EN.540 (CHEMICAL & BIOMOLECULAR ENGINEERING)

EN.540.101. Chemical Engineering Today. 1 Credit.
A series of weekly lectures to introduce students to chemical and biomolecular engineering and its role as a profession in addressing contemporary technological, social, ethical, and economic issues in today's world. The lectures will include examples of how chemical and biomolecular engineers apply the principles of physics and chemistry to develop new products, improve process efficiencies, and alleviate the strain on the ecosystem through the design of novel environmentally conscious processes. In addition, the lectures will highlight exciting new areas now being advanced by chemical and biomolecular engineers, such as biochemical engineering, tissue engineering, nanoparticle fabrication, and processing smart polymers for applications in computer technology and as sensors. Freshmen Only.
Area: Engineering

EN.540.202. Introduction to Chemical & Biological Process Analysis. 4 Credits.
Introduction to chemical and biomolecular engineering and the fundamental principles of chemical process analysis. Formulation and solution of material and energy balances on chemical processes. Reductionist approaches to the solution of complex, multi-unit processes will be emphasized. Introduction to the basic concepts of thermodynamics as well as chemical and biochemical reactions.
Prerequisite(s): (AS.030.101 OR AS.030.103) AND (AS.171.101 OR AS.171.107) AND (AS.030.102 OR AS.030.103 OR AS.110.109 OR AS.171.102)
Area: Engineering

EN.540.203. Engineering Thermodynamics. 3 Credits.
Formulation and solution of material, energy, and entropy balances with an emphasis on open systems. A systematic problem-solving approach is developed for chemical and biomolecular process-related systems. Extensive use is made of classical thermodynamic relationships and constitutive equations for one and two component systems. Applications include the analysis and design of engines, refrigerators, heat pumps, compressors, and turbines.
Prerequisite(s): EN.540.202; AS.110.202
Area: Engineering

EN.540.290. Chemical Engineering Modeling and Design for Sophomores. 3 Credits.
The courses EN.540.290, 291, 390, and 391 guide the students through the open-ended problems in product and process design. Product design concerns the recognition of customer needs, the creation of suitable specifications, and the creation of new products to fulfill a societal need. Process design concerns the quantitative description of processes which serve to produce chemically-derived materials and the estimation of process profitability. Students work in small teams to complete a major project demonstrating their understanding of and proficiency in the principles of unit operations and design. Students report weekly both orally and in writing on their accomplishments. Some projects are single semester, but others can be multi-semester. Students can start in any semester and can work on projects for as many semesters as they want.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Engineering

EN.540.291. Chemical Engineering Modeling and Design for Sophomores. 3 Credits.
The courses EN.540.290, 291, 390, and 391 guide the students through the open-ended problems in product and process design. Product design concerns the recognition of customer needs, the creation of suitable specifications, and the creation of new products to fulfill a societal need. Process design concerns the quantitative description of processes which serve to produce chemically-derived materials and the estimation of process profitability. Students work in small teams to complete a major project demonstrating their understanding of and proficiency in the principles of unit operations and design. Students report weekly both orally and in writing on their accomplishments. Some projects are single semester, but others can be multi-semester. Students can start in any semester and can work on projects for as many semesters as they want.
Area: Engineering

EN.540.301. Kinetic Processes. 4 Credits.
Review of numerical methods applied to kinetic phenomena and reactor design in chemical and biological processes. Homogeneous kinetics and interpretation of reaction rate data. Batch, plug flow, and stirred tank reactor analyses, including reactors in parallel and in series. Selectivity and optimization considerations in multiple reaction systems. Non isothermal reactors. Elements of heterogeneous kinetics, including adsorption isotherms and heterogeneous catalysis. Coupled transport and chemical/biological reaction rates.
Prerequisite(s): EN.540.203 AND EN.540.303
Area: Engineering

EN.540.303. Transport Phenomena I. 3 Credits.
Molecular mechanisms of momentum transport (viscous flow), energy transport (heat conduction), and mass transport (diffusion). Isothermal equations of change (continuity, motion, and energy). The development of the Navier Stokes equation. The development of non isothermal and multi component equations of change for heat and mass transfer. Exact solutions to steady state, isothermal unidirectional flow problems, to steady state heat and mass transfer problems. The analogies between heat, mass, and momentum transfer are emphasized throughout the course. Co-requisite: AS.110.302
Prerequisite(s): AS.110.302
Area: Engineering
EN.540.304. Transport Phenomena II. 4 Credits.
Prerequisite(s): EN.540.303
Area: Engineering

EN.540.306. Chemical & Biomolecular Separation. 4 Credits.
This course covers staged and continuous-contacting separations processes critical to the chemical and biochemical industries. Separations technologies studied include distillation, liquid-liquid extraction, gas absorption, membrane ultrafiltration, reverse osmosis, dialysis, adsorption, and chromatography. Particular emphasis is placed on the biochemical uses of these processes and consequently on how the treatment of these processes differs from the more traditional approach.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;EN.540.203 AND EN.540.303
Area: Engineering

EN.540.307. Cell Biology for Engineers. 3 Credits.
This course explores fundamental structural details and molecular functions of different parts of the cell. Considerable emphasis is placed on experimental/quantitative approaches to answering these questions. Topics include Central dogma and the nucleus; protein trafficking; ion transporters; cytoskeleton; molecular motors; cell cycle and cell division; signal transduction, cell growth and cancer; cell death, the extracellular matrix; cell adhesion, cell junctions and epithelium; and muscle contraction, cell motility and morphogenesis.
Prerequisite(s): Cell Biology restriction: students who have completed AS.020.306 may not enroll.;AS.020.305
Area: Natural Sciences

