CHEMICAL ENGINEERING (CHEME)

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

CHEME 2200 - Physical Chemistry II for Engineers (4 Credits)
Applications of quantum chemistry to (1) the interaction of electromagnetic radiation with matter for spectroscopy and strategic bond breaking and (2) the behavior of electrons in solids - insulators, conductors, and semiconductors. Quantum and statistical mechanics for classical thermodynamics - 1st and 2nd laws, phase equilibrium, chemical equilibrium, and heat pumps. Devising rate equations for chemical reactor design from experiment and theory - kinetic theory of gases and transition state theory.
Prerequisites: MATH 2930, CHEM 3890, PHYS 2213, and ENGRD 2190.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023
Learning Outcomes:

- Predict the outcome of electromagnetic radiation interacting with a substance - heating, chemical dissociation, or ionization.
- Predict if a solid is an insulator, conductor, or semiconductor.
- Understand the effects of doping a semiconductor for electronic devices - conduction paths, diodes, and transistors.
- Analyze experimental data to obtain a rate equation.
- Analyze a rate equation, an overall reaction, and chemical intuition to devise a mechanism of elementary chemical reactions for homogeneous and heterogeneous (solid-catalyzed) reactions.
- Predict the spontaneity of a chemical process.
- Devise a heat engine or heat pump and calculate the efficiency.
- Analyze the phase behavior of a pure substance.
- Analyze the phase behavior of a binary mixture.
- Predict the spontaneity of a chemical process; design a chemical reactor with recycle.

Schedule of Classes

CHEME 2880 - Biomolecular Engineering: Fundamentals and Applications (4 Credits)
An introduction to modern biology including aspects of biochemistry and molecular and cellular biology intended for students with no significant background in this area. An emphasis on practical applications of this knowledge in a variety of settings including the production of industrial enzymes, pharmaceuticals, and biologics.
Prerequisites: CHEM 2080, CHEM 2090, and MATH 2930.
Corequisites: ENGRD 2190.
Course Fee: Course Fee, $15. Lab fee.
Last Four Terms Offered: Fall 2024, Fall 2022, Fall 2021, Fall 2020
Learning Outcomes:

- Course project built experience working with teams and communicating effectively.
- Lectures on pharmaceutical research and development and clinical trials introduced concepts of professional and societal ethics.
- Course quizzes, project and final exam applied knowledge of mathematics, biology and engineering.

Schedule of Classes

CHEME 3010 - Career Perspectives (1 Credit)
Weekly presentations by visiting chemical and biomolecular engineers to describe career paths and current professions. Job overviews and day-to-day details. Lessons learned from experiences.
Enrollment Information: Enrollment limited to: juniors affiliated with CBE.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Assist with a specialized job search.
- See the application of specific ChemE fundamentals such as process development and product development in the workplace.
- Understand the extent of degree required, progression in industry, managerial technical ladder, career options and the importance of teamwork in specific careers.
- Emphasis on safety and ethics particularly in the pharmaceutical industry.

Schedule of Classes

CHEME 3130 - Chemical Engineering Thermodynamics (4 Credits)
Studies the first and second laws and their consequences for chemical systems. Covers thermodynamic properties of pure fluids, solids, and mixtures; phase and chemical reaction equilibrium; heat effects in batch and flow processes; and power cycles and refrigeration.
Prerequisites: CHEME 2200.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Apply fundamental concepts of thermodynamics to engineering applications.
- Work as a team to analyze and design a thermodynamic system (e.g. power generator) and communicate results in a written report.

Schedule of Classes

CHEME 3230 - Fluid Mechanics (4 Credits)
Fundamentals of fluid mechanics. Macroscopic and microscopic balances. Applications to problems involving viscous flow.
Prerequisites: ENGRD 2190 and MATH 2930.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Demonstrate the ability to explain the physical mechanisms governing fluid behavior in a variety of materials and settings.
- Solution of the equations of motion: solution of the microscopic balance equations for hydrostatics, unidirectional flows, boundary layer flows, and other simple flow situations.
- Solving engineering fluid dynamics applications involving macroscopic mass and momentum balances, and Bernoulli's equations. Use of macroscopic balances together with unidirectional flow analysis.
- Understanding the role of nonlinearity, instability, and turbulence in fluid dynamics.

Schedule of Classes

CHEME 3240 - Heat and Mass Transfer (4 Credits)
Fundamentals of heat and mass transfer. Macroscopic and microscopic balances. Applications to problems involving conduction, convection, and diffusion.
Prerequisites: CHEME 3230.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Learn to formulate and solve mathematical models that capture the primary processes governing heat and mass transfer in simple physical settings.
- Design heat exchangers and heat transfer equipment.

Schedule of Classes

CHEME 3320 - Analysis of Separation Processes (4 Credits)
Analysis and design of chemical separation processes involving phase equilibria and mass transfer. Topics include: continuous and batch processing; counter-current and co-current flow patterns; tray columns and packed columns for distillation, gas absorption/stripping, and liquid-liquid extraction; batch separation by selective adsorption on solids; continuous separation by selective permeation through membranes; and choosing among separation options.
Prerequisites: CHEME 3130 and CHEME 3240.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Combine mass balances, energy balances, thermodynamic equilibrium constraints, and constitutive models for convective mass transfer to develop mathematical models for the performance of various separation systems.
- Optimize designs of separation systems to achieve targets for product purity.
- Acquire experience using modern computer software for designing separation processes.
- Develop and apply criteria for selecting among available separation technologies.

Schedule of Classes

CHEME 3720 - Introduction to Process Dynamics and Control (2 Credits)
Modeling and analysis of the dynamics of chemical processes, Laplace transforms, block diagrams, feedback control systems, and stability analysis.
Prerequisites: CHEME 3130 and CHEME 3230.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students apply mathematical analysis to develop models for chemical process systems.
- Students complete all problem sets in groups of 2-3 people.
- The first problem set is an open-ended assignment, which helps introduce basic concepts of control, including the identification of variables, parameters, inputs an outputs. Students are encouraged to select a system that is not a traditional chemical process.

Schedule of Classes

CHEME 3900 - Chemical Kinetics and Reactor Design (4 Credits)
Study of chemical reaction kinetics and principles of reactor design for chemical processes.
Prerequisites: CHEME 3130 and CHEME 3240. Corequisite: CHEME 3320.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Develop a sound fundamental (molecular level) understanding of chemical reaction kinetics.
- Develop practical approaches to modeling complex reactions to obtain a rate equation; (1) identify dominant effects and estimate the consequences of neglecting secondary effects, (2) test assumptions and assess predictions, and (3) perform numerical analysis.
- Develop the ability to construct from first principles mathematical models to predict system behavior.
- Develop approaches to optimize reactor design with regard to multiple performance criteria.

