 and PHYS 2213; and CEE 3040 or permission of instructor.
**Exploratory Studies:** (CU-SBY)

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

- 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 improve their ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions (ABET 6).

Schedule of Classes

**BEE 4520 - Advances in Bioremediation (3 Credits)**
This course will primarily be an in-depth analysis of the various areas in which organisms are be used to physically remove or metabolize (and co-metabolize) various pollutants in the environment. We will examine various types of bioremediation including: bacterial degradation of organic pollutants, biotransformation of per- and polyfluoroalkyl substances, bioremediation of microplastics, and phytoremediation of pesticides and heavy metals. We will evaluate the promise of such technologies as well as the current obstacles to realizing their potential. We will examine the current efforts to "design" organisms to be better bioremediators and talk about the use of genetically altered organisms in the field.
**Prerequisites:** CEE 4510.
**Learning Outcomes:**

- Have knowledge of what bioremediation is and a broad understanding of its current application in the field of environmental engineering.
- Have an improved appreciation of how research in bioremediation is leading to new tools for protecting human health and the environment, as well as managing sites in the future.
- Become familiar with biological research tools (including synthetic biology) and how they are applied to bioremediation.
- Become familiar with chemical analysis research techniques and how they are used in bioremediation.
- Develop a strong familiarity with primary literature focused on bioremediation and have the ability to read scientific papers with a critical eye to identify knowledge gaps and understand how the work fits into the field.
- Gain experience working in teams and leading paper discussions in class.

Schedule of Classes

**BEE 4530 - Computer-Aided Engineering: Applications to Biological Processes (3 Credits)**
Crosslisted with MAE 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 isa major part of the course (no final exam).
**Prerequisites:** BEE 3500 or MAE 3240 or CHEME 3240 or BME 2000.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
**Learning Outcomes:**

- think of computer simulation as an important practical tool in design and research projects in the industry as well as academia
- know the guts of a typical computer prototyping software
- have realistic ideas about the advantages and pitfalls of such a software
- know about some thermal therapy
- be comfortable in solving less complex problems and working with a group of experts in solving problems with increasing complexity.

Schedule of Classes

**BEE 4550 - Biologically Inspired Microsystems Engineering (2-3 Credits)**
Covers fundamental mechanisms that nature uses to build and control living systems at micro- and nano-meter length scales; engineering principles for fabricating micro/nano-meter scale devices; examples of solving contemporary problems in the health sector and environment.
**Prerequisites:** BIOMG 1350, BIOG 1440, BIOG 1445 or BIOEE 1610; BEE 2220, or co-registration in BEE 3500 or permission of instructor.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Fall 2022, Fall 2021
Schedule of Classes

**BEE 4560 - Ecological Biomechanics (3 Credits)**
Ecological mechanics explores ecological relations from a mechanics perspective, including fluid, solid, structural mechanics, and heat and mass transport. While other ecological studies incorporate transport of mass, energy, and information, consideration of momentum transport and its consequence in biotic and abiotic relations in organisms is unique to this discipline. We begin the course by introducing the fundamental and advanced concepts in mechanics. Then we will learn how to incorporate these concepts by considering response function (the functional relationship between condition imposed on the system and its response) to understand and predict ecological phenomena such as predator-prey relation and pattern formation.
**Prerequisites:** at least one of the following courses or their equivalent: ENGRD 2020, BEE 3310, BEE 3500, and BEE 3400 or equivalent.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023
Schedule of Classes

**BEE 4590 - Physical Design in Biological Engineering (3 Credits)**
Students will choose a project depending on their interests and complete the project goal by integrating the knowledge of biology, physics, and engineering. Students will present their proposal and final results, and write a report at the end of the semester. Students who have not met the prerequisite must obtain the instructor's permission to enroll in the class. This course satisfies the BE capstone design requirement.
**Prerequisites:** ENGRC 3350.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 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

**BEE 4620 - Water Quality and Management (3 Credits)**
This course investigates aspects of physical, chemical, and biological water quality and management approaches. The course highlights relationships between human activities, water scarcity, water quality degradation, and ecological and health consequences. We will then examine policies aimed at managing water quality.
**Exploratory Studies:** (CU-SBY)

**Learning Outcomes:**

- Describe physical, chemical, and biological factors impacting water quality;
- Assess water quality concerns for a water body based on available data;
- Explain national and international policies that improved water quality;
- Develop management strategies to address water quality issues

Schedule of Classes

**BEE 4630 - Digital Food Physics and Engineering (3 Credits)**
Mechanistic, model-based understanding and digital tools critically innovate in the design cycle for products and processes, food manufacturing is no exception. The course will introduce tools such as computational modeling, digital twins, and predictive knowledge bases, exploring deeper into the underlying universal physics-based frameworks describing transformations in food during processing. Grading is based on in-class and online quizzes, homework and project (no exams).
**Prerequisites:** BEE 3310 or BEE 3500, or thier equivalent, or permission of instructor.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023
**Learning Outcomes:**

- Explain a food physics framework in terms of its basic building blocks that can describe many food processes.
- Compare and contrast between simpler and more comprehensive physics frameworks for understanding food processes.
- Apply a food physics framework to complex food processes for their understanding and optimization.
- Create framework-based computational model of a food process that speeds up the design cycle.

Schedule of Classes

**BEE 4670 - Applied Water Research In NYS (1 Credit)**
Every year, the New York State Water Resources Institute (NYSWRI) at Cornell supports applied research that addresses critical water resource problems in the New York State and the nation. This seminar series brings together researchers who work with NYSWRI and state agency partners to support and improve water management in the state. Speakers will present on a broad range of water related topics including water engineering and infrastructure, climate and flood resilience, water quality monitoring and assessment and aquatic ecosystems. The seminar will focus on ways in which robust science can support and influence on-ground management and policy outcomes, and center collaborative and interdisciplinary work between academics, water resource scientists, educators, managers, and policymakers in New York State.
**Last Four Terms Offered:** Spring 2025, Spring 2024
**Learning Outcomes:**

- Evaluate the relevance of research questions, study design, and data collection methods in the context of water policy in New York State.
- Engage in discussions on water-related topics and actively participate in question-and-answer sessions with guest speakers.
- Synthesize and connect information from presentations to analyze the connections between different topics in water management.
- Demonstrate an expanded knowledge of the complexities of real-world water problems and their implications for water resource management.