EN.540.309. Product Design Part 1. 3 Credits.
This course guides the student through the steps of product design. Product design concerns the recognition of customer needs, the creation of suitable specifications, and the selection of best products to fulfill the needs. Students work in small teams to complete a major project demonstrating their understanding of and proficiency in the primary objectives of the course. Students report several times both orally and in writing on their accomplishments. This course is the first part of a two-semester sequence that optionally can be taken instead of EN.540.314 Chemical and Biomolecular Engineering Product Design. The material covered is the same as in EN.540.314, but more time is allowed so that laboratory tests can be performed and/or prototypes can be made. Note that students must take 540.310 to complete this sequence andbefore receiving credits for 540.309.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;EN.540.303 AND EN.540.490;EN.540.306 AND EN.540.301
Area: Engineering

EN.540.310. Product Design Part 2. 3 Credits.
This course is the second part of a two semester sequence (with EN.540.309) that optionally can be taken instead of EN.540.314 Chemical and Biomolecular Engineering Product Design. Students continue to work with their team on their product design project. Students report several times both orally and in writing on their accomplishments. The material covered is the same as in EN.540.314, but more time is allowed so that laboratory tests can be performed and/or prototypes can be made. Note that both courses, EN.540.309 and EN.540.310 must be taken to satisfy the Undergraduate degree requirement of the Chemical and Biomolecular Engineering program. The two courses can be started in any term. Recommended Course Background: EN.540.301, EN.540.304, EN.540.311 or EN.540.313 or permission of instructor.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;EN.540.309
Area: Engineering

EN.540.311. Projects in ChemE Unit Operations with Experiments. 4 Credits.
This course challenges students with laboratory projects that are not well-defined. Students work in groups to develop an effective approach to experiments. They identify the important operating variables, decide how best to obtain them using measured or calculated values. Based on their results they predict, carryout, analyze and improve experiments. Each student analyzes three of the following projects: distillation, gas absorption, and one of the projects in EN.540.313. In addition to technical objectives, this course stresses oral and written communication. In addition to technical objectives, this course stresses oral and written communication. Students will have additional meeting times with the instructors and outside of class.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;EN.540.301 AND EN.540.304 AND EN.540.306 AND EN.661.315;EN.540.490 can be taken concurrently with EN.540.311
Area: Engineering
Writing Intensive

EN.540.313. Projects in ChemBE Unit Operations with Experiments. 4 Credits.
This course challenges students with laboratory projects that are not well-defined. Students work in groups to develop an effective approach to experiments. They identify the important operating variables, decide how best to obtain them using measured or calculated values. Based on their results they predict, carryout, analyze and improve experiments. Each student analyzes at least two of the following biomolecular projects: bioreactor, biocatalysis and membrane separation and one of the projects in EN.540.313. In addition to technical objectives, this course stresses oral and written communication. Based on their results they predict, carryout, analyze and improve experiments. Each student analyzes at least two of the following biomolecular projects: bioreactor, biocatalysis and membrane separation and one of the projects in EN.540.313. In addition to technical objectives, this course stresses oral and written communication. Students will have additional meeting times with the instructors and outside of class.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;EN.540.301 AND EN.540.304 AND EN.540.306 AND EN.661.315;EN.540.490 can be taken concurrently with EN.540.313
Area: Engineering
Writing Intensive
EN.540.314. ChemBE Product Design. 3 Credits.
This course guides the student through the steps of a project in product design. Product design concerns the recognition of customer needs, the creation of suitable specifications, and the selection of best products to fulfill the needs. It includes the design of a manufacturing process for the product and an estimation of the economic profitability of the concept. Students work in small teams to complete a major project demonstrating their understanding of and proficiency in the primary objectives of the course. Students report several times both orally and in writing on their accomplishments.
Prerequisite(s): EN.540.490;EN.540.303;EN.540.306 AND EN.540.301
Area: Engineering

EN.540.315. Process Design with Aspen. 2 Credits.
The course guides the students through process design where they study the production of a chemical compound. They select a preferred process and create a flowsheet of the production process. They use Aspen simulation to evaluate the major unit operations of their process. They will carry out a hazard operations analysis on the process and perform an economic analysis when appropriate. Students work in small teams to complete their project and write a report on their work and conclusions.
Prerequisite(s): EN.540.490;EN.540.303;EN.540.306 AND EN.540.301
Area: Engineering

EN.540.382. Statistical Modeling and Analysis with Python. 2 Credits.
The course introduces several statistical methods, used to analyze and extract useful information from data. Topics covered include descriptive statistics, basic probability theory, error analysis, confidence intervals, hypothesis testing, regression, design of experiments and an introduction to Bayesian Statistics. Students will also learn to perform statistical analysis of data using Python libraries.
Prerequisite(s): (EN.500.113 OR EN.500.133) AND AS.110.202 AND AS.110.302
Area: Engineering, Quantitative and Mathematical Sciences

EN.540.390. Chemical Engineering Modeling and Design for Juniors. 3 Credits.
The courses EN.540.290, 291, 390, and 391 guide the students through the open-ended problems in product and process design. Product design concerns the recognition of customer needs, the creation of suitable specifications, and the creation of new products to fulfill a societal need. Process design concerns the quantitative description of processes which serve to produce chemically-derived materials and the estimation of process profitability. Students work in small teams to complete a major project demonstrating their understanding of and proficiency in the principles of unit operations and design. Students report weekly both orally and in writing on their accomplishments. Some projects are single semester, but others can be multi-semester. Students can start in any semester and can work on projects for as many semesters as they want.
Prerequisite(s): EN.540.490;EN.540.303;EN.540.306 AND EN.540.301
Area: Engineering

