Department of Chemical and Biomolecular Engineering

Vasan Venugopalan, Department Chair
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http://www.eng.uci.edu/dept/cbe (http://www.eng.uci.edu/dept/cbe/)

The Department of Chemical and Biomolecular Engineering offers the B.S. in Chemical Engineering, and the M.S. and Ph.D. in Chemical and Biomolecular Engineering.

Chemical Engineering uses knowledge of chemistry, mathematics, physics, biology, and humanities to solve societal problems in areas such as energy, health, the environment, food, clothing, materials, and sustainability and serves a variety of processing industries whose vast array of products include chemicals, petroleum products, plastics, pharmaceuticals, foods, textiles, fuels, consumer products, and electronic and cryogenic materials. Chemical Engineering also advances societal goals by developing environmentally conscious and sustainable technologies to meet global challenges.

The undergraduate curriculum in Chemical Engineering builds on basic courses in chemical engineering, other branches of engineering, and electives which provide a strong background in humanities and human behavior. Elective programs developed by the student with a faculty advisor may include such areas as applied chemistry, biomolecular engineering, chemical reaction engineering, chemical processing, environmental engineering, materials science, process control systems engineering, and biomedical engineering.

- Chemical and Biomolecular Engineering, M.S.
- Chemical and Biomolecular Engineering, Ph.D.
- Chemical Engineering, B.S.

Faculty

Tayloria Adams, Ph.D. Michigan Technological University, *Assistant Professor of Chemical and Biomolecular Engineering; Biomedical Engineering* (dielectrophoresis, microfluidic devices, stem cells, biomarker development, cell membrane biophysics, cell sorting)

Herdeline Ann Ardoña, Ph.D. John Hopkins University, *Assistant Professor of Chemical and Biomolecular Engineering; Biomedical Engineering; Chemistry* (biomaterials, self-assembly, optoelectronics, stimuli-responsive materials, in vitro tissue models, biosensors)

Plamen Atanassov, Ph.D. Bulgarian Academy of Sciences, *UCI Chancellor's Professor of Chemical and Biomolecular Engineering; Materials Science and Engineering* (electrocatalysis and electrocatalysts for energy conversion processes; bio-electrocatalysis and energy harvesting systems)

Nancy A. Da Silva, Ph.D. California Institute of Technology, *Professor of Chemical and Biomolecular Engineering; Biomedical Engineering* (molecular biotechnology, metabolic engineering and synthetic biology, eukaryotic expression systems, biorenewable chemicals)

Alon A. Gorodetsky, Ph.D. California Institute of Technology, *Associate Professor of Chemical and Biomolecular Engineering; Materials Science and Engineering* (cephalopods, adaptive materials, camouflage, bioelectronics)

Ryan Hayes, Ph.D. Rice University, *Assistant Professor of Chemical and Biomolecular Engineering* (computational protein engineering, therapeutics, biocatalysis, drug design, molecular simulation)

Juan Hong, Ph.D. Purdue University, *Professor Emeritus of Chemical and Biomolecular Engineering*

Han Li, Ph.D. University of California, Los Angeles, *Associate Professor of Chemical and Biomolecular Engineering; Biomedical Engineering* (metabolic engineering, synthetic biology, biomanufacturing renewable chemicals, protein engineering)

Ali Mohraz, Ph.D. University of Michigan, *Professor of Chemical and Biomolecular Engineering; Materials Science and Engineering* (colloid science, soft matter engineering with applications in health care and energy materials)

Robert J. Nielsen, Ph.D. California Institute of Technology, *Assistant Professor of Chemical and Biomolecular Engineering* (electronic structure, electrocatalysis, mechanism, alkane activation, homogenous catalysis)

Elizabeth L. Read, Ph.D. University of California, Berkeley, *Associate Professor of Chemical and Biomolecular Engineering* (stochastic processes in cell biology, computational modeling)

Erdem Sasmaz, Ph.D. Stanford University, *Assistant Professor of Chemical and Biomolecular Engineering* (heterogeneous catalysis and nanoparticle synthesis for clean energy production and carbon dioxide utilization)