Schedule of Classes

**BEE 4710 - Introduction to Groundwater (3 Credits)**
Crosslisted with EAS 4710
Fresh water has become a limited resource in many parts of the world. In arid and semi-arid regions, groundwater levels are declining at unstainable levels. In several industrial areas, groundwater is contaminated and unsuitable as potable water. This course will address the sustainability and pollution of groundwater by first understanding the theory of saturated and unsaturated flow and contaminant transport under ideal conditions. Subsequently, we learn to simplify groundwater systems in complex subsurface environments to obtain practical solutions. At the end of the course, the learned material will be put in a broader context as they are affected by natural or human actions. Throughout the course, guest speakers will discuss topics of current interest related to water. This elective course is intended for seniors interested in subsurface water and solute transport applications to sustainable groundwater use and prevention of pollution. Well-prepared EAS, CEE and BEE juniors are welcome, too.
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

**BEE 4730 - Watershed Engineering (4 Credits)**
Teaches basic engineering design and analysis as practiced for water control and nonpoint source pollution prevention. Discusses the origins of design approaches, including their theoretical bases and recent or emerging methods and concepts. Most of the course is dedicated to practicing applied design. Assignments are generally representative of real-life engineering problems and involve as much hands-on experience as possible. Some example topics include risk analysis, water conveyance, stormwater management, including green infrastructure and low-impact development. Satisfies EnvE capstone design requirement. Satisfies College of Engineering technical communications requirement.
**Prerequisites:** CEE 3310.
**Exploratory Studies:** (CU-CEL, CU-SBY)

**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**
- Apply scientific and engineering principles and methods to create designs.
- Evaluate different approaches especially with respect to climate change.
- Present work in concise, organized reports, presentations, and other professional communication formats.
- Work in groups.
- Collect “real-world” data necessary for engineering design and analyses.
- Engage stakeholders/community members in design projects.

Schedule of Classes

**BEE 4750 - Environmental Systems Analysis (3 Credits)**
Applications of mathematical modeling, simulation, and optimization to environmental systems planning and management. Fate and transport models for contaminants in air, water, and soil. Optimization methods (search techniques, linear programming, integer programming) to evaluate alternatives for power systems, solid- waste management, and water and air pollution control. Introduction to the impact of uncertainty on solutions and risk assessment through simulation.
**Prerequisites:** BEE 2510 or BEE 2600, ENGRD 2700 or CEE 3040, CEE 3200.
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**
- Construct mathematical models of environmental systems.
- Use systems models to simulate dynamics and outcomes.
- Analyze environmental system risk and vulnerabilities.
- Determine strategies for managing systems using optimization.
- Identify the trade-offs that result from competing objectives in environmental decision -making.
- Evaluate modeled outcomes with respect to model assumptions and limits.

Schedule of Classes

**BEE 4800 - Atmospheric Chemistry: From Air Pollution to Global Change (3 Credits)**
Crosslisted with EAS 4800
This course investigates the science of atmospheric chemistry as its relation to air pollution and global change. Students examine the chemistry and physics that determines atmospheric composition on local to global scales including the effects of biogeochemistry and atmospheric photochemistry.
**Prerequisites:** CHEM 2070 or CHEM 2090, MATH 1920, and PHYS 1112 or permission of instructor.
**Distribution Requirements:** (OPHLS-AG), (PHS-AS)
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2022, Fall 2021
**Learning Outcomes:**
- Apply the principles of chemistry and physics to the atmosphere, its composition, its chemistry and air quality.
- Use simple analytical models and concepts to analyze and describe the complex system of the atmosphere and its chemistry.
- Relate environmental problems to the science behind them, in terms of methodologies in which they can be addressed scientifically, the uncertainty in the results, and the ability to make informed decisions about environmental policy.

Schedule of Classes

**BEE 4830 - Engineering Sustainability (3 Credits)**
Sustainability is a complex and multifaceted concept without straightforward solutions. This course is a multidisciplinary introduction to the evaluation of sustainability, sustainable development obstacles and opportunities, and explore engineering research needs. We will practice both qualitative and quantitative approaches with a heavy focus on writing about sustainability concepts and sustainability analysis in practice. The course spans modules that focus on understanding the root causes of unsustainability to sustainability assessment frameworks to design and innovation. The culmination of the course will be a final team project that will be developed by an industry, campus, or community partner to practice the quantitative approaches learned in the course and tie to the relevant qualitative concept discussed in class.
**Prerequisites:** BEE 2220 and BEE 2510 or BEE 2600.
**Distribution Requirements:** (DLG-AG, SCH-AG)
**Exploratory Studies:** (CU-SBY)

**Learning Outcomes:**
- Identify, formulate, and solve quantitative sustainability assessments of products and processes for industry and research applications.
- Understand the complex, interdisciplinary nature of sustainable engineering and be able to produce relevant information for identifying tradeoffs and making decisions.
- Critically think about practical ways that engineers can include social, ecological and technological systems into our problem solving and efforts towards sustainable design.
- Quantify various ecosystem services (ES) and apply ES frameworks within sustainability assessment and design.