Schedule of Classes

CHEME 4020 - Molecular Principles of Biomedical Engineering (3 Credits)

Crosslisted with BME 3020

Genomic and proteomic thinking and tools have revolutionized the way scientists study biology and medicine. We are now beginning to understand the molecular level mechanisms that underlie normal and pathologic cellular functions. As a consequence, novel molecular level approaches provide the basis for better diagnostic and therapeutic strategies to effectively treat or prevent human diseases. This course aims to present a broad overview of molecular level techniques that are relevant in many aspects of biomedical engineering. We will discuss the underlying principles, how to interpret representative data, limitations of current approaches, and engineering challenges for the development of new and improved techniques.The lectures will cover existing and emerging technologies and instrumentation critical to molecular - level analysis in biomedical engineering. These will include DNA recombinant technology, design of primers, vectors and gene-modified organisms, gene therapy approaches, DNA sequencing, quantification of RNA expression, fundamentals of protein biochemistry and biophysics, protein structure determination, mass spectrometry, protein purification, thermodynamic principles of biomolecular interactions, enzyme kinetics and modes of inhibition, and design and application of nano- and microtechnologies for diagnosis and therapeutic applications.The laboratory work consists of three modules: DNA isolation and sequencing, surface plasmon resonance technique, and design of microfluidic systems for molecular biology applications.

Prerequisites: BIOMG 1350 or other coursework that covers basics of DNA, RNA, and proteins or permission of instructor.

Enrollment Information: Enrollment preference given to: Biomedical Engineering majors.

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

Schedule of Classes

CHEME 4130 - Introduction to Nuclear Science and Engineering (3 Credits)

Crosslisted with ECE 4130, MAE 4580, 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

CHEME 4320 - Chemical Engineering Laboratory (4 Credits)
Laboratory experiments in fluid dynamics, heat transfer, mass transfer, separations, process control, and other unit operations fundamental to large-scale chemical processing. Data collection, analysis, and interpretation. Technical report writing. Process design and scale-up based on pilot-plant data.
Prerequisites: CHEME 3230, CHEME 3240, CHEME 3320, CHEME 3720, and CHEME 3900.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Design experiments and choose operating conditions to acquire data for solving a stated technical problem.
- Operate pilot-plant equipment and collect data accurately and safely.
- Use rigorous statistical methods, e.g. linear regression analysis and propagation of errors, to identify sources of uncertainty in measured variables and in parameters derived from curve-fits.
- Prepare graphs, data tables, and process flowcharts for concise, unambiguous presentation of results.
- Use results of small-scale, pilot-plant experiments for preliminary design of large-scale process equipment.
- Write laboratory reports that use graphs, data tables, process flowcharts, and equations to describe the methodology and present the results of data collection, data analysis, and process design.
- Work in four-person teams throughout.

Schedule of Classes

CHEME 4620 - Chemical Engineering Design (4 Credits)
Students work in teams to address a chemical plant or chemical product design challenge. Teams will prepare, depending on the project type, a full-scale feasibility study of a chemical process including product supply and demand forecasts, assess product functionality through prototyping, scale-up risks, identify energy and waste minimization opportunities, develop mass and energy balances that results in a process flow sheet sufficient for estimating the capital and operating costs of the process facilities. Students also define off-plot support facilities and estimate the capital and operating costs of those facilities to develop an economic analysis of the facilities and to provide an ultimate recommendation as to the project's viability. Some teams will engage company sponsors for key process/product data and design constraints. Students develop presentation and teamwork skills through weekly presentations of their work culminating in a final presentation to a panel of internal and external appraisers.
Prerequisites: CHEME 4320.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- By simulating a corporate work environment the students are introduced to the demands and expectations that they will face when they enter the workforce, and are thus better prepared to function in either the academic or the corporate environment.
- Each system design within the overall plant design requires the identification of relevant process design parameters and the solution of chemical engineering calculations to arrive at a design recommendation. The students are also taught an in house capital cost estimating algorithm, which they must use in determining the capital cost of their recommended designs. (e) The students use Aspen Tech Process Simulator and the ASPEN cost estimating system to first simulate and then determine the capital and operating cost of their design solutions.
- The students work in either three or four member teams and learn by experience and by instruction how to manage team dynamics to complete the work in a timely fashion.
- The students prepare power point presentations describing the results of their work for the week and present them to professors and TA's who critically evaluate both content and presentation. Written clarification memos for points arising from the presentation are also required.
- Stress is placed on the concept of designing to minimize environmental footprint and good corporate stewardship in design.

Schedule of Classes

CHEME 4800 - Principles of Computational Thinking for Engineers (4 Credits)
Engineering practice increasingly relies on computational tools and data analysis approaches. The course introduces computational thinking into engineering analysis. Integrates data science and statistics, linear algebra, artificial intelligence, and mathematical modeling approaches into the context of contemporary problems in the design and analysis of processes, products, and systems. Focuses on paradigms, not syntax. Use of the Julia programming language and its associated toolchain to transition from idea to implementation. In addition, cloud computing resources for course materials, assignments, and projects. Weekly labs provide guided hands-on practice. Course assignments use data sets and examples from industrial practice to develop fluency and understanding of real-life problems.
Last Four Terms Offered: Fall 2024, Spring 2024, Spring 2023
Learning Outcomes:

- Analyze process and product data sets using tools from data science/statistics, and machine learning (ML).
- Identify and test quantitative models of process and product performance using real-time dynamic and static data sets.
- Demonstrate mastery of quantitative decision-making and risk management approaches in the context of a process, product, or system design.

Schedule of Classes

CHEME 4840 - Microchemical and Microfluidic Systems (3 Credits)
Principles of chemical kinetics, thermodynamics, and transport phenomena applied to microchemical and microfluidic systems. Applications in distributed chemical production, portable power, micromixing, separations, and chemical and biological sensing and analysis. Fabrication approaches (contrasted with microelectronics), transport phenomena at small dimensions, modeling challenges, system integration, case studies.
Prerequisites: CHEME 3900 or permission of instructor.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Students learn about the use of a variety of fabrication techniques used for both microelectronics and microchemical systems. In a number of cases the fabrication techniques involve chemical processes, and the students apply their knowledge in transport phenomena, thermodynamics and kinetics to model these processes. In addition, microchemical systems involve virtually every unit operation conducted in traditional macro chemical processing.
- Students complete all problem sets in groups of 2 people. The final exam is an oral presentation (Power Point, typically) that is also done in groups of 2 people, although individual presentations are permitted. Students are given the opportunity to select the topic of their final presentation. Often, this involves the selection of a topic that is of current interest, such as ink jets, micro-total analytical systems, miniature fuel cells, etc. Since the presentation must be centered around patents and intellectual property, the topics selected are clearly of industrial and practical interest.
- Students conduct a laboratory experiment involving fabrication of a number of micromixers, followed by characterization of these devices. The experiment is done in teams, and a laboratory report is required.

Schedule of Classes

CHEME 4880 - Global Food, Energy, and Water Nexus – Engage the US, China, and India for Sustainable Future (3-4 Credits)
Crosslisted with ANSC 4880, FDSC 4880, AEM 4880, GDEV 4880
This course is offered by six Departments at Cornell, in collaboration with five Universities in China and India. Video conferencing will be used to connect classrooms in the three countries in real time. Important issues related to the food, energy, and water nexus and its implications for nutrition security, one health, environmental sustainability,climate change, and economic development in the US, China, India, and other countries will be described. Challenges associated with these issues will be evaluated and strategies to address them will be proposed. Engagement of these countries with each other and the rest of the world will be explored. The course serves as a platform for students from Cornell, China, and India to learn from and interact with each other in the same class, and to share their thinking, creativity, and perspectives on these issues.
Enrollment Information: Enrollment limited to: juniors or seniors only.
Distribution Requirements: (D-AG, SCH-AG)
Exploratory Studies: (CU-ITL, CU-SBY); (SAAREA)

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

- Identify and compare the major food, nutrition and health, energy, water, and economic challenges facing the US, China, and India.
- Describe barriers to food and nutrition security for all people in each of the three countries and globally and propose solutions for overcoming these barriers.
- Identify and quantify the requirements of energy and water for producing, processing, transporting, and/or preparing food.
- Evaluate various predictions of regional and global impacts of climate change on agricultural production and human health in the 21st century.
- Collaborate as members of interdisciplinary teams composed of students from the US, China, and India to analyze and solve problems that affect food, water, and energy security.
- Effectively and respectfully debate, with people of opposing views, issues related to food, water, and energy nexus.
- Prepare and deliver focused, clear, impactful, and culturally sensitive presentations to an international audience of peers .