EN.540.391. Chemical Engineering Modeling and Design for Juniors. 3 Credits.
The courses 540.290, 291, 390, and 391 guide the students through the open-ended problems in product and process design. Product design concerns the recognition of customer needs, the creation of suitable specifications, and the creation of new products to fulfill a societal need. Process design concerns the quantitative description of processes which serve to produce chemically-derived materials and the estimation of process profitability. Students work in small teams to complete a major project demonstrating their understanding of and proficiency in the principles of unit operations and design. Students report weekly both orally and in writing on their accomplishments. Some projects are single semester, but others can be multi-semester. Students can start in any semester and can work on projects for as many semesters as they want.
Prerequisite(s): EN.540.490;EN.540.303;EN.540.306 AND EN.540.301
Area: Engineering

EN.540.400. Project in Design: Pharmacokinetics. 3 Credits.
This is a design course in which the design projects will be to develop pharmacokinetic models of the human body that can be used to understand the temporal distribution, spatial distribution and bioavailability of pharmaceutical drugs. The course (and software to be developed) will cover the spectrum of factors affecting pharmaceutical bioavailability including drug formulation, mode of dosing and dosing rate, metabolism and metabolic cascades, storage in fatty tissues, and diffusional limitations (such as in crossing the blood-brain barrier or diffusional differences between normal and cancerous cells). The goal is to develop process models of the human body that will predict pharmaceutical bioavailability as a function of time and organ (or cell) type that will work for a wide variety of pharmaceuticals including small molecules, biologics, and chemotherapy agents. This course is organized to replicate group project work as it is practiced in industry. The class is divided into groups (typically 3 or 4 students) and each group will meet separately each week with the instructor. Hence, there is no regularly scheduled class times; student groups sign up for weekly meeting times using Starfish in Blackboard. These meetings typically will be 90 minutes long. The expectations and assignments for this course are quite different from most other courses. There are no weekly lectures by the instructor. Rather, each week each group will make a PowerPoint presentation on the week's topic or their progress on their project.
Area: Engineering, Natural Sciences

EN.540.402. Metabolic Systems Biotechnology. 3 Credits.
The aim of this course is to provide a fundamental understanding of the quantitative principles and methodologies of systems biology and biochemical engineering of metabolism. This includes concepts of cellular growth, cellular stoichiometric models, metabolic networks, metabolite fluxes, and genome-scale metabolic models. Quantitative methods and systems biology approaches for metabolic flux analysis and metabolic control theory will be included as well as an analysis of biochemical systems and bioreactors including a consideration of mass transport processes.
Prerequisite(s): AS.020.306 OR (EN.580.440 OR EN.580.441) OR EN.540.307
Area: Engineering
EN.540.403. Colloids and Nanoparticles. 3 Credits.
Fundamental principles related to interactions, dynamics, and structure in colloidal, nanoparticle, and interfacial systems. Concepts covered include hydrodynamics, Brownian motion, diffusion, sedimentation, electrophoresis, colloidal and surface forces, polymeric forces, aggregation, deposition, and experimental methods. Modern topics related to colloids in nano-science and technology will be discussed throughout the course with frequent references to recent literature. Meets with EN.540.603
Area: Engineering, Natural Sciences

EN.540.407. Renewable Energy Technologies. 3 Credits.
This course will discuss the recent progress of renewable energy technologies, emphasizing a perspective from chemical engineering. Engineering principles in terms of mass and energy balance, phase equilibrium, kinetics and catalysis, transport, etc. will be applied to analyze the performance of new energy conversion and storage technologies. Topics of interest include solar cells, fuel cells, batteries and biofuels.
Prerequisite(s): EN.540.203 AND EN.540.303 AND EN.540.301
Area: Engineering

EN.540.409. Dynamic Modeling and Control. 4 Credits.
Introduction to modeling, dynamics, and control. Unsteady state analysis of biomolecular and chemical process control systems. State space and Laplace transform techniques, block diagram algebra, and transfer functions. Feedback and feedforward control. Frequency response and stability analysis. Applications in chemical engineering (chemical reactors and separative processes) as well as biomolecular engineering (biosynthesis, pharmacokinetic modeling and biomolecular modeling based upon central dogma/gene expression). Introduction to nonlinear dynamics.
Prerequisite(s): EN.540.301 AND EN.540.306
Area: Engineering, Quantitative and Mathematical Sciences

EN.540.414. Computational Protein Structure Prediction and Design. 3 Credits.
This class will introduce the fundamental concepts in protein structure, biophysics, optimization and informatics that have enabled the breakthroughs in computational structure prediction and design. Problems covered will include protein folding and docking, design of ligand-binding sites, design of turns and folds, design of protein interfaces. Class will consist of lectures and hands-on computer workshops. Students will learn to use molecular visualization tools and write programs with the PyRosetta protein structure software suite, including a computational project. Programming experience is recommended.
Area: Engineering

EN.540.415. Interfacial Science with Applications to Nanoscale Systems. 3 Credits.
Nanomaterials intrinsically possess large surface area (interface area) to volume ratios. It is this large interfacial area that gives rise to many of the amazing properties and technologies associated with nanotechnology. In this class we will examine how the properties of surfaces, interfaces, and nanoscale features differ from their macroscopic behavior. We will compare and contrast fluid-fluid interfaces with solid-fluid and solid-solid interfaces, discussing fundamental interfacial physics and chemistry, as well as touching on state-of-the-art technologies.
Area: Engineering

EN.540.418. Projects in the Design of a Chemical Car. 2 Credits.
Ready to put those concepts from class into practice? Members work over the course of the semester to design and build a chemically powered vehicle that will compete with other college teams at the American Institute of Chemical Engineers (AIChE) Regional Conference. In this course, the students work in small groups to design and construct the chassis along with chemically powered propulsion and break mechanisms within the constraints of the competition. In addition, students will give oral presentation, write reports, and do thorough safety analysis of their prototypes. Both semesters (EN.540.418 and EN.540.419) must be completed with passing grades to receive credit. This course may be repeated.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, log in to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Engineering