Schedule of Classes

**BEE 4850 - Environmental Data Analysis and Simulation (3 Credits)**
Understanding data is an increasingly integral part of working with environmental systems. Data analysis is an integral part of developing statistical and numerical models to understand system dynamics and project future conditions and outcomes. Simulation from models can represent alternative datasets consistent with a set of assumptions about the underlying data-generating process, facilitating model assessment and hypothesis testing. This course will provide an overview of a generative approach to environmental data analysis, which uses simulation and assessments of predictive performance to provide insight into the structure of data and its data-generating process. The goal is to provide students with a framework and an initial toolkit of methods that they can use to formulate and update hypotheses about data and models. Students will actively analyze and use real data from a variety of environmental systems, potentially including the climate system, sea levels, air pollution, and the electric power system.
**Prerequisites:** CEE 3040, ENGRD 2700, or equivalent, CS 1110 or CS 1112; or permission of instructor.
**Distribution Requirements:** (DLS-AG)
**Last Four Terms Offered:** Spring 2025, Spring 2024
**Learning Outcomes:**
- Create, interpret, and critique data visualizations.
- Calibrate environmental models to observations, possibly including censored and missing data.
- Simulate alternative datasets from models using statistical methods such as the bootstrap and Monte Carlo.
- Assess model adequacy and performance using predictive simulations.
- Apply and contextualize model selection criteria.
- Evaluate evidence for and against hypotheses about environmental systems using model simulations.
- Emulate computationally-complex models with simpler representations.

Schedule of Classes

**BEE 4880 - Applied Modeling and Simulation for Renewable Energy Systems (3 Credits)**
Crosslisted with CEE 4880
This course will provide an applied introduction to modeling, simulation and optimization techniques for various renewable energy systems. The course will be modular in nature. Each module will focus on a particular renewable energy application and relevant modeling/simulation tools. Some modules are independent and some will build on previous modules. The instructional format of the course will include lectures, scientific paper reviews, and some AMPL programming. Students will have an opportunity to apply new techniques to a relevant modeling project. The course will culminate with a modeling project relevant to renewable energy. Undergraduates will work in teams of 2-3 students to complete the term project.
**Enrollment Information:** Enrollment limited to: seniors in Engineering, or permission of instructor.
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2021
Schedule of Classes

**BEE 4940 - Special Topics in Biological and Environmental Engineering (1-4 Credits)**
The department teaches trial courses under this number. Offerings vary by semester and will be advertised by the department. Courses offered under this number will be approved by the department curriculum committee and the same course will not be offered twice under this number. Each 4940 has a unique course ID for enrollment.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

**BEE 4970 - Individual Study in Biological and Environmental Engineering (1-4 Credits)**
Special work in any area of biological and environmental engineering on problems under investigation by the department or of special interest to the student, provided, in the latter case, that adequate facilities can be obtained.
**Prerequisites:** adequate ability and training for work proposed.
**Exploratory Studies:** (CU-UG)

**Last Four Terms Offered:** Fall 2025, Spring 2025, Fall 2024, Spring 2024
Schedule of Classes

**BEE 4980 - Undergraduate Teaching (1-4 Credits)**
The student assists in teaching a biological and environmental engineering course appropriate to his or her previous training. The student meets with a discussion or laboratory section, prepares course materials, grades assignments, and regularly discusses objectives and techniques with the faculty member in charge of the course.
**Last Four Terms Offered:** Fall 2025, Spring 2025, Fall 2024, Spring 2024
Schedule of Classes

**BEE 4990 - Undergraduate Research (1-8 Credits)**
Research in any area of biological or environmental engineering on problems under investigation by the department or of special interest to the student, provided that adequate facilities can be obtained. The student must review pertinent literature, prepare a project outline, carry out an approved plan, and submit a formal final report.
**Prerequisites:** adequate training for work proposed.
**Exploratory Studies:** (CU-UG)

**Last Four Terms Offered:** Fall 2025, Spring 2025, Fall 2024, Spring 2024
Schedule of Classes

**BEE 4993 - Honors Thesis (3-6 Credits)**
Intended for students pursuing the research honors program in BEE. This course is the culmination of the program's honors project requirement. Students enrolled in the BEE Honors program will prepare an honors thesis based on the subject matter of a BEE 4990 project from the previous semester, under the supervision of their research mentor. A preliminary draft and the final copy will be submitted according to the deadline and formatting requirements of the Honors program.
**Prerequisites:** BEE 4990.
**Enrollment Information:** Primarily for: BEE honors program students.
**Exploratory Studies:** (CU-UG)

**Last Four Terms Offered:** Fall 2025, Spring 2025, Fall 2024, Spring 2024
Schedule of Classes

**BEE 4994 - Research for Visiting Students (1-12 Credits)**
Research in any area of biological and environmental engineering on problems under investigation by the department or of special interest to the student, provided that adequate facilities can be obtained. The student must review pertinent literature, prepare a project outline, carry out an approved plan and submit a formal final report.
**Last Four Terms Offered:** Fall 2025, Spring 2025, Fall 2024, Spring 2024
Schedule of Classes

**BEE 5270 - Water Measurement and Analysis Methods (3 Credits)**
Managing soil and water resources requires monitoring. In this field-based lab course, you learn techniques to quantify water flow in surface and subsurface environments and monitor water quality in lakes, rivers, and groundwater. Soil health considerations, measurement accuracy, and water sampling quality assurance are discussed. The final project involves designing a water quality monitoring plan for a research or industrial site. Graduate students review the literature on the accuracy of the lab methods and present the results in class.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes

**BEE 5280 - Systems and Synthetic Biology for Sustainable Energy (3 Credits)**
The world today is in a state of enormous transition. In the coming few decades, billions of people will leave poverty and enter the developed world. This unprecedented development will be one of the greatest opportunities ever presented to improve global public health and quality of life, but it will only be realized if it's done right. The challenge of sustainable energy is not just to provide energy without polluting the atmosphere with fossil carbon, but to do so at a global scale at a cost that everyone can afford. Thanks to capabilities ranging from room temperature and pressure catalysis to self-assembly, biology offers first draft solutions to problems in sustainable energy from the safe use of nuclear energy, the capture and storage of solar power, mining and purifying elements critical for sustainable energy technologies like rare earths and even in the construction of advanced materials. In each class we will discuss a set of scientific journal articles and use these discuss the advantages, disadvantages and potential of biology in applications in sustainable energy. In each of the past two years we have used these discussions to write a scientific article with students as co-authors.
**Prerequisites:** at least one of the following courses or their equivalent: BIOG 1440, BIOMG 3300, MATH 2930, and MATH 2940.
**Last Four Terms Offered:** Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**

- Find, evaluate, and integrate biochemical data on enzymatic reactions from multiple online sources.
- Combine integrated biochemical data, numerical models, and back of the envelope calculations to assess the feasibility of a chosen sustainability technology.
- Graduate students will learn how to lead a group writing project that describes mathematical assessment of the mathematical assessment of a chosen sustainability technology.