Schedule of Classes

CHEME 4900 - Undergraduate Projects in Chemical Engineering (1-7 Credits)
Research or studies on special problems in chemical engineering.
Exploratory Studies: (CU-UG)

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

CHEME 4998 - International Research Internship (6-12 Credits)
Research or studies on special problems in chemical engineering for visiting international students.
Enrollment Information: Enrollment limited to: undergraduates in PIRIP.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes

CHEME 5020 - Immersive Professional Development for Chemical Engineering M. Eng. (3 Credits)
The development of professional skills and their application to a project-based working environment for students in the Master of Engineering (M.Eng.) program in the Department of Chemical and Biomolecular Engineering. Students will focus on developing their management, communication and presentation skills, project management skills, networking, innovative mindset, early phase market interpretation as it applies to new products/processes, self-awareness, working as a team and managing conflict. A focus on basic finance skills which enable scientists and engineers to make quantitative financial decisions in corporate and wealth management contexts. The material from this course can be applied to traditional economic and engineering fields while simultaneously providing a core set of tools for students interested in entrepreneurship or opportunities in the financial and consulting industries.
Enrollment Information: Enrollment limited to: ChemE M.Eng. students only.
Last Four Terms Offered: Fall 2024
Learning Outcomes:

- Apply fundamental project management principles to a team based design project.
- Apply core career management skills related to resumes, interviewing, personal pitch, networking.
- Apply and demonstrate effective technical communication skills in written and presentation formats.
- Identity, formulate, and solve complex engineering problems by applying principles of engineering, science, and finance.
- Apply key leadership and team based skills related to communication, accountability, and conflict resolution.

Schedule of Classes

CHEME 5235 - Design of Soft Materials (3 Credits)
Crosslisted with MSE 5235
Soft materials have unique properties, exploited widely by nature and industry. They are made from a variety of building blocks, including small molecules, macromolecules, and particles. These basic constituents can be arranged into a vast range of microstructures that determine their macroscopic material properties. This course will explore this broad material space, identify unifying scientific ideas, and explore practical strategies for their design. A top-down approach, which emphasizes their macroscopic behavior, will be combined with a bottom-up approach, that describes their microscopic structure and dynamics.
Prerequisites: CS 1110 or CS 1112, PHYS 1112, PHYS 2213, MSE 3030.
Last Four Terms Offered: Spring 2025, Spring 2024
Schedule of Classes

CHEME 5240 - Chemical Process Safety Management (2 Credits)
Implementation of Process Safety Management (PSM) is a complex task that requires planning, coordination, and considerable resources. PSM is typically a risk-based management process with higher risk processing units receiving higher priority. PSM will be broken down into smaller, manageable pieces that can be developed and implemented in a logical sequence. Industry standard structure, covering the various aspects that define PSM, will be followed.
Enrollment Information: Enrollment limited to: Master of Engineering students or permission of instructor.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:

- Students will be able to describe Process Safety Culture.
- Students will be able to review and define process safety competencies required to implement PSM.
- Students will be able to apply relevant codes and standards.
- Students will be able to demonstrate knowledge of safety through design.
- Students will be able to develop format for pre-startup safety review.

Schedule of Classes

CHEME 5310 - Principles of Electrochemical Engineering (3 Credits)
With the growing focus on renewable energy and electrification of transport for climate control, electrochemical engineering will play an increasingly critical role in enabling such a paradigm shift. This course introduces fundamentals of electrochemical conversion and storage including an introduction on electrochemical cells, characteristics of electrochemical reactions and Faraday's law as well as basic principles on cell potential and thermodynamics, electrochemical kinetics, and ionic mass transport. Students will also learn about standard electroanalytical techniques and applications of electrochemical engineering with particular focus on batteries. In addition to lecture-style classes, the course will engage the students in critical reading, presentation, and discussion of relevant research publications in energy storage systems providing them a holistic view of the current state of the field.
Prerequisites: CHEME 3130, CHEME 3900, and CHEME 3240 or equivalent.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2024
Learning Outcomes:

- Demonstrate understanding of the fundamental concepts of electrochemical cell potential and thermodynamics, kinetics and transport.
- Demonstrate understanding of basic electroanalytical techniques.
- Analyze and interpret electrochemical cell data.
- Demonstrate critical paper reading and presentation.

Schedule of Classes

CHEME 5320 - Glass: Structure, Properties and Modern Applications (3 Credits)
Crosslisted with MSE 5320
Course develops a foundational understanding of the glassy state and nature of the glass transition. Introduces phenomenology, chemistry and structure of key oxide glass families, with an emphasis on silicate glasses and the interaction of oxide components. Recent advances in glass relaxation and the implications of the statistical nature of glass structure are also discussed. Contemporary and emerging applications in optical communication, displays, and electronics packaging are explored within the context of key optical, mechanical and thermal properties. Students will gain an understanding of modern glass theory, familiarity with glass technology, and practical know-how of a glass power user.
Prerequisites: MSE 2060, MSE 3030. Corequisite: MSE 3040 or equivalent background.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes

CHEME 5430 - Bioprocess Engineering (3 Credits)
Discusses principles involved in using biomolecules (e.g., antibodies, enzymes, DNA) and living organisms (e.g., bacteria, yeast, tissue cultures) for engineering biological processes. Examples will be taken from the following application areas: biopharmaceuticals, biofuels, biomedical technologies, foods, and environmental processes.
Prerequisites: CHEME 3900 or permission of instructor.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Learn and reinforce fundamental biology principles and how to apply them to engineering problems.
- Build mathematical models of cell growth, metabolism and bioreactor operation.
- Learn current methods in biotechnology from critically reading current literature and orally answering questions in class based on reading material.
- Design a biological product as well as a process for its production and manufacturing (team-based design project).
- Gain experience with working in teams. (d) Gain experience giving formal oral presentations.

Schedule of Classes

CHEME 5440 - Advanced Principles of Biomolecular Engineering (3 Credits)
This course will cover the physical principles required for understanding the molecular basis of life and its use in biotechnologies. Emphasis will be placed on deconstructing biological phenomena from a quantitative perspective of core engineering principles. Specific topics will include: thermodynamics and kinetics of gene expression and genetic circuitry, biophysical principles of molecular interaction, molecular mechanisms in the definition of cell state and differentiation, molecular modes of cellular communication, and biophysical considerations for multicellular life.
Prerequisites: CHEME 3900 or, an equivalent course in kinetics.
Enrollment Information: Enrollment limited to: seniors and graduate students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2021
Learning Outcomes:

- Learn how to apply core engineering concepts (kinetics, thermodynamics, transport phenomena) to understanding and engineering the function of living systems.
- Gain familiarity with primary literature in biomolecular engineering, and systems, synthetic and computation biology through quantitative deconstruction of fundamental problems in biotechnology.