EN.540.419. Projects in the Design of a Chemical Car. 2 Credits.
Ready to put those concepts from class into practice? Members work over the course of the semester to design and build a chemically powered vehicle that will compete with other college teams at the American Institute of Chemical Engineers (AIChE) Regional Conference. In this course, the students work in small groups to design and construct the chassis along with chemically powered propulsion and break mechanisms within the constraints of the competition. In addition, students will give oral presentation, write reports, and do thorough safety analysis of their prototypes. Both semesters (EN.540.418 and EN.540.419) must be completed with passing grades to receive credit. This course may be repeated.
Area: Engineering

EN.540.421. Project in Design: Pharmacodynamics. 3 Credits.
This is continuation of 540.400 Project in Design: Pharmacokinetics. It is a design course in which the design projects will be to develop pharmacodynamic models of the human body that can be used to understand the physiologic effects of drugs on the body. The course (and software to be developed) will cover the spectrum of ways in which pharmaceuticals affect human physiology. The goal is to develop process models of the human body that will predict pharmaceutical effects as a function of time and organ (or cell) type that will work for a wide variety of pharmaceuticals including small molecules, biologics, and chemotherapy agents. This course is organized to replicate group project work as it is practiced in industry. The class is divided into groups (typically 3 or 4 students) and each group will meet separately each week with the instructor. Hence, there is no regularly scheduled class times; student groups sign up for weekly meeting times using Starfish in Blackboard. These meetings typically will be 90 minutes long. The expectations and assignments for this course are quite different from most other courses. There are no weekly lectures by the instructor. Rather, each week each group will make a PowerPoint presentation on the week’s topic or their progress on their project. Prerequisites 540.421 has a prerequisite of 540.400 Pharmacokinetics.
Prerequisite(s): EN.540.400
Area: Engineering, Natural Sciences
EN.540.422. Introduction to Polymeric Materials. 3 Credits.
Polymeric materials are ubiquitous in our society from Nature-made proteins and polysaccharides to synthetic plastics and fibers. Their applications range from day-to-day consumables to high performance materials used in critically demanding areas, such as aviation, aerospace and medical devices. The objective of this course is to provide an introductory overview on the field of polymer science and engineering. Students will learn some basic concepts in polymer synthesis, characterization, and processing. With the basic concepts established, industrial applications of polymeric materials will be discussed in two categories: structural polymers and functional polymers. Structural polymers, including plastics, fibers, rubbers, coatings, adhesives, and composites, will be discussed in terms of their structure, processing, and property relationship with a flavor of industrial relevant products and applications. Future trends in developing environmentally friendly polymers from renewable resources (“green polymer chemistry”) will also be covered. Lectures on functional polymers will be focused on their unique properties that are enabled by rational molecular design, controlled synthesis and processing (e.g. supramolecular assembly, and microfabrication). This class of specialty materials can find their use in high performance photovoltaics, batteries, membranes, and composites, and can also serve as “smart” materials for use in coatings, sensors, medical devices, and biomimicry.
Area: Engineering

EN.540.428. Supramolecular Materials and Nanomedicine. 3 Credits.
Nanomedicine is a quickly growing area that exploits the novel chemical, physical, and biological properties of nanostructures and nanostructured materials for medical treatments. This course presents basic design principles of constructing nanomaterials for use in drug delivery, disease diagnosis and imaging, and tissue engineering. Three major topics will be discussed, including 1) nanocarriers for drug delivery that are formed through soft matter assembly (e.g., surfactants, lipids, block copolymers, DNA, polyelectrolytes, peptides), 2) inorganic nanostructures for disease diagnosis and imaging (e.g., nanoparticles of gold and silver, quantum dots and carbon nanotubes), and 3) supramolecular scaffolds for tissue engineering and regenerative medicine. Students are expected to learn the physical, chemical and biological properties of each nanomaterial, the underlying physics and chemistry of fabricating such material, as well as their advantages and potential issues when used for biomedical applications. This course will also provide students opportunities for case studies on commercialized nanomedicine products. After this class, students should gain a deeper understanding of current challenges in translating nanoscience and nanotechnology.
Area: Engineering

EN.540.440. Micro/Nanotechnology: The Science and Engineering of Small Structures. 3 Credits.
The field of micro / nanotechnology has been gaining tremendous momentum as evidenced by an explosive rise in the number of publications, patents and commercial activities. This is an introductory course intended to expose students to the field as well as real world applications. Lectures will include an overview of scaling of material properties at the nanoscale, micro and nanofabrication methods and essential analytical tools of relevance to the field. All through the course, we will go over electronic, optical and biological applications of emerging micro and nanoscale devices and materials. Co-listed with EN.540.640. Only Undergraduate Seniors and Graduate students may join the course.
Area: Engineering

EN.540.465. Engineering Principles of Drug Delivery. 3 Credits.
Fundamental concepts in drug delivery from an engineering perspective. Biological organisms are viewed as highly interconnected networks where the surfaces/interfaces can be activated or altered ‘chemically’ and ‘physically/mechanically’. The importance of intermolecular and interfacial interactions on drug delivery carriers is the focal point of this course. Topics include: drug delivery mechanisms (passive, targeted); therapeutic modalities and mechanisms of action; engineering principles of controlled release and quantitative understanding of drug transport (diffusion, convection); effects of electrostatics, macromolecular conformation, and molecular dynamics on interfacial interactions; thermodynamic principles of self-assembly; chemical and physical characteristics of delivery molecules and assemblies (polymer based, lipid based); significance of biodistributions and pharmacokinetic models; toxicity issues and immune responses.
Prerequisite(s): Students may take EN.540.465 or EN.540.665, but not both.
Area: Engineering, Natural Sciences