Schedule of Classes

**BEE 5299 - Sustainable Development (3 Credits)**
Sustainable development is a predominant environmental, economic, and social concern of the 21st century. This course introduces the key concepts of sustainable development and how they are integrated into life cycle analysis (LCA) assessments of sustainability. Students seeking to expand their knowledge of sustainable development through readings, videos, written assignments, and interaction with their peers are welcome to take the course. Students learn to evaluate sustainability by carrying out a multi-phase LCA assessment from environmental, economic, and social perspectives throughout the semester for a system/product of their choice relevant to their majors. Over the course of the semester, work is posted on an e-portfolio to enable peer sharing and commenting. Course is solely asynchronous and web-based. This course follows the same trajectory as BEE 3299, but with greater required depth of research and extent of peer interaction. Additional course information can be found at our Sustainable Development page.
**Enrollment Information:** Enrollment limited to: graduate/professional and (with instructor permission) advanced undergraduate students.
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

**BEE 5310 - Bio-Fluid Mechanics (4 Credits)**
Properties of Newtonian and non-Newtonian fluids; hydrostatic and dynamic forces; principles of continuity, conservation of mass, energy and momentum and their applications; laminar and turbulent flows, introduction to Navier Stokes; dimensional analysis and similarity; internal and external bio-fluid examples will be covered e.g., blood circulatory systems and animal locomotion.
**Prerequisites:** MATH 2930.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**

- Interpret fundamental equations of fluid mechanics.
- Apply fundamental equations of fluid mechanics to solve problems in biology.
- Apply dimensionless parameters in fluid mechanics to explain fluid phenomena.
- Compute and analyze fluid flow data.
- Review recent works in biofluid mechanics.

Schedule of Classes

**BEE 5330 - Engineering Professionalism (1 Credit)**
Crosslisted with ENGRG 5330
The primary focus is to prepare students for the Fundamentals of Engineering (FE) exam, which is the first step in obtaining a Professional Engineering license. Students complete a formal comprehensive review of engineering subjects associated with the FE exam. Engineering professionalism topics will be covered in some of the lectures or asynchronous videos.Students are advised to sign up to take the Fundamental of Engineering (FE) exam during the semester. Students sign up directly with the NCEES site. Once the nationally conducted FE exam is passed, it is valid forever in any state as part of Professional Engineering registration.Course grading is based upon weekly quizzes, assignments within the asynchronous videos, attendance, and a comprehensive online final that is similar to the FE exam. Alternatively, the quizzes and final portion of the grade can be covered by passing of the FE Exam during the semester.
**Enrollment Information:** Enrollment limited to: seniors who will graduate with an accredited engineering degree and graduate students with accredited engineering degree.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

**BEE 5459 - Energy Seminar I (1 Credit)**
Crosslisted with ECE 5870, CHEME 5870, MAE 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 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes

**BEE 5469 - Energy Seminar II (1 Credit)**
Crosslisted with ECE 5880, CHEME 5880, MAE 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

**BEE 5500 - Heat and Mass Transfer in Biological Engineering (4 Credits)**
Focuses on understanding the principles of heat and mass transfer in the context of biological (biomedical/bioprocessing/bioenvironmental) systems. Emphasizes physical understanding of transport processes with application examples from plant, animal and human biology, the bioenvironment (soil/water/air), and industrial processing of food and biomaterials. Students in BEE 5500 will develop a more complex computational model (for which analytical solution is difficult) using the software used in one of the homework. The goal of this activity will not be computation itself but using numerical computation to probe deeper into one or more aspects of conduction/diffusion, flow, generation/depletion, or geometry effect in a transport process.
**Prerequisites:** Prerequisite or corequisite: MATH 2930 and BEE 3310 or equivalent.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**

- Develop problem formulation and solution ability following a step-by-step approach, applying to heat and mass transfer in biological systems
- Describe the various modes of heat and mass transfer: conduction, convection, radiation, mass diffusion, dispersion and mass convection
- Apply mass and energy conservation to develop governing equations for heat and mass transfer
- Formulate appropriate types and number of boundary conditions to solve the governing equations for a particular situation
- Identify the ranges of biomaterial properties affecting the heat and mass transfer processes
- Build conceptual knowledge of temperatures/concentrations and heat/mass fluxes in biological systems and calculate the same: I. Under steady and unsteady conduction and diffusion II. In conduction and diffusion in presence of flow III. In radiative and combined radiative-convective situations IV. In systems undergoing phase change (freezing and thawing).