Schedule of Classes

CHEME 5460 - Introduction to Synthetic Biology (1 Credit)
This course offers a concise introduction to the foundational concepts and tools of Synthetic Biology. Students will explore how biological systems can be engineered to perform novel functions, with applications in health, biotechnology, and sustainability. Topics include genetic circuits, modular design principles, and emerging technologies such as cell-free systems. Through case studies and hands-on activities, students will gain insight into how synthetic biology is shaping the future of science and engineering. This course is ideal for students from diverse backgrounds seeking a gateway into this rapidly evolving field.
Enrollment Information: Open to: Graduate students and undergraduate juniors and seniors in STEM disciplines.
Learning Outcomes:

- Integrate biology, chemistry, and engineering principles to manipulate complex biological networks for applications in human health, biopharmaceutical production, and bioenergy systems.
- Demonstrate mastery of emerging Synthetic Biology trends and technologies to address health and biopharmaceutical challenges for advanced research and professional practice.
- Engage in collaborative projects, applying the knowledge to solve real-world inspired problems with broad societal impact.

Schedule of Classes

CHEME 5470 - Bioprocess Engineering Design and Practice (1 Credit)
This course provides immersive, hands-on experience in the design, operation, and analysis of bioprocesses. Students will engage in laboratory-based projects that integrate upstream and downstream processing, bioprocess control, and data-driven optimization. Emphasis is placed on translating biological and engineering principles into scalable solutions for biotechnology, pharmaceuticals, and sustainable manufacturing. Through team-based experiments, real-world case studies, and exposure to industry-standard tools, students will develop practical skills and critical thinking essential for careers in bioprocess engineering. This course is ideal for students seeking to bridge theory with practice in a dynamic, application-focused setting.
Enrollment Information: Open to: Graduate students and undergraduate juniors and seniors in STEM disciplines.
Learning Outcomes:

- Design and implement bioprocess workflows that integrate upstream and downstream operations for microbial systems, including recombinant plasmid design.
- Evaluate the impact of bioprocess parameters (e.g., pH, temperature, oxygen transfer) on cell growth, product formation, and system stability.
- Perform and interpret SDS-PAGE to assess protein expression, purity, and molecular weight.
- Execute affinity chromatography techniques for selective purification of recombinant proteins and evaluate purification efficiency using quantitative and qualitative methods.
- Communicate technical findings effectively through written reports and peer collaboration.

Schedule of Classes

CHEME 5540 - Principles of Molecular Simulation (4 Credits)
Introduction to molecular simulation methods, Molecular Dynamics and Monte Carlo. Understanding options for interatomic and intermolecular modeling and appropriate representation of materials.
Prerequisites: familiarity with a programming language.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

CHEME 5610 - Concepts of Chemical Engineering Product Design (3 Credits)
Chemical products range from specialty chemicals, biologic based products, to electromechanical devices that perform chemical transformations. This course integrates the steps of chemical product design from brainstorming and concept selection through design and manufacturing while recognizing the overlap with Lean operating principles. Students will be taught house of quality, robust design, failure modes and effects analysis. Other topics include multi-generational product planning, FMEA, sustainability and product life-cycle analysis, basic economic evaluations, process mapping, cycle time content and balance, lead-time assessment and management, quality performance analysis and remediation, entrepreneurship and new business development, as well as patents, and intellectual property. Case studies will illustrate concepts.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Exploratory Studies: (CU-SBY)

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

- Identify and analyze potential market segments in support of a new product design and commercialization.
- Prioritize customer requirements and relate requirements to product engineering characteristics using the house of quality approach.
- Demonstrate DOE and Taguchi methods (also known as Robust Design) to improve product quality in the earliest stages of product design.
- Demonstrate failure modes and effects analysis on a new product design.
- Analyze and project financial performance for a new commercialized product.

Schedule of Classes

CHEME 5650 - Design Project (1-9 Credits)
Design study and economic evaluation of a chemical processing facility, alternative methods of manufacture, raw-material preparation, food processing, waste disposal, or some other aspect of chemical processing.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes

CHEME 5651 - M. Eng. Design Project Studio (1 Credit)
Studio design team work sessions for the Master of Engineering chemical process project.
Corequisites: CHEME 5650.
Enrollment Information: Open to: ChemE M. Eng. students.
Last Four Terms Offered: Spring 2025, Fall 2024
Schedule of Classes

CHEME 5660 - Financial Data, Markets, and Mayhem for Scientists and Engineers (3 Credits)
A quantitative finance course that enables scientists and engineers to make quantitative financial decisions in corporate and wealth management contexts. We'll use tools from engineering, statistics, artificial intelligence (AI), data science (DS), and machine learning (ML) to model, analyze, and ultimately optimize financial systems and financial decision-making. The material from this course can be applied to traditional economic and engineering fields while simultaneously providing a core set of tools for students interested in entrepreneurship or opportunities in the financial and consulting industries. Course assignments will be completed using LaTeX.
Prerequisites: knowledge of programming languages, such as Python, Matlab, Julia and mathematical and computing topics, such as probability, statistics, optimization, and data science tools, such as Jupyter notebooks, DataFrames, etc.
Enrollment Information: Open to: students in any STEM field.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Analyze financial data sets using tools from artificial intelligence (AI), data science (DS), and machine learning (ML).
- Identify quantitative models of asset pricing and process performance using real-time and static financial data sets.
- Demonstrate mastery of quantitative decision-making and risk management approaches in the context of corporate finance and personal wealth management.

Schedule of Classes

CHEME 5710 - Lean Operations Design and Process Optimization (1 Credit)
An introduction into Lean base process design and operations management based on the Toyota Production System model (Lean). A deeper dive into the specific focus points of effective and clear process design, effective problem solving along with managerial expectations will be investigated and discussed. Tools/principles such as process mapping, data collection and analysis, gap analysis, cycle time content and balance, lead-time assessment and management, quality performance analysis and remediation, sustainable control measures, demand/takt time analysis and relation to demonstrated equipment/process capacity, process stability assessment, six sigma will be covered in detail. These tools will drive towards effective observation and analysis of process performance so that relevant and impactful process improvements related to cycle time, quality, lead time, and cost can be achieved. Content of delivery is supported through business case analyses and class discussion/debate by the students along with hands-on team activities throughout the semester in order to link theory with some level of practical outcomes. Industrial examples will also be linked to the theory throughout the class as case studies or videos. Guest speakers may be included where possible to link theory with practice.
Enrollment Information: Enrollment limited to: seniors and M.Eng. students.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

CHEME 5730 - Interdisciplinary Design Concepts (4 Credits)
Crosslisted with MSE 5070
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.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes

CHEME 5740 - Probability, Statistics, and Data Analysis for the Physical Sciences (3 Credits)
Crosslisted with MSE 5730
Statistical analysis of experimental data and processes, and the design of experiments are increasingly critical in both research and industrial environments. The course will review the fundamentals of probability and statistics, common probability distribution functions, data analysis and model parameter estimation, including characterization of sources of error and uncertainty, least-squares fitting, parameter correlation, as well as formal design of experiments (DOE) methodology.
Prerequisites: MATH 2930 and MATH 2940, some familiarity with statistics/probability.
Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2019, Fall 2017
Schedule of Classes