EN.540.468. Introduction to Nonlinear Dynamics and Chaos. 3 Credits.
An introduction to the phenomenology of nonlinear dynamic behavior with emphasis on models of actual physical, chemical, and biological systems, involving an interdisciplinary approach to ideas from mathematics, computing, and modeling. The common features of the development of chaotic behavior in both mathematical models and experimental studies are stressed, and the use of modern data-mining tools to analyze dynamic data will be explored. Knowledge of Linear Algebra and Ordinary Differential Equations is a prerequisite (at an undergraduate level); Some computing experience is desirable. Emphasis will be placed on the geometric/visual computer-aided description and understanding of dynamics and chaos.
Prerequisite(s): Students may receive credit for only one of EN.553.473 OR EN.553.475 OR EN.540.468 OR EN.540.668.;((AS.110.201 OR AS.110.212) AND (AS.110.302 OR AS.110.306)) OR EN.553.291
Area: Engineering, Quantitative and Mathematical Sciences

EN.540.490. Introduction to Chemical Process Safety. 1 Credit.
This course covers topics in chemical process safety. Chemical process safety concerns itself with discovery, analysis, and control of risks arising from chemical processes. Starting with the definition of risk and ethical principles that apply to safety-critical situations, we will progress to several types of hazard analysis, discussion of the safety implications of construction materials, incident investigation, fire, toxicity, and the technique called Inherently Safer Design).
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;EN.540.203 AND EN.540.303
Area: Engineering

EN.540.501. Independent Research. 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration & Online Forms.

EN.540.502. Independent Study. 1 - 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration & Online Forms.

EN.540.503. Independent Research. 1 - 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration & Online Forms.
EN.540.511. Group Undergraduate Research. 1 - 3 Credits.
Students do individual projects (or in collaboration with faculty and/or graduate students) in areas basic to chemical engineering. This section has weekly research group meeting that students are expected to attend.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration &gt; Online Forms.

EN.540.513. Group Undergraduate Research. 1 - 3 Credits.
Students do individual projects (or in collaboration with faculty and/or graduate students) in areas basic to chemical engineering. This section has weekly research group meeting that students are expected to attend.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration &gt; Online Forms.

EN.540.597. Undergraduate Research. 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration &gt; Online Forms.

EN.540.600. Chemical and Biomolecular Engineering Seminar. 1 Credit.
Lectures are presented on current subjects relevant to chemical engineering. Attendance at 80% of departmental seminars is required to receive credit for this class.
Area: Engineering

EN.540.601. Chemical and Biomolecular Engineering Seminar. 1 Credit.
Area: Engineering

EN.540.602. Metabolic Systems Biotechnology. 3 Credits.
The aim of this course is to provide a fundamental understanding of the quantitative principles and methodologies of systems biology and biochemical engineering of metabolism. This includes concepts of cellular growth, cellular stoichiometric models, metabolic networks, metabolite fluxes, and genome-scale metabolic models. Quantitative methods and systems biology approaches for metabolic flux analysis and metabolic control theory will be included as well as an analysis of biochemical systems and bioreactors including a consideration of mass transport processes.
Area: Engineering

EN.540.603. Colloids and Nanoparticles. 3 Credits.
Fundamental principles related to interactions, dynamics, and structure in colloidal, nanoparticle, and interfacial systems. Concepts covered include hydrodynamics, Brownian motion, diffusion, sedimentation, electrophoresis, colloidal and surface forces, polymeric forces, aggregation, deposition, and experimental methods. Modern topics related to colloids in nano- science and technology will be discussed throughout the course with frequent references to recent literature. Meets with EN.540.403
Area: Engineering

EN.540.604. Transport Phenomena in Practice. 3 Credits.
Required course for ChemBE Masters students
Area: Engineering, Quantitative and Mathematical Sciences

EN.540.605. Modern Data Analysis and Machine Learning for ChemBEs. 3 Credits.
This class will provide an introduction for chemical and biomolecular engineering students to modern methods of measuring and testing hypotheses using experimental or computational data. The course will cover methods of regression and data analysis such as linear and nonlinear regression, Bayesian analysis and principal or independent component analysis. The course will introduce concepts of machine learning including linear and nonlinear separation, neural networks, Gaussian processes and will provide exposure to deep learning concepts. The course will focus generally on image data and will consider topics of image processing, feature extraction and will cover for general data dimensionality reduction. Familiarity with computer programming (ideally Python), statistics and linear algebra are prerequisites.
Area: Engineering

EN.540.606. Chemical & Biomolecular Separation. 4 Credits.
This course covers staged and continuous-contacting separations processes critical to the chemical and biochemical industries. Separation technologies studied include distillation, liquid-liquid extraction, gas absorption, membrane ultrafiltration, reverse osmosis, dialysis, adsorption, and chromatography. Particular emphasis is placed on the biochemical uses of these processes and consequently on how the treatment of these processes differs from the more traditional approach. Only with permission of the instructor. Co-listed with EN.540.306
Area: Engineering

EN.540.607. Renewable Energy Technologies. 3 Credits.
This course will discuss the recent progress of renewable energy technologies, emphasizing a perspective from chemical engineering. Engineering principles in terms of mass and energy balance, phase equilibrium, kinetics and catalysis, transport, etc. will be applied to analyze the performance of new energy conversion and storage technologies. Topics of interest include solar cells, fuel cells, batteries and biofuels.
Area: Engineering