Schedule of Classes

**BEE 5520 - Advances in Bioremediation (3 Credits)**
This course will primarily be an in-depth analysis of the various areas in which organisms are be used to physically remove or metabolize (and co-metabolize) various pollutants in the environment. We will examine various types of bioremediation including: bacterial degradation of organic pollutants, biotransformation of per- and polyfluoroalkyl substances, bioremediation of microplastics, and phytoremediation of pesticides and heavy metals. We will evaluate the promise of such technologies as well as the current obstacles to realizing their potential. We will examine the current efforts to “design” organisms to be better bioremediators and talk about the use of genetically altered organisms in the field.
**Prerequisites:** CEE 4510.
**Learning Outcomes:**

- Develop a deep understanding of how research in bioremediation is leading to new tools for protecting human health and the environment, as well as managing sites in the future.
- Increased familiarity with biological research tools (including synthetic biology) and how they are applied to bioremediation.
- Increased familiarity with chemical analysis research tool and how they are used in bioremediation.
- Become familiar with professional associations and publications in the field of environmental microbiology and bioremediation.
- Develop a deep understanding of the primary literature focused on bioremediation and have the ability to read scientific paper with a critical eye to identify knowledge gaps and understand how the work fits into the field.
- Gain experience leading paper discussions in class. Gain experience leading or co-leading a team to complete a well-communicated group project focused on a bioremediation application.

Schedule of Classes

**BEE 5530 - Computer-Aided Engineering: Applications to Biological Processes (3 Credits)**
Crosslisted with MAE 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).
**Prerequisites:** BEE 3500 or MAE 3240 or CHEME 3240 or BME 2000.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
**Learning Outcomes:**

- think of computer simulation as an important practical tool in design and research projects in the industry as well as academia
- know the guts of a typical computer prototyping software
- have realistic ideas about the advantages and pitfalls of such a software
- know about some thermal therapy
- be comfortable in solving less complex problems and working with a group of experts in solving problems with increasing complexity.

Schedule of Classes

**BEE 5590 - Physical Design in Biological Engineering (3 Credits)**
Students will choose a project depending on their interests, and complete the project goal by integrating the knowledge of biology, physics, and engineering. Students will present their proposal and final results, and write a report at the end of the semester.
**Prerequisites:** BEE 3310, BEE 3500.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes

**BEE 5600 - Molecular and Cellular Bioengineering (3 Credits)**
In this class you'll learn about mathematical models of biology that you can use to build engineered organisms. We will cover how to make back of the envelope calculations about biological systems, study the mathematics of metabolic networks for producing commodity chemicals and pharmaceuticals, learn how to approach building a new mathematical model of a biological system, and study mathematical models of gene regulation.
**Prerequisites:** BEE 2600, BIOMG 3300 or equivalent, MATH 2930 and MATH 2940, or permission of instructor.
**Last Four Terms Offered:** Fall 2025, Spring 2024, Spring 2023, Spring 2022
**Learning Outcomes:**

- After this class students should be able to weigh the ethical arguments for and against developing a biotechnology.
- After this class students should be able to search biological databases and condense the results into a mathematical representation.
- After this class students should be able to Install python code using the Unix command line and make calculations using condensed biological data.
- After this class students should be able to present the results of computer calculation and interpret them.
- After this class students should be able to use computer models to understand modes of gene regulation.

Schedule of Classes

**BEE 5710 - Physical Hydrology for Ecosystems (3 Credits)**
Introduction to physical hydrology with an emphasis on roles and interactions between hydrological processes and ecological, biogeochemical, and human systems.
**Prerequisites:** MATH 1920.
**Exploratory Studies:** (CU-SBY)

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

- Explain the components of the hydrological cycle and calculate the major fluxes.
- Create a simple watershed model.
- Manipulate and analyze basic hydrologic data.
- Connect hydrologic processes with ecological and chemical processes in the landscape.
- Assess impacts and risk to water resources due to climate change & human-activities.
- Make basic hydrologic field measurements such as snow-water equivalent, stream discharge, and infiltration (weather depending).

Schedule of Classes

**BEE 5730 - Watershed Engineering (4 Credits)**
Teaches basic engineering design and analysis as practiced for water control and nonpoint source pollution prevention. Discusses the origins of design approaches, including their theoretical bases and recent or emerging methods and concepts. Most of the course is dedicated to practicing applied design. Assignments are generally representative of real-life engineering problems and involve as much hands-on experience as possible. Some example topics include risk analysis, water conveyance, stormwater management, including green infrastructure and low-impact development.
**Prerequisites:** CEE 3310.
**Exploratory Studies:** (CU-CEL, CU-SBY)

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

- Apply scientific and engineering principles and methods to create designs.
- Evaluate different approaches especially with respect to climate change.
- Present work in concise, organized reports, presentations, and other professional communication formats.
- Work in groups.
- Collect "real-world" data necessary for engineering design and analyses.
- Engage stakeholders/community members in design projects.

Schedule of Classes

**BEE 5750 - Environmental Systems Analysis (3 Credits)**
Applications of mathematical modeling, simulation, and optimization to environmental systems planning and management. Fate and transport models for contaminants in air, water, and soil. Optimization methods (search techniques, linear programming, integer programming) to evaluate alternatives for power systems, solid waste management, and water and air pollution control. Introduction to the impact of uncertainty on solutions and risk assessment through simulation.
**Prerequisites:** BEE 2510 or BEE 2600, ENGRD 2700 or CEE 3040, CEE 3200.
**Exploratory Studies:** (CU-SBY)

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

- Construct mathematical models of environmental systems.
- Use systems models to simulate dynamics and outcomes.
- Analyze environmental system risk and vulnerabilities.
- Determine strategies for managing systems using optimization.
- Identify the trade-offs that result from competing objectives in environmental decision -making.
- Evaluate modeled outcomes with respect to model assumptions and limits.

Schedule of Classes

**BEE 5850 - Environmental Data Analysis and Simulation (3 Credits)**
Understanding data is an increasingly integral part of working with environmental systems. Data analysis is an integral part of developing statistical and numerical models to understand system dynamics and project future conditions and outcomes. Simulation from models can represent alternative datasets consistent with a set of assumptions about the underlying data-generating process, facilitating model assessment and hypothesis testing. This course will provide an overview of a generative approach to environmental data analysis, which uses simulation and assessments of predictive performance to provide insight into the structure of data and its data-generating process. The goal is to provide students with a framework and an initial toolkit of methods that they can use to formulate and update hypotheses about data and models. Students will actively analyze and use real data from a variety of environmental systems, potentially including the climate system, sea levels, air pollution, and the electric power system.
**Prerequisites:** CEE 3040, ENGRD 2700, or equivalent, CS 1110 or CS 1112, or permission of instructor.
**Last Four Terms Offered:** Spring 2025, Spring 2024
**Learning Outcomes:**

- Create, interpret, and critique data visualizations.
- Calibrate environmental models to observations, possibly including censored and missing data.
- Simulate alternative datasets from models using statistical methods such as the bootstrap and Monte Carlo.
- Assess model adequacy and performance using predictive simulations.
- Apply and contextualize model selection criteria.
- Evaluate evidence for and against hypotheses about environmental systems using model simulations.
- Emulate computationally-complex models with simpler representations.