CHEME 5760 - Quantitative Decisions in Life, Love, and Finance (3 Credits)
Decision-making is essential to almost everything facet of life. However, are you making the best possible decisions? This course introduces quantitative decision-making tools and strategies that will give students a framework to make the best possible decisions in life, love, and finance. Students will be introduced to concepts such as utility maximization using personalized happiness functions. Students will also be introduced to modern machine learning and artificial intelligence approaches to decision-making, such as Markov Decisions Processes (MDP), Reinforcement Learning (RL), Imitation Learning (IL), and Multiagent decision-making tools and methods.
Last Four Terms Offered: Fall 2023
Learning Outcomes:

- Students will identify personalized happiness functions and use these functions, along with key concepts such as utility maximization, to make optimal decisions in personal and professional contexts.
- Students will demonstrate fluency in developing and applying artificial intelligence and machine learning tools to problems in decision-making in personal and professional contexts.
- Students will interrogate process, product, and financial data sets to compute optimal decisions in offline and real-time contexts.

Schedule of Classes

CHEME 5770 - Principles in Process and Lean Engineering (3 Credits)
Introduces essential process engineering and lean tools used by leading companies to improve the design and performance of new and existing processes. Clearly defined problem statements with stakeholders, targeted data analysis, and effective implementation of solutions will be discussed. The following tools and principles, with a Lean philosophy overlay, will be covered: process mapping, data collection and analysis, standard operating setpoints, audits, training, change control, experiment planning, materials and tooling control, measurement and calibration systems, maintenance management, gap analysis, cycle time content and balance, lead-time assessment and management, quality performance analysis and remediation, sustainable control measures, demand/takt time analysis and relation to demonstrated equipment/process capacity, and process stability assessment. Six sigma tools will also be introduced. Effective use of these tools enables engineers to drive towards consistent process capability and improved cycle time, quality, lead time, and cost.
Enrollment Information: Open to: ChemE Seniors, M. Eng. and MS Engineering. Permission of instructor required.
Last Four Terms Offered: Fall 2024
Learning Outcomes:

- Apply fundamental process performance assessment principles such as constraint analysis and apply consistent, data driven thinking related to process/business improvement.
- Apply core lean and process engineering tools, terminology, and principles to modern day manufacturing.
- Apply and demonstrate the practical principles around process problem solving and optimization.
- Using relevant process data, identify and remediate process constraints and install key performance indicators (KPIs) for sustainability.

Schedule of Classes

CHEME 5800 - Principles of Computational Thinking for Engineers (4 Credits)
Engineering practice increasingly relies on computational tools and data analysis approaches. The course introduces computational thinking into engineering analysis. Integrates data science and statistics, linear algebra, artificial intelligence, and mathematical modeling approaches into the context of contemporary problems in the design and analysis of processes, products, and systems. Focuses on paradigms, not syntax. Use of the Julia programming language and its associated toolchain to transition from idea to implementation. In addition, cloud computing resources for course materials, assignments, and projects. Weekly labs provide guided hands-on practice. Course assignments use data sets and examples from industrial practice to develop fluency and understanding of real-life problems.
Prerequisites: CS 1110 or CS 1112 or equivalent.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Last Four Terms Offered: Fall 2024, Spring 2024
Learning Outcomes:

- Demonstrate mastery of basic software engineering paradigms, data structures, common programming idioms, and algorithms.
- Analyze scientific, engineering, and financial data sets using tools from data science/statistics and machine learning (ML).
- Identify and test quantitative models of process and product performance using real-time dynamic and static data sets
- Demonstrate mastery of quantitative decision-making and risk management approaches in the context of a process, product, or system design.

Schedule of Classes

CHEME 5820 - Machine Learning and Artificial Intelligence Methods for Engineers (4 Credits)
Engineering practice increasingly relies on computational tools, data analysis, and Machine Learning approaches. This one-semester course introduces machine learning, focusing on supervised learning and its theoretical foundations in the context of engineering practice. Topics include regularized linear models, boosting, kernel methods, deep learning approaches, generative modeling tools, decision-making in stochastic systems, and reinforcement learning approaches.
Prerequisites: CHEME 4800 or CHEME 5800.
Last Four Terms Offered: Spring 2025
Learning Outcomes:

- Demonstrate mastery of basic machine learning principles and applications in the context of engineering practice.
- Demonstrate the ability to implement basic machine learning models, apply them to real-world data sets, and evaluate their performance.
- Demonstrate an understanding of the impact of assumptions on the applicability of machine learning methods, identify which settings various methods apply, and analyze the strengths and weaknesses of methods in different applications.

Schedule of Classes

CHEME 5870 - Energy Seminar I (1 Credit)
Crosslisted with ECE 5870, MAE 5459, 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

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

CHEME 5990 - Medical and Industrial Biotechnology Seminar (1 Credit)
Students attend seminars of their selection and write one-page summaries. Eligible seminars include all listings that are related to medical and industrial biotechnology.
Prerequisites: medical and industrial biotechnology trainees.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes

CHEME 5999 - Special Projects in Chemical Engineering (1-9 Credits)
Nonthesis research or studies on special problems in chemical engineering.
Enrollment Information: Enrollment limited to: graduate students.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes

CHEME 6110 - Mathematical Methods of Chemical Engineering Analysis (3 Credits)
Techniques covered include mathematical modeling, scaling, dimensional analysis, regular and singular perturbations, multiple scales, asymptotic analysis, stability analysis, linear and nonlinear ordinary and partial differential equations, numerical methods for initial and boundary value problems, finite Fourier transform method, and introduction to finite element analysis.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes

CHEME 6130 - Advanced Chemical Engineering Thermodynamics (3 Credits)
Molecular thermodynamics of gases, lattices, and liquids, including special applications to problems in chemical engineering.
Prerequisites: CHEM 3890-CHEM 3900, CHEME 3130 or equivalent.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes

CHEME 6230 - Transport Phenomena for Chemical and Biomolecular Engineering (3 Credits)
Builds foundational knowledge of transport phenomena to provide conceptional and mathematical tools to address research topics in chemical and biomolecular engineering. Significant use will be made of primary literature from biological, materials, energy, and sustainability contexts to motivate and illustrate concepts.
Prerequisites: MATH 1910, MATH 1920, MATH 2930, MATH 2940, CHEME 3230 and CHEME 3240 or equivalent.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022
Learning Outcomes:

- Analyze transport phenomena physically and mathematically.
- Develop the ability to design research approaches and analyze experimental data.
- Interpret and use concepts related to transport phenomena from primary research literature.