EN.540.614. Computational Protein Structure Prediction and Design. 3 Credits.
This class will introduce the fundamental concepts in protein structure, biophysics, optimization and informatics that have enabled the breakthroughs in computational structure prediction and design. Problems covered will include protein folding and docking, design of ligand-binding sites, design of turns and folds, design of protein interfaces. Class will consist of lectures and hands-on computer workshops. Students will learn to use molecular visualization tools and write programs with the PyRosetta protein structure software suite, including a computational project. Programming experience is recommended.
Area: Engineering

EN.540.615. Interfacial Science with Applications to Nanoscale Systems. 3 Credits.
Nanostructured materials intrinsically possess large surface area (interface area) to volume ratios. It is this large interfacial area that gives rise to many of the amazing properties and technologies associated with nanotechnology. In this class we will examine how the properties of surfaces, interfaces, and nanoscale features differ from their macroscopic behavior. We will compare and contrast fluid-fluid interfaces with solid-fluid and solid-solid interfaces, discussing fundamental interfacial physics and chemistry, as well as touching on state-of-the-art technologies.
Area: Engineering
EN.540.621. Project in Design: Pharmacodynamics. 3 Credits.
This is a continuation of 540.400 Project in Design: Pharmacokinetics. It is a design course in which the design projects will be to develop pharmacodynamic models of the human body that can be used to understand the physiologic effects of drugs on the body. The course (and software to be developed) will cover the spectrum of ways in which pharmaceuticals affect human physiology. The goal is to develop process models of the human body that will predict pharmaceutical effects as a function of time and organ (or cell) type that will work for a wide variety of pharmaceuticals including small molecules, biologics, and chemotherapy agents. This course is organized to replicate group project work as it is practiced in industry. The class is divided into groups (typically 3 or 4 students) and each group will meet separately each week with the instructor. Hence, there is no regularly scheduled class times; student groups sign up for weekly meeting times using Starfish in Blackboard. These meetings typically will be 90 minutes long. The expectations and assignments for this course are quite different from most other courses. There are no weekly lectures by the instructor. Rather, each week each group will make a PowerPoint presentation on the week’s topic or their progress on their project. Prerequisites 540.421 has a prerequisite of Pharmacokinetics.

Prerequisite(s): EN.540.632
Area: Engineering, Natural Sciences

EN.540.622. Introduction to Polymeric Materials. 3 Credits.
Polymeric materials are ubiquitous in our society from Nature-made proteins and polysaccharides to synthetic plastics and fibers. Their applications range from day-to-day consumables to high performance materials used in critically demanding areas, such as aviation, aerospace and medical devices. The objective of this course is to provide an introductory overview on the field of polymer science and engineering. Students will learn some basic concepts in polymer synthesis, characterization, and processing. With the basic concepts established, industrial applications of polymeric materials will be discussed in two categories: structural polymers and functional polymers. Structural polymers, including plastics, fibers, rubbers, coatings, adhesives, and composites, will be discussed in terms of their structure, processing, and property relationship with a flavor of industrial relevant products and applications. Future trends in developing environmentally friendly polymers from renewable resources (“green polymer chemistry”) will also be covered. Lectures on functional polymers will be focused on their unique properties that are enabled by rational molecular design, controlled synthesis and processing (e.g. supramolecular assembly, and microfabrication). This class of specialty materials can find their use in high performance photovoltaics, batteries, membranes, and composites, and can also serve as “smart” materials for use in coatings, sensors, medical devices, and biomimicry.

Area: Engineering

EN.540.628. Supramolecular Materials and Nanomedicine. 3 Credits.
Nanomedicine is a quickly growing area that exploits the novel chemical, physical, and biological properties of nanostructures and nanostructured materials for medical treatments. This course presents basic design principles of constructing nanomaterials for use in drug delivery, disease diagnosis and imaging, and tissue engineering. Three major topics will be discussed, including 1) nanocarriers for drug delivery that are formed through soft matter assembly (e.g., surfactants, lipids, block copolymers, DNA, polyelectrolytes, peptides), 2) inorganic nanostructures for disease diagnosis and imaging (e.g., nanoparticles of gold and silver, quantum dots and carbon nanotubes), and 3) supramolecular scaffolds for tissue engineering and regenerative medicine. Students are expected to learn the physical, chemical and biological properties of each nanomaterial, the underlying physics and chemistry of fabricating such material, as well as their advantages and potential issues when used for biomedical applications. This course will also provide students opportunities for case studies on commercialized nanomedicine products. After this class, students should gain a deeper understanding of current challenges in translating nanoscience and nanotechnology into medical therapies.

Area: Engineering, Natural Sciences

EN.540.630. Thermodynamics & Statistical Mechanics. 3 Credits.
In this course we will aim for understanding the thermodynamics of chemical and bio-molecular systems. We will first review classical, macroscopic thermodynamics covering concepts such as equilibrium, stability and the role of thermodynamic potentials. Our goal will be to gain a feel for the generality of thermodynamics. Statistical mechanics provides a link between the mechanics of atoms and macroscopic thermodynamics. We will introduce this branch in two distinct ways: 1) following standard methods of developing concepts such as ensembles and partition functions, and 2) where we will treat the basis of statistical mechanics as a problem in inference. With this foundation, we will consider concepts relevant to understanding the liquid state. Chemical transformations in a liquid are of importance in much of chemistry and biology; quasi-chemical generalizations of the potential distribution theorem will be introduced to present these ideas. We hope to give an overview of modern developments relating equilibrium work to non-equilibrium work, as these are of increasing importance in studies on single molecule systems. Course is open to Chemical and Biomolecular Engineering BS/MS Concurrent and MSE students.

Area: Engineering

EN.540.631. Kinetic Processes. 4 Credits.
Review of numerical methods applied to kinetic phenomena and reactor design in chemical and biological processes. Homogeneous kinetics and interpretation of reaction rate data. Batch, plug flow, and stirred tank reactor analyses, including reactors in parallel and in series. Selectivity and optimization considerations in multiple reaction systems. Non isothermal reactors. Elements of heterogeneous kinetics, including adsorption isotherms and heterogeneous catalysis. Coupled transport and chemical/biological reaction rates.