Schedule of Classes

**BEE 5900 - Bio-Robotics (3 Credits)**
Introduction to bio-inspired and bio-enabled robotics across scales by an interdisciplinary approach, by gradually integrating knowledge in mechanical engineering and bioengineering. The concept and basic principles of biorobotics are discussed through macroscale robots in various fields including agriculture such as fruit picking robots. Homework includes programming, literature searches, and design studies of their own biorobots.
**Prerequisites:** MATH 2930 or permission of instructor.
**Exploratory Studies:** (CU-SBY)

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

- Identify, formulate, and solve complex engineering robotic components by applying principles of engineering, science and mathematics.
- Apply robotic design to produce solutions that meet specified needs with consideration of agricultural health and safety.
- Integrate/synthesize your knowledge of biology, physics, chemistry, and/or engineering analysis to create a robot.

Schedule of Classes

**BEE 5910 - Advanced Bio-Robotics (3 Credits)**
**Last Four Terms Offered:** Spring 2023
Schedule of Classes

**BEE 5951 - Master of Engineering Design Project (1-6 Credits)**
Comprehensive engineering design projects relating to the candidate's area of specialization. Projects are supervised by a BEE faculty member on an individual basis. A formal project report and oral presentation of the design project are required for completion of the course(s). A minimum of 6 to a maximum of 9 credits of 5951-BEE 5952 is required for the M.Eng. degree.
**Enrollment Information:** Enrollment limited to: students in the BEE M.Eng. degree program.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
Schedule of Classes

**BEE 5952 - Master of Engineering Design Project (1-6 Credits)**
Comprehensive engineering design projects relating to the candidate's area of specialization. Projects are supervised by a BEE faculty member on an individual basis. A formal project report and oral presentation of the design project are required for completion of the course(s). A minimum of 6 to a maximum of 9 credits of BEE 5951-5952 is required for the M.Eng. degree.
**Enrollment Information:** Enrollment limited to: students in the BEE M.Eng. degree program.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

**BEE 5980 - Graduate Teaching (1-3 Credits)**
The student assists in teaching a biological and environmental engineering course appropriate to his/her previous training. The student meets with a discussion or laboratory section, prepares course materials, grades assignments, and regularly discusses objectives and techniques with the faculty member in charge of the course.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
**Learning Outcomes:**
- Demonstrate the capability to work both independently and in cooperation with others.

Schedule of Classes

**BEE 6310 - Environmental Statistics and Learning (4 Credits)**
This course introduces statistical and machine learning techniques for analyzing complex datasets in the environmental sciences and engineering. It focuses on supervised learning methods, such as regression, decision trees, and neural networks, applied to real environmental data, with emphasis on both prediction and inference. Designed for students with basic statistics knowledge, the course provides a practical foundation in applied statistics and machine learning. It includes review of key mathematical and coding concepts needed to implement these tools. The goal is to build a toolbox of methods not covered in introductory courses and to help students understand when and why to use each method. Learning is hands-on, with in-class programming exercises that translate theory into application using real-world datasets.
**Prerequisites:** CEE 3040 or ENGRD 2700; or BTRY 3010.
**Enrollment Information:** Preferred prerequisite of MATH 2940.
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Fall 2025, Fall 2024, Spring 2022, Spring 2021
**Learning Outcomes:**
- Apply statistical and machine learning techniques in modern programming languages.
- Interpret and communicate analyses of data to support scientific discovery and advance engineering solutions in environmental fields.
- Appropriately use generative AI to assist and enhance data analysis skills to support higher-order synthesis, thinking, and learning.

Schedule of Classes

**BEE 6400 - Advanced Topics in Biomaterials (2 Credits)**
In this class, we will discuss some classical as well as cutting-edge research papers from the biomaterials field on topics including: (1) Polymer Biomaterials; (2) Hydrogel Biomaterials; (3) Inorganic and Composite Biomaterials; and (4) Applications of Biomaterials in Agriculture and Life Sciences. For each topic, the professor will first give introductory lectures, and the students will then give presentations and lead discussions on chosen papers.
**Prerequisites:** BEE 3400 or permission of instructor.
**Enrollment Information:** Enrollment limited to: graduate level or senior standing.
**Last Four Terms Offered:** Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes

**BEE 6550 - Biologically Inspired Microsystems Engineering (2-3 Credits)**
Covers fundamental mechanisms that nature uses to build and control living systems at micro- and nano-meter length scales; engineering principles for fabricating micro/nano-meter scale devices; examples of solving contemporary problems in the health sector and environment.
**Prerequisites:** BIOMG 1350, BIOG 1440, BIOG 1445 or BIOEE 1610; BEE 2220, or co-registration in BEE 3500 or permission of instructor.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Fall 2022, Fall 2021
Schedule of Classes

**BEE 6560 - Ecological Biomechanics (3 Credits)**
Ecological mechanics explores ecological relations from a mechanics perspective, including fluid, solid, structural mechanics, and heat and mass transport. While other ecological studies incorporate transport of mass, energy, and information, consideration of momentum transport and its consequence in biotic and abiotic relations in organisms is unique to this discipline. We begin the course by introducing the fundamental and advanced concepts in mechanics. Then we will learn how to incorporate these concepts by considering response function (the functional relationship between condition imposed on the system and its response) to understand and predict ecological phenomena such as predator-prey relation and pattern formation.
**Prerequisites:** at least one of the following courses or their equivalent: ENGRD 2020, BEE 3310, BEE 3500, and BEE 3400.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023
Schedule of Classes