Frank G. Shi, Ph.D. California Institute of Technology, *Professor Emeritus of Chemical and Biomolecular Engineering*

Quinton Smith, Ph.D. John Hopkins University, *Assistant Professor of Chemical and Biomolecular Engineering; Biomedical Engineering* (pluripotent stem cells, regenerative medicine, organoids, microfluidics, tissue engineering)

Vojislav Stamenkovic, Ph.D. University of Belgrade, *Professor of Chemical and Biomolecular Engineering; Chemistry* (energy conversion and storage, surface modifications, thin films, nanoscale synthesis, electrochemical interfaces, fuel cells, electrolyzers and batteries)

Vasan Venugopalan, Sc.D. Massachusetts Institute of Technology, *Department Chair and Professor of Chemical and Biomolecular Engineering; Biomedical Engineering; Mechanical and Aerospace Engineering; Surgery* (laser-generated thermal, mechanical and radiative transport processes for application in medical diagnostics, imaging, therapeutics, biotechnology)

Szu-Wen Wang, Ph.D. Stanford University, *Professor of Chemical and Biomolecular Engineering; Biomedical Engineering* (bioinspired materials, immunomodulatory materials, nanoparticle vaccines, therapeutics, protein engineering, drug delivery)

Albert Fan Yee, Ph.D. University of California, Berkeley, *Professor Emeritus of Chemical and Biomolecular Engineering; Biomedical Engineering*

Iryna Zenyuk, Ph.D. Carnegie Mellon University, *Associate Director of National Fuel Cell Research Center and Associate Professor of Chemical and Biomolecular Engineering; Materials Science and Engineering; Mechanical and Aerospace Engineering* (renewable energy, fuel cells, electrolyzers, batteries, X-ray imaging techniques, multi-scale modeling, transport phenomena)

Affiliate Faculty

Shane Ardo, Ph.D. Johns Hopkins University, *Professor of Chemistry; Chemical and Biomolecular Engineering; Materials Science and Engineering* (inorganic and organometallic, physical chemistry and chemical physics, polymer, materials, nanoscience)

Jacob Brouwer, Ph.D. Massachusetts Institute of Technology, *Director of Advanced Power and Energy Program and Director of National Fuel Cell Research Center and Professor and Chancellor's Fellow of Mechanical and Aerospace Engineering; Chemical and Biomolecular Engineering; Civil and Environmental Engineering* (fuel cells, energy systems dynamics, electrochemical systems design and analysis, chemical kinetics, reacting flows)

John Charles Chaput, Ph.D. University of California, Riverside, *Professor of Pharmaceutical Sciences; Chemical and Biomolecular Engineering; Chemistry; Molecular Biology and Biochemistry* (chemical and synthetic biology)

Stacy Copp, Ph.D. University of California, Santa Barbara, *Samueli Faculty Development Chair and Assistant Professor of Materials Science and Engineering; Chemical and Biomolecular Engineering; Physics and Astronomy* (soft matter-based photonic materials; metal nanoclusters; polymer nanostructures; self-assembly; biomimetics; machine learning for materials discovery)

Sarah Finkeldei, Ph.D. RWTH Aachen University, *Assistant Professor of Chemistry; Chemical and Biomolecular Engineering; Materials Science and Engineering* (nuclear chemistry)

Anna Grosberg, Ph.D. California Institute of Technology, *Associate Professor of Biomedical Engineering; Chemical and Biomolecular Engineering* (computational modeling of biological systems, biomechanics, cardiac tissue engineering)

Zhibin Guan, Ph.D. University of North Carolina at Chapel Hill, *Professor of Chemistry; Biomedical Engineering; Chemical and Biomolecular Engineering; Materials Science and Engineering* (chemical biology, organic and synthetic, polymer, materials, nanoscience)

Jered Haun, Ph.D. University of Pennsylvania, *Associate Professor of Biomedical Engineering; Chemical and Biomolecular Engineering; Materials Science and Engineering* (nanotechnology, molecular engineering, computational simulations, targeted drug delivery, clinical cancer detection)