Area: Engineering
EN.540.632. Project in Design: Pharmacokinetics. 3 Credits.
This is a design course in which the design projects will be to
develop pharmacokinetic models of the human body that can be
used to understand the temporal distribution, spatial distribution and
bioavailability of pharmaceutical drugs. The course (and software to be
developed) will cover the spectrum of factors affecting pharmaceutical
bioavailability including drug formulation, mode of dosing and dosing
rate, metabolism and metabolic cascades, storage in fatty tissues,
and diffusional limitations (such as in crossing the blood-brain barrier
or diffusional differences between normal and cancerous cells). The
goal is to develop process models of the human body that will predict
pharmaceutical bioavailability as a function of time and organ (or cell)
type that will work for a wide variety of pharmaceuticals including small
molecules, biologics, and chemotherapy agents. This course is organized
to replicate group project work as it is practiced in industry. The class is
divided into groups (typically 3 or 4 students) and each group will meet
separately each week with the instructor. Hence, there is no regularly
scheduled class times; student groups sign up for weekly meeting
times using Starfish in Blackboard. These meetings typically will be 90
minutes long. The expectations and assignments for this course are
quite different from most other courses. There are no weekly lectures
by the instructor. Rather, each week each group will make a PowerPoint
presentation on the week’s topic or their progress on their project.
Area: Engineering, Natural Sciences

EN.540.635. Software Carpentry. 3 Credits.
A ‘crash course’ intended to teach new graduate students the
fundamentals of programming and practical coding skills that will
accelerate facility with computational aspects of graduate study.
The course covers how computers work from the inside out, with an
introduction to the Linux operating system. Programming will be taught
primarily in Python, with an emphasis on solving research-related
problems. This peer-taught course will cover variables, conditionals,
loops, functions, classes, plotting, data structures and algorithms, with
some advanced topics (C++, gradient-based minimization, Procrustes,
eigenvalue/vector data analysis, embarrassingly parallel ‘for’ loops). No
prior programming skills are required, but experience with an introductory
computing language will be helpful. Familiarity with differential equations
and linear algebra will be assumed.
Area: Engineering

EN.540.637. Application of Molecular Evolution to Biotechnology. 3
Credits.
One of the most promising strategies for successfully designing
complex biomolecular functions is to exploit nature’s principles of
evolution. This course provides an overview of the basics of molecular
evolution as well as its experimental implementation. Current research
problems in evolution-based biomolecular engineering will be used to
illustrate principles in the design of biomolecules (i.e. protein
engineering, RNA/DNA engineering), genetic circuits and complex
biological systems including cells. A course in Biochemistry or Molecular
Biology is recommendedMeets with EN.540.437Undergraduates with
the appropriate background can take the course with permission of the
instructor.
Area: Engineering, Natural Sciences

EN.540.638. Advanced Topics in Pharmacokinetics and
Pharmacodynamics I. 3 Credits.
This course involves a semester-long project in pharmacodynamics.
Topics are chosen in consultation with instructor.
Prerequisite(s): EN.540.400 AND EN.540.421 OR EN.540.436
Area: Engineering, Natural Sciences

EN.540.639. Advanced Topics in Pharmacokinetics and
Pharmacodynamics II. 3 Credits.
This course involves a semester-long project in pharmacodynamics.
Topics are chosen in consultation with instructor.
Prerequisite(s): EN.540.400 AND EN.540.421 OR EN.540.436
Area: Engineering, Natural Sciences

EN.540.640. Micro/Nanotechnology: The Science and Engineering of
Small Structures. 3 Credits.
The field of micro / nanotechnology has been gaining tremendous
momentum as evidenced by an explosive rise in the number of
publications, patents and commercial activities. This is an introductory
course intended to expose students to the field as well as real world
applications. Lectures will include an overview of scaling of material
properties at the nanoscale, micro and nanofabrication methods and
essential analytical tools of relevance to the field. All through the course,
we will go over electronic, optical and biological applications of emerging
micro and nanoscale devices and materials. Co-listed with EN.540.440.

EN.540.652. Advanced Transport Phenomena. 3 Credits.
It is the goal of this course to move the graduate student (and advanced
undergraduate student) from the introductory level of transport
phenomena (undergraduate) to a level that will allow them to be effective
in researching transport-related topics in a variety of biomedical,
chemical and biochemical engineering areas. The basic equations that
govern mass, momentum, and energy transport will be derived and used
to solve problems that demonstrate the physical insight necessary to
apply these equations to original situations. Some topics include solution
techniques utilizing expansions of harmonic functions, singularity
solutions, lubrication theory for flow in confined geometries, boundary
layer theory, Stokes flow, forced convection, buoyancy-driven flow, Taylor-
Aris dispersion, and reaction-diffusion. Open to PhD students as well as
Chemical and Biomolecular Engineering BS/MSE Concurrent and MSE
students.
Area: Engineering