**BEE 6620 - Water Quality and Management (3 Credits)**
**Exploratory Studies:** (CU-SBY)

**Learning Outcomes:**
- Describe physical, chemical, and biological factors impacting water quality;
- Assess water quality concerns for a water body based on available data;
- Explain national and international policies that improved water quality;
- Develop management strategies to address water quality issues

Schedule of Classes

**BEE 6630 - Digital Food Physics and Engineering (3 Credits)**
Mechanistic, model-based understanding and digital tools critically innovate in the design cycle for products and processes, food manufacturing is no exception. The course will introduce tools such as computational modeling, digital twins, and predictive knowledge bases, exploring deeper into the underlying universal physics-based frameworks describing transformations in food during processing.
**Prerequisites:** BEE 3310 or equivalent, BEE 3500 or equivalent, or permission of instructor.
**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023
**Learning Outcomes:**
- Explain a food physics framework in terms of its basic building blocks that can describe many food processes.
- Compare and contrast between simpler and more comprehensive physics frameworks for understanding food processes.
- Apply a food physics framework to complex food processes for their understanding and optimization.
- Create framework-based computational model of a food process that speeds up the design cycle.
- Analyze the transport phenomena, solid mechanics, and multiphysics (such as when microwave heating is added) at research level.
- Build computational models for more complex food processes

Schedule of Classes

**BEE 6640 - Sustainable Bioenergy Production on Marginal Lands of New York and the Northeast (1 Credit)**
Marginal agricultural lands are an oft-cited but largely untapped regional resource base for bioenergy crop production. They constitute the primary available land base for production of second generation bioenergy crops such as perennial grasses and short-rotation woody crops in New York and the Northeast. In this broadly multidisciplinary seminar series, we will explore the challenges of and opportunities for using marginal lands from multiple viewpoints. Our goal is to expose participants to issues involved in the development of low-cost sustainable perennial bioenergy feedstock production based on marginal lands of New York and the Northeast. Having heard and interacted with speakers representing a spectrum of disciplines and perspectives, participants will be better able to understand, evaluate, and/or contribute to the development of bioenergy resources in the region. Participants will develop an appreciation for challenges of bioenergy development and the cross-disciplinary efforts required to address them.
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Spring 2018
Schedule of Classes

**BEE 6670 - Applied Water Research In NYS (1 Credit)**
Every year, the New York State Water Resources Institute (NYSWRI) at Cornell supports applied research that addresses critical water resource problems in the New York State and the nation. This seminar series brings together researchers who work with NYSWRI and state agency partners to support and improve water management in the state. Speakers will present on a broad range of water related topics including water engineering and infrastructure, climate and flood resilience, water quality monitoring and assessment and aquatic ecosystems. The seminar will focus on ways in which robust science can support and influence on-ground management and policy outcomes, and center collaborative and interdisciplinary work between academics, water resource scientists, educators, managers, and policymakers in New York State.
**Last Four Terms Offered:** Spring 2025, Spring 2024
**Learning Outcomes:**
- Evaluate the relevance of research questions, study design, and data collection methods in the context of water policy in New York State.
- Engage in discussions on water-related topics and actively participate in question-and-answer sessions with guest speakers.
- Synthesize and connect information from presentations to analyze the connections between different topics in water management.
- Demonstrate an expanded knowledge of the complexities of real-world water problems and their implications for water resource management.

Schedule of Classes

**BEE 6710 - Introduction to Groundwater (3 Credits)**
Crosslisted with EAS 6710
Fresh water has become a limited resource in many parts of the world. In arid and semi-arid regions, groundwater levels are declining at unstainable levels. In several industrial areas, groundwater is contaminated and unsuitable as potable water. This course will address the sustainability and pollution of groundwater by first understanding the theory of saturated and unsaturated flow and contaminant transport under ideal conditions. Subsequently, we learn to simplify groundwater systems in complex subsurface environments to obtain practical solutions. At the end of the course, the learned material will be put in a broader context as they are affected by natural or human actions. Throughout the course, guest speakers will discuss topics of current interest related to water. This elective course is intended for graduate students interested in subsurface water and solute transport applications to sustainable groundwater use and prevention of pollution.
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

**BEE 6740 - Ecohydrology (3 Credits)**
The objective of this course is to investigate novel topics that involve the interactions between physical hydrological processes and ecosystem processes, including the impacts of human activities on the ecohydrological system. The course is designed to encourage teams of students from historically disparate disciplines to collaboratively combine their unique skills and insights to answer multidisciplinary ecohydrological questions. This course will consider a broad range scales from a stomate and a soil pore to a forest, watershed, and region, with emphasis placed on those scales and systems most appropriate to student interests. Through course work we will clarify the current understanding of various topics, identify knowledge gaps, develop hypotheses, and test them quantitatively by creating models and analyzing available data. The goal of this course is to identify the basic principles of ecohydrology and become familiar and comfortable with a range of quantitative tools and approaches for answering ecohydrological questions.
**Prerequisites:** BIOEE 1610, BIOEE 3610, BIOEE 4560 or an equivalent ecology course or BEE 5710, CEE 6320 or an equivalent hydrology course.
**Last Four Terms Offered:** Spring 2022, Spring 2018, Spring 2016, Spring 2014
Schedule of Classes

**BEE 6800 - Atmospheric Chemistry: From Air Pollution to Global Change (3 Credits)**
Crosslisted with EAS 6800
This course investigates the science of atmospheric chemistry as its relation to air pollution and global change. Students examine the chemistry and physics that determines atmospheric composition on local to global scales including the effects of biogeochemistry and atmospheric photochemistry.
**Prerequisites:** CHEM 2070 or CHEM 2090, MATH 1920, and PHYS 1112 or permission of instructor.
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2022, Fall 2021
**Learning Outcomes:**
- Apply the principles of chemistry and physics to the atmosphere, its composition, its chemistry and air quality.
- Use simple analytical models and concepts to analyze and describe the complex system of the atmosphere and its chemistry.
- Relate environmental problems to the science behind them, in terms of methodologies in which they can be addressed scientifically, the uncertainty in the results, and the ability to make informed decisions about environmental policy.
- Synthesize scientific literature on a basic research problem in atmospheric chemistry.