Schedule of Classes

CHEME 6240 - Advanced Fluid Mechanics and Heat Transfer (3 Credits)
Topics include derivation of conservation equations; conductive heat transfer; low Reynolds number fluid dynamics; lubrication theory; inviscid fluid dynamics; boundary layer theory; forced convection; and introduction to non-Newtonian fluid mechanics (polymeric liquids and suspensions), microfluidics, stability analysis, and turbulent flow.
Prerequisites: CHEME 3230-CHEME 3240 or equivalent.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Fall 2021
Schedule of Classes

CHEME 6310 - Engineering Principles for Drug Delivery (3 Credits)
Crosslisted with BME 6210
Application of engineering design principles to problems in drug formulation and delivery. Specific topics include traditional drug formulation, mechanisms and kinetics of pharmaceutical stability, stimuli-sensitive systems, controlled-release devices, prodrugs, targeted drug delivery, transdermal drug delivery, biomaterials, and gene therapy.
Prerequisites: background in organic and polymer chemistry or permission of instructor.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes

CHEME 6400 - Polymeric Materials (3 Credits)
Covers chemistry and physics of the formation and characterization of polymers; principles of fabrication.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2021
Learning Outcomes:

- Learn about the synthesis of polymers, their properties, and their industrial applications.
- Acquire knowledge of sources of raw materials, the applications and limitations of available polymers/plastics, their benefits and disadvantages.
- Gain experience in working in teams and presenting a recent development of an engineering solution based on the development of new polymeric materials.

Schedule of Classes

CHEME 6420 - Chemical Kinetics and Transport (4 Credits)
Topics include microscopic and macroscopic viewpoints; connections between phenomenological chemical kinetics and molecular reaction dynamics; reaction cross sections, potential energy surfaces, and dynamics of biomolecular collisions; molecular beam scattering; transition state theory. Unimolecular reaction dynamics; complex chemically reacting systems: reactor stability, multiple steady states, oscillations, and bifurcation; reactions in heterogeneous media; and free-radical mechanisms in combustion and pyrolysis.
Prerequisites: CHEME 3900 or equivalent.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

CHEME 6430 - Advanced Principles of Biomolecular Engineering (4 Credits)
This course will cover the physical principles required for understanding the molecular basis of life and its use in biotechnologies. Emphasis will be placed on deconstructing biological phenomena from a quantitative perspective of core engineering principles. Specific topics will include: thermodynamics and kinetics of gene expression and genetic circuitry, biophysical principles of molecular interaction, molecular mechanisms in the definition of cell state and differentiation, molecular modes of cellular communication, and biophysical considerations for multicellular life.
Prerequisites: CHEME graduate core or equivalent, or permission of instructors.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2022, Spring 2021
Learning Outcomes:

- Learn how to apply core engineering concepts (kinetics, thermodynamics, transport phenomena) to understanding and engineering the function of living systems.
- Gain familiarity with primary literature in biomolecular engineering, and systems, synthetic and computation biology through quantitative deconstruction of fundamental problems in biotechnology.

Schedule of Classes

CHEME 6440 - Aerosols and Colloids (3 Credits)
Dynamics of micro-and nano-particles, which contain many molecules but are small enough that molecular effects are important. Topics include: the formation and growth of particles; their transport, theological and phase behaviors; and their role in technologies including paints, foods, health-care products, drug delivery, composite materials and air pollution control.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Spring 2019
Schedule of Classes

CHEME 6660 - Analysis of Sustainable Energy Systems (2 Credits)
Quantitative methods of engineering and life cycle analysis for energy choices in a contemporary sustainability context. Fundamental principles of thermodynamics, transport, and reaction kinetics applied to representative energy supply and end use technologies. Topics include: resource assessment, energy extraction/capture, conversion, distribution, storage, consumption, environmental and economic consequences, local to global scales.
Exploratory Studies: (CU-SBY)

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

- Quantify current energy supplies and demands. Learn and appreciate the importance of geopolitical/social context in sustainability analysis.
- Develop advanced skills for engineering analysis, including process thermodynamics, 2nd-law/availability analysis, transient heat conduction, and economics.
- Minimize energy consumption or maximize energy production in processes, e.g., heat-to-work in Rankine cycles, heat and work inputs for chemical conversions, work inputs for refrigeration.
- Assess and compare options for sustainable energy recovery from our natural environment, including geothermal, bio, and solar energy.
- Complete a comprehensive design project, working in teams of typically two students each, that involves both oral and written communication of results.

Schedule of Classes

CHEME 6661 - Bioenergy and Biofuels Module (1 Credit)
Energy technology module of CHEME 6660 will introduce students to issues and challenges in utilizing biomass feedstocks to produce bioenergy, biofuels and/or other products. The focus will be on converting biomass feedstocks to bioenergy using a variety of thermochemical processes. Case study material will include biomass feedstock cultivation and harvesting, processing and conversion technologies, co-products, and environmental and economic impacts over their full life cycle. The course will culminate in a final project in which students will use Life Cycle Assessment to measure the energetic viability and environmental performance.
Enrollment Information: Permission of instructor required.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2024, Spring 2023, Fall 2020, Spring 2019
Schedule of Classes

CHEME 6662 - Solar Energy Module (1 Credit)
Energy technology module of CHEME 6660 provides a comprehensive overview of solar energy conversion technologies. Major themes range from fundamental (nuts and bolts) solid-state concepts and operating principles of photovoltaics to manufacturing of cells and modules, balance of system aspects, and perspectives on second- and third-generation photovoltaic technologies. The module also summarizes solar thermal power technologies including passive and active solar heating, concentrated solar power plants.
Exploratory Studies: (CU-SBY)

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

CHEME 6663 - Geothermal Energy Module (1 Credit)
Energy technology module of CHEME 6660 focuses on the utilization of low-temperature geothermal energy: geothermal heat pumps, district heating systems for heating and cooling, hybrid geothermal systems and cogeneration applications. It also discusses shallow and deep geothermal reservoir thermal modeling. Technical economic and environmental aspects of large scale geothermal deployment will be covered.
Exploratory Studies: (CU-SBY)

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

CHEME 6664 - Hydrokinetic and Aerodynamic Energy Module (1 Credit)
Crosslisted with CEE 6364
Energy technology module of CHEME 6660. An overview of water and wind energy resources and technology both on and off shore. Emphasis will be placed on water power from conventional impoundment dams and run of river resources to pumped hydro, wave energy, and tidal basin systems. Covering water resource assessment, basic fundamentals of hydrokinetic energy capture, hydro turbine technology, designs and performance, wave power energy recovery systems, siting issues and environmental impacts, and cost estimates and projections.
Enrollment Information: Permission of instructor required.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2023, Spring 2023, Spring 2020, Spring 2018
Schedule of Classes

CHEME 6667 - Transportation Energy Systems Module (1 Credit)
Crosslisted with CEE 6667
Energy technology module of CHEME 6660 covering transportation energy systems. Focuses on understanding the link between transportation demand and energy consumption and on how to build a path for a conversion to sustainable energy sources. Covers engineering systems tools for analyzing the interactions among the transportation, economic, energy, and environmental systems. Analytical tools from transportation economics and engineering will be covered to assess the energy consumption and environmental effects of long-term projects over complex, large-scale transportation systems.
Enrollment Information: Permission of instructor required.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2023, Fall 2021, Fall 2019, Fall 2018
Schedule of Classes

CHEME 6670 - Fossil Fuels Module (1 Credit)
Energy technology module of CHEME 6660 covering fossil fuels.
Enrollment Information: Permission of instructor required.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2024, Spring 2023, Spring 2022, Fall 2020
Schedule of Classes

CHEME 6671 - Nuclear Energy Module (1 Credit)
Energy technology module of CHEME 6660 will provide a description of the operation of nuclear fission power plants in their several manifestations and the fuel cycle associated with them. Their benefits and reasons why they are cause for concern will be described. Topics will include the principles of reactor operation and control, reactor safety features (natural and engineered), normal and abnormal operation, spent fuel safety and nuclear waste disposal, etc. Advanced reactors now runder construction and to be constructed in the near and more distant future will be discussed.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2024, Spring 2023, Fall 2019, Spring 2018
Schedule of Classes