EN.540.665. Engineering Principles of Drug Delivery. 3 Credits.
Fundamental concepts in drug delivery from an engineering perspective.
Biological organisms are viewed as highly interconnected networks
where the surfaces/interfaces can be activated or altered ‘chemically’
and ‘physically/mechanically’. The importance of intramolecular and
interfacial interactions on drug delivery carriers is the focal point of this
course. Topics include: drug delivery mechanisms (passive, targeted);
therapeutic modalities and mechanisms of action; engineering principles
of controlled release and quantitative understanding of drug transport
(diffusion, convection); effects of electrostatics, macromolecular
conformation, and molecular dynamics on interfacial interactions;
thermodynamic principles of self-assembly; chemical and physical
characteristics of delivery molecules and assemblies (polymer based,
lipid based); significance of biodistributions and pharmacokinetic
models; toxicity issues and immune responses.Recommended
prerequisite: Transport Phenomena - EN.540.303 or equivalent
Prerequisite(s): Students may take EN.540.465 or EN.540.665, but not
both.
Area: Engineering, Natural Sciences
EN.540.668. Introduction to Nonlinear Dynamics and Chaos. 3 Credits.
An introduction to the phenomenology of nonlinear dynamic behavior with emphasis on models of actual physical, chemical, and biological systems, involving an interdisciplinary approach to ideas from mathematics, computing, and modeling. The common features of the development of chaotic behavior in both mathematical models and experimental studies are stressed, and the use of modern data-mining tools to analyze dynamic data will be explored. Knowledge of Linear Algebra and Ordinary Differential Equations is a prerequisite (at an undergraduate level); Some computing experience is desirable. Emphasis will be placed on the geometric/visual computer-aided description and understanding of dynamics and chaos.
Prerequisite(s): Students may receive credit for only one of EN.553.473 OR EN.553.673 OR EN.540.468 OR EN.540.668.;((AS.110.201 OR AS.110.212) AND ( S.110.302 OR AS.110.306) OR EN.553.291[C])
Area: Engineering, Quantitative and Mathematical Sciences

EN.540.671. Advanced Thermodynamics in Practice. 3 Credits.
In this course, we will discuss the important role that thermodynamics plays in chemical engineering practice. After a short review of the first and second laws, we will examine how thermodynamic concepts affect mass and energy balances. We will discuss the properties of systems containing pure species and mixtures and how to analyze the behavior of ideal and real systems. We will estimate heat effects associated with temperature change, phase change, and chemical reaction. The theory associated with properties of pure fluids will be discussed along its application to flow processes. We will present the framework for understanding solution thermodynamics and mixing. Applications of thermodynamics especially important to chemical engineers, such as vapor-liquid equilibrium in distillation and chemical reaction equilibrium in kinetics and reaction engineering, will be discussed. Examples will serve to illustrate how thermodynamic calculations are an integral part of the design and optimization of chemical processes.
Area: Engineering

EN.540.673. Advanced Chemical Reaction Engineering in Practice. 3 Credits.
Chemical reaction engineering deals with the analysis on data and the design of equipment in which reactions occur. Reactors may contain one or more phases and be used to conduct chemical or biochemical transformations. The course will cover the fundamental aspects of kinetics, data acquisition, data interpretation, heterogeneous catalysis and heat and mass transfer for each type of reactor. Special emphasis will be placed on the practical application of reaction engineering in the petrochemical, chemical, biochemical and materials industries. The course will make student aware of the needs and opportunities for chemical reaction engineering in industry.
Area: Engineering, Quantitative and Mathematical Sciences

EN.540.690. Chemical and Biomolecular Engineering Design. 3 Credits.
This course is one part of a two semester sequence in Chemical and Biomolecular Engineering Product Design. It is intended for students in the ChemBE master's program. This course guides the student through the complex process of new product design. Product design concerns the recognition of customer needs, the creation of suitable specifications, and the selection of best products to fulfill needs. Students work in small teams to develop a new product idea, design the product and then iterate on prototype development. Students report several times both orally and in writing on their accomplishments. Time is allowed so that laboratory tests can be performed and/or prototypes can be built. Note that generally both courses, 540.609 and 540.610 must be taken to complete the prototype development. The two courses can be started in any term.
Area: Engineering

EN.540.691. Product Design 1. 3 Credits.
This course is the first of a two, three or four semester sequence in Product Design. It is intended for students in the ChemBE master's program. This course guides the student through the complex process of new product design. Product design concerns the recognition of customer needs, the creation of suitable specifications, and the selection of best products to fulfill needs. It also requires consideration of safety of product production workers, public safety and environment impact. Students work in small teams to develop a new product idea, design the product and then iterate on prototype development. Students report weekly both orally and in writing on their accomplishments. Time is allowed so that laboratory tests can be performed and/or prototypes can be built. Note that generally at least two courses, 540.691 and 540.692, must be taken to complete the prototype development. These courses can be started in any term.
Area: Engineering

EN.540.693. Product Design 3. 3 Credits.
This course is the third of a two, three or four semester sequence in Product Design. It is intended for students in the ChemBE master's program. This course guides the student through the complex process of new product design. Product design concerns the recognition of customer needs, the creation of suitable specifications, and the selection of best products to fulfill needs. It also requires consideration of safety of product production workers, public safety and environment impact. Students work in small teams to develop a new product idea, design the product and then iterate on prototype development. Students report weekly both orally and in writing on their accomplishments. Time is allowed so that laboratory tests can be performed and/or prototypes can be built. Note that generally at least two courses, 540.691 and 540.692, must be taken to complete the prototype development. These courses can be started in any term.
Area: Engineering
EN.540.694. Product Design 4. 3 Credits.
This course is the fourth of a two, three or four semester sequence in Product Design. It is intended for students in the ChemBE master’s program. This course guides the student through the complex process of new product design. Product design concerns the recognition of customer needs, the creation of suitable specifications, and the selection of best products to fulfill needs. It also requires consideration of safety of product production workers, public safety and environment impact. Students work in small teams to develop a new product idea, design the product and then iterate on prototype development. Students report weekly both orally and in writing on their accomplishments. Time is allowed so that laboratory tests can be performed and/or prototypes can be built. Note that generally at least two courses, 540.691 and 540.692, must be taken to complete the prototype development. These courses can be started in any term.
Area: Engineering

EN.540.801. Graduate Research. 3 - 20 Credits.

EN.540.803. Independent Research. 3 - 20 Credits.