Schedule of Classes

**BEE 6830 - Engineering Sustainability (3 Credits)**
Sustainability is a complex and multifaceted concept without straightforward solutions. This course is a multidisciplinary introduction to the evaluation of sustainability, sustainable development obstacles and opportunities, and explore engineering research needs. We will practice both qualitative and quantitative approaches with a heavy focus on writing about sustainability concepts and sustainability analysis in practice. The course spans modules that focus on understanding the root causes of unsustainability to sustainability assessment frameworks to design and innovation. The culmination of the course will be a final team project that will be developed by an industry, campus, or community partner to practice the quantitative approaches learned in the course and tie to the relevant qualitative concept discussed in class.
**Prerequisites:** BEE 2220 and BEE 2510 or BEE 2600.
**Exploratory Studies:** (CU-SBY)

**Learning Outcomes:**
- Identify, formulate, and solve quantitative sustainability assessments of products and processes for industry and research applications.
- Understand the complex, interdisciplinary nature of sustainable engineering and be able to produce relevant information for identifying tradeoffs and making decisions.
- Critically think about practical ways that engineers can include social, ecological and technological systems into our problem solving and efforts towards sustainable design.
- Quantify various ecosystem services (ES) and apply ES frameworks within sustainability assessment and design.

Schedule of Classes

**BEE 6880 - Applied Modeling and Simulation for Renewable Energy Systems (3 Credits)**
Crosslisted with CEE 6880
This course will provide an applied introduction to modeling, simulation and optimization techniques for various renewable energy systems. The course will be modular in nature. Each module will focus on a particular renewable energy application and relevant modeling/simulation tools. Some modules are independent and some will build on previous modules. The instructional format of the course will include lectures, scientific paper reviews, and some AMPL programming. Students will have an opportunity to apply new techniques to a relevant modeling project. The course will culminate with a modeling project relevant to renewable energy. Graduate students will be required to complete the term project on an individual basis.
**Enrollment Information:** Enrollment limited to: graduate students, or permission of instructor.
**Exploratory Studies:** (CU-SBY)

**Last Four Terms Offered:** Spring 2025, Spring 2024, Spring 2023, Spring 2021
Schedule of Classes

**BEE 6940 - Graduate Special Topics in Biological and Environmental Engineering (1-4 Credits)**
The department teaches trial courses under this number. Offerings vary by semester and are advertised by the department. Courses offered under this number will be approved by the department curriculum committee and the same course will not be offered twice under this number. Each 6940 has a unique course ID for enrollment.
**Exploratory Studies:** (LAAREA)

**Last Four Terms Offered:** Spring 2025, Fall 2023, Spring 2023, Spring 2022
Schedule of Classes

**BEE 6970 - Graduate Individual Study in Biological and Environmental Engineering (1-6 Credits)**
Topics are arranged by the faculty at the beginning of the semester.
**Last Four Terms Offered:** Fall 2025, Spring 2025, Fall 2024, Spring 2024
Schedule of Classes

**BEE 7000 - Orientation to Graduate Study (1 Credit)**
This course is intended to introduce students to graduate school in Biological and Environmental Engineering. It is intended for first year graduate students although others may find it helpful. It consists of a seminar series and series of classes introducing students to such topics as: how to write a research proposal, how to give a scientific talk, how to get the most out of Cornell resources and time management.
**Enrollment Information:** Enrollment limited to: new graduate students in BEE. Required for new MS/PhD graduate students in BEE. MEng/MPS students may attend for audit.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Fall 2023, Fall 2022
**Learning Outcomes:**

- Students will learn the skills to write a research proposal.
- Students will employ the necessary skills to succeed in graduate school.

Schedule of Classes

**BEE 7600 - Nucleic Acid Engineering (3 Credits)**
Nucleic Acid Engineering provides a comprehensive examination of the engineering aspects of nucleic acids beyond their biological context. By integrating molecular biology, bioengineering, and Artificial Intelligence, this course promotes a multidisciplinary and active learning environment. It explores the structure-property-function relationships of nucleic acids, focusing on the development of various nanostructures, devices, and materials derived from nucleic acids. The course also covers molecular toolkits for nucleic acid manipulation, their non-biological functions, and practical applications.
**Enrollment Information:** Enrollment limited to: graduate students; seniors with permission from instructor.
**Last Four Terms Offered:** Fall 2025, Fall 2024, Spring 2015, Spring 2014
**Learning Outcomes:**

- Describe and identify the structures and functions of nucleic acids, demonstrating a deep understanding of their biological and engineering aspects.
- Apply engineering principles to biological molecules, specifically connecting these principles to the manipulation and use of nucleic acids.
- Design and evaluate nucleic acid-based systems, showcasing their ability to conceive and assess innovative engineering solutions.
- Utilize AI in nucleic acid engineering projects, applying AI tools to enhance the design and analysis of nucleic acid systems.

Schedule of Classes

**BEE 7710 - Soil and Water Engineering Seminar (1 Credit)**
Study and discussion of research or design procedures related to selected topics including watershed management, erosion control, hydrology, colloid transport, and water quality.
**Enrollment Information:** Enrollment limited to: graduate students or permission of instructor.
**Last Four Terms Offered:** Fall 2025, Spring 2025, Fall 2024, Spring 2024
Schedule of Classes