CHEME 6676 - Energy Markets and Regulations Module (1 Credit)
Energy regulation, public interest, and the challenge of the social license are the main topics of this offering. This course will review the nature of energy regulation using the lens of government policy oversight, legal responsibilities, investment incentives, and the role of the public regulatory process in ensuring reliable, affordable, and environmentally responsible infrastructure development matched to technological innovation within North America.
Enrollment Information: Permission of instructor required.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Fall 2022, Fall 2021, Fall 2017
Schedule of Classes

CHEME 6679 - Energy Storage Module (1 Credit)
The performance, cost, and safety of energy storage technology are recognized at the Achilles' heel in our transition towards a sustainable energy portfolio. The broad integration of inherently intermitted renewable energy sources (e.g., solar and wind) is critically dependent on technological advances in energy storage. The infrastructure used to store chemical, electrical, and thermal energy is extensive, multiscale, and capital intensive. Coverage in this module includes thermal energy storage, and electrical energy storage and conversion. Technologies evaluated include fuel cells, batteries, compressed air energy storage (CAES), pumped hydro, supercapacitors and flywheels.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2025, Spring 2024, Fall 2022, Fall 2021
Schedule of Classes

CHEME 6681 - Energy Analysis Project (1 Credit)
Capstone energy analysis project covering a topic of interest. Relevant background information will be provided in CHEME 6660: Analysis of Sustainable Energy Systems - course lectures as well as from the other energy modules offered. Specific projects should include, to the extent possible, a quantitative discussion of resource assessment, energy extraction/capture, conversion, distribution, storage, and consumption; environmental and economic consequences spanning local to global scales.
Prerequisites: CHEME 6660.
Enrollment Information: Permission of instructor required.
Exploratory Studies: (CU-SBY)

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

CHEME 6682 - Energy Economics for Engineers (1 Credit)
Energy Economics for Engineers will prepare students to employ engineering and economic tools and techniques to analyze large and small energy projects and make effective recommendations on energy choices. The course will also cover energy systems, markets, innovation, and policy with a focus on aspects that are required to support thorough and complete project analysis. Energy technology module of CHEME 6660 - Analysis of Sustainable Energy Systems.
Enrollment Information: Required for: ChemE M. Eng. Energy Economics track students. Open to: graduate students, seniors and juniors.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2025
Learning Outcomes:

- Learn and apply economic principles including the time value of money, interest rates, and cash flow analyses.
- Demonstrate techniques for incorporating engineering principles into economic analyses to model project performance and inform decision making.
- Design and implement comprehensive technoeconomic analyses, including externalities as appropriate.
- Analyze energy systems, markets, and policy choices relevant to energy project analyses.
- Structure analyses to support good decision making and effectively communicate results.

Schedule of Classes

CHEME 6780 - Global Food, Energy, and Water Nexus – Engage the US, China, and India for Sustainable Future (3-4 Credits)
Crosslisted with ANSC 6880, FDSC 6880, AEM 6880, CEE 5820, GDEV 6880
This course is offered by six Departments at Cornell, in collaboration with five Universities in China and one India. Video conferencing will be used to connect classrooms in the three countries in real time. Important issues related to the food, energy, and water nexus and its implications for nutrition security, one health, environmental sustainability, climate change, and economic development in the US and these two countries will be described. Challenges associated with these issues will be evaluated and strategies to address them will be proposed. Engagement of these countries with each other and the rest of the world will be explored. The course serves as a platform for students from Cornell, China, and India to learn from and interact with each other in the same class, and to share their thinking, creativity, and perspectives on these issues.
Enrollment Information: Enrollment limited to: graduate student status, or permission of the instructors.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Learning Outcomes:

- Identify and compare the major food, nutrition and health, energy, water, and economic challenges facing the US, China, and India.
- Describe barriers to food and nutrition security for all people in each of the three countries and globally and propose solutions for overcoming these barriers.
- Identify and quantify the requirements of energy and water for producing, processing, transporting, and/or preparing food.
- Evaluate various predictions of regional and global impacts of climate change on agricultural production and human health in the 21st century.
- Collaborate as members of interdisciplinary teams composed of students from the US, China, and India to analyze and solve problems that affect food, water, and energy security.
- Effectively and respectfully debate, with people of opposing views, issues related to food, water, and energy nexus.
- Prepare and deliver focused, clear, impactful, and culturally sensitive presentations to an international audience of peers.

Schedule of Classes

CHEME 6800 - Computational Optimization (4 Credits)
Crosslisted with SYSEN 6800
Systems optimization modeling, computation, and applications. Includes theory and algorithms of linear, nonlinear, mixed-integer linear, mixed-integer nonlinear, and deterministic global optimization, as well as stochastic programming, robust optimization and optimization methods for big-data analytics. Real-world applications of large-scale computational optimization in process manufacturing, bioengineering, energy systems, and sustainability.
Prerequisites: MATH 2220 and MATH 2940 or equivalents.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Last Four Terms Offered: Fall 2024, Fall 2022, Fall 2021, Fall 2020
Schedule of Classes

CHEME 6810 - AI for Sustainability (3 Credits)
Crosslisted with SYSEN 6810
This studio-style course emphasizes collaborative learning and innovation in sustainability. Students will explore foundational and cutting-edge literature, research, and potential future directions in AI for Sustainability. The course will cover a range of topics related to the use of AI and machine learning in sustainability science and engineering, including energy systems decarbonization, sustainable agriculture, climate modeling, resource optimization, and biodiversity conservation. Students will gain hands-on experience with AI/ML methodologies, tools, and software and engage in discussions on the latest advancements and applications of AI in addressing global sustainability challenges.
Enrollment Information: Permission of instructor required.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2025
Learning Outcomes:
- Describe the key challenges in applying AI to sustainability.
- Explain how to define and formulate AI-driven solutions to sustainability challenges, applying computational and AI techniques to address problems that span multiple scales and systems.
- Analyze and discuss existing literature on AI for Sustainability and related interdisciplinary research in science and engineering.

Schedule of Classes

CHEME 6820 - AI for Materials (1 Credit)
This course module of CHEME 6888 focuses on the application of artificial intelligence (AI) in materials science. Students will explore how AI and machine learning techniques can accelerate the design, discovery, and optimization of materials for energy storage, conversion, and sustainability. Key topics include using AI to predict material properties, enhance materials synthesis, and model complex material behaviors. The course emphasizes practical applications of deep learning models in materials science, featuring hands-on projects and case studies from recent research. Students will also discuss the challenges and opportunities of applying AI to advance innovations in materials science.
Exploratory Studies: (CU-SBY)

Last Four Terms Offered: Spring 2025
Learning Outcomes:
- Understand the role of AI in advancing materials discovery and development.
- Apply deep learning models to predict material properties and outcomes in materials science.
- Analyze case studies of successful AI-driven materials discoveries.
- Identify challenges and emerging trends in the use of AI for materials innovations.