Allon Hochbaum, Ph.D. University of California, Berkeley, *Associate Professor of Materials Science and Engineering; Chemical and Biomolecular Engineering; Chemistry; Molecular Biology and Biochemistry* (biological materials, protein materials, electronic conductivity in proteins, materials and methods to study microbes and microbial communities)

Young Jik Kwon, Ph.D. University of Southern California, *Professor of Pharmaceutical Sciences; Biomedical Engineering; Chemical and Biomolecular Engineering; Molecular Biology and Biochemistry* (gene therapy, drug delivery, cancer-targeted therapeutics, artificially-induced cellular vesicles, multi-modal therapies)

Matthew Law, Ph.D. University of California, Berkeley, *Department Vice Chair and Professor of Chemistry; Chemical and Biomolecular Engineering; Materials Science and Engineering* (inorganic and organometallic, physical chemistry and chemical physics, polymer, materials, nanoscience)

Wendy F. Liu, Ph.D. Johns Hopkins University, *Professor of Biomedical Engineering; Chemical and Biomolecular Engineering; Molecular Biology and Biochemistry; Pharmaceutical Sciences* (biomaterials, microdevices in cardiovascular engineering, cell-cell and cell-micro-environment interactions, cell functions and controls)

Ray Luo, Ph.D. University of Maryland, College Park, *Professor of Molecular Biology and Biochemistry; Biomedical Engineering; Chemical and Biomolecular Engineering; Materials Science and Engineering* (protein structure, noncovalent associations involving proteins)

Bihter Padak, Ph.D. Stanford University, *Associate Director of UCI Combustion Laboratory and Assistant Professor of Mechanical and Aerospace Engineering; Chemical and Biomolecular Engineering* (combustion, reaction kinetics, emission control technologies, catalysis)

Xiaoqing Pan, Ph.D. Saarlandes University, *Henry Samueli Endowed Chair and Director of Irvine Materials Research Institute (IMRI) and Professor of Materials Science and Engineering; Chemical and Biomolecular Engineering; Physics and Astronomy* (atomic-scale structure, properties and dynamic behaviors of advanced materials including thin films and nanostructures for memories, catalysts, and energy conversion and storage devices)

Regina Ragan, Ph.D. California Institute of Technology, *Professor of Materials Science and Engineering; Chemical and Biomolecular Engineering* (self-assembly, nanophotonic sensors for medical diagnostics and environmental monitoring, machine learning analysis of spectral data)

Diego Rosso, Ph.D. University of California, Los Angeles, *Director of the UCI Water-Energy Nexus Center (WEX) and Professor of Civil and Environmental Engineering; Chemical and Biomolecular Engineering* (environmental process engineering, mass transfer, wastewater treatment, carbon- and energy-footprint analysis)

Seunghyun Sim, Ph.D. The University of Tokyo, Japan, *Assistant Professor of Chemistry; Biomedical Engineering; Chemical and Biomolecular Engineering* (chemical biology, organic and synthetic, polymer, materials and nanoscience)

William C. Tang, Ph.D. University of California, Berkeley, *Professor of Biomedical Engineering; Chemical and Biomolecular Engineering; Electrical Engineering and Computer Science; Materials Science and Engineering* (micro-electro-mechanical systems (MEMS) nanoscale engineering for biomedical applications, microsystems integration, microimplants, microbiomechanics, microfluidics)

Weian Zhao, Ph.D. McMaster University, *Professor of Pharmaceutical Sciences; Biological Chemistry; Biomedical Engineering; Chemical and Biomolecular Engineering* (stem cell therapy, diagnostics, biosensors, immunotherapy, single-cell analysis)

Courses

CBE 1. Introduction to Chemical Engineering. 1 Unit.
Helps new students successfully transition to UCI, build a sense of community in the department, develop networking and professional skills, and introduce a variety of industries who employ chemical engineers through a series of guest lectures.

Grading Option: Pass/no pass only.