Schedule of Classes

CHEME 6830 - AI for Energy Systems (1 Credit)
Crosslisted with SYSEN 6820
This course focuses on the application of artificial intelligence (AI) to energy systems over four weeks. Students will explore how AI techniques can optimize the performance of energy and power systems, with a particular focus on sustainable energy systems and renewable energy transition. Key topics include the optimization of energy generation, distribution, storage, and consumption. Specific case studies will cover topics such as optimizing solar and wind energy integration into the grid, improving battery storage management for renewable energy, and enhancing energy efficiency in smart grids. The course will also highlight AI applications in balancing supply and demand for renewable energy systems.
Exploratory Studies: (CU-SBY)

Learning Outcomes:
- Understand the role of AI in energy and power systems.
- Apply AI techniques to optimize the efficiency and sustainability of energy generation, distribution, and consumption, with a focus on renewables like solar, wind, biomass, and geothermal.
- Analyze case studies of AI-driven innovations such as optimizing renewable energy integration, improving battery storage, and managing smart grids.
- Identify challenges and emerging trends in the use of AI for renewable energy systems and energy transition.

Schedule of Classes

CHEME 6840 - AI for Digital Agriculture (1 Credit)
Crosslisted with SYSEN 6840
This course focuses on the application of artificial intelligence (AI) in the digital transformation of agriculture. Students will explore how AI techniques are applied to optimize and automate agricultural systems, improve productivity, and enhance sustainability. The course covers a broad range of topics, including AI-driven crop management, precision farming, livestock monitoring, and data analytics for sustainable agriculture. Case studies on AI applications in plant and animal production systems, as well as food supply chains, will provide practical insights into the future of farming. Students will engage in discussions on the ethical, social, and economic implications of AI in agriculture, while hands-on projects will offer experience in applying AI tools to real-world agricultural challenges.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Exploratory Studies: (CU-SBY)

Learning Outcomes:
- Understand the role of AI in transforming agricultural practices for improved efficiency and sustainability.
- Apply AI techniques to optimize crop production, livestock management, and resource use in agriculture.
- Analyze case studies of AI-driven innovations in digital agriculture, including precision farming, smart irrigation, and disease detection.
- Identify challenges and trends in AI for sustainable food systems, addressing environmental, social, and economic considerations.

Schedule of Classes

CHEME 6880 - Industrial Big Data Analytics and Machine Learning (4 Credits)
Crosslisted with SYSEN 6880
This course covers the basic concepts, models and algorithms of Bayesian learning, classification, regression, dimension reduction, clustering, density estimation, artificial neural networks, deep learning, and reinforcement learning. Application and methodology topics include process monitoring, fault diagnosis, preventive maintenance, root cause analysis, soft sensing, quality control, machine learning for process optimization, data-driven decision making under uncertainty, missing data imputation, data de-noising, and anomaly/outlier detection.
Prerequisites: CEE 3040 or MATH 4710 or ORIE 3500 or equivalent, CHEME 6800/SYSEN 6800 or ORIE 3310 or ORIE 5310 or ORIE 5380.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021
Schedule of Classes

CHEME 6888 - Deep Learning (4 Credits)
Crosslisted with SYSEN 6888
This course provides a comprehensive overview of deep learning, covering basic concepts, models, algorithms, and applications. Topics include artificial neural networks, training techniques, convolutional neural networks, recurrent neural networks, generative deep learning, deep reinforcement learning, and deep learning hardware and software. Recent advances in deep learning, such as graph neural networks, attention, Transformer, ViT, BERT, and GPT, will also be discussed. The course explores deep learning-based applications in optimization, sensing, control, and automation, and in AI for Science, including molecular design, material discovery, and pharmaceutical development.
Enrollment Information: Enrollment limited to: graduate or professional students only.
Last Four Terms Offered: Spring 2025, Fall 2023
Learning Outcomes:
- Analyze and understand modern deep learning models, algorithms, and applications.
- Demonstrate ability to develop deep learning models and algorithms for real-world applications.
- Demonstrate ability to apply deep learning to solve application problems.

Schedule of Classes

CHEME 6920 - Principles and Practices of Graduate Research (1 Credit)
A colloquium/discussion group series for first-year graduate students. Topics include the culture and responsibilities of graduate research and the professional community; the mechanics of conducting research (experimental design, data analysis, serendipity in research, avoiding self-deception), documenting research (lab notebooks, computer files) and reporting research (writing a technical paper and oral presentations).
Enrollment Information: Enrollment limited to: graduate or professional students only.
Last Four Terms Offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021
Schedule of Classes

CHEME 6930 - Peer Mentoring and Leadership Essentials (1 Credit)
Crosslisted with ENGRG 7930, MSE 7930
This course develops fundamental communication, coaching, mentorship and leadership skills for PhD students. It is designed specifically for PhD mentors in the Ezra's Bridge program; however, the course is appropriate for all PhD students who wish to be more effective lab members and leaders.
Enrollment Information: Enrollment limited to: PhD students in Ezra's Bridge Program. Additional seats open to PhD students in any STEM field.
Last Four Terms Offered: Spring 2024, Spring 2023, Spring 2022
Learning Outcomes:
- Demonstrate competence in core skills of peer coaching and mentoring.
- Demonstrate competence in creating an inclusive and psychologically safe academic work environment.
- Demonstrate competence in proactive leadership communication skills.

Schedule of Classes

CHEME 6950 - Engineering Education Teaching and Research Methods (3 Credits)
Crosslisted with SYSEN 6950
Intended for graduate students who are interested in teaching engineering or related fields as part of their future careers. Includes both discussion and practice of effective teaching techniques, assessments and technologies, an overview of current engineering education research, equity and inclusion in the undergraduate engineering classroom, and action research methods using qualitative/quantitative/mixed methodologies to develop teacher scholars.
Last Four Terms Offered: Spring 2025, Spring 2024
Learning Outcomes:
- Describe the attributes of effective teaching in undergraduate engineering or closely related fields grounded in evidence from literature.
- Leverage backwards design principles to formulate assessment, content, and pedagogy for a course.
- Create a statement of teaching goals, methods, and philosophy.
- Analyze classroom practices to effectively teach and include diverse learner needs.
- Explore research methods for studying and improving educational practice.

Schedule of Classes

CHEME 7700 - Chemical Engineering Graduate Research Seminar (1 Credit)
Chemical Engineering graduate students in their third year and above must present an annual seminar on their research. Provides training in public presentation and dissemination of scientific data. Constructive feedback on the quality of the presentation and research will be submitted by attendees.
Enrollment Information: Enrollment limited to: ChemE graduate students.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Learning Outcomes:

- Define a problem and propose a solution.
- Demonstrate command of literature, prior work and identify the impact of the proposed research.
- Demonstrate critical thinking, explain the intellectual merit and broader impacts of the research project.

Schedule of Classes

CHEME 7740 - Principles of Molecular Simulation (4 Credits)
Introduction to molecular simulation methods, Molecular Dynamics and Monte Carlo. Understanding options for interatomic and intermolecular modeling and appropriate representation of materials.
Prerequisites: familiarity with a programming language essential.
Last Four Terms Offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
Schedule of Classes

CHEME 7900 - Chemical Engineering Seminar (1 Credit)
General chemical engineering seminar.
Enrollment Information: Enrollment limited to: ChemE graduate students.
Last Four Terms Offered: Spring 2025, Fall 2024, Spring 2024, Fall 2023
Schedule of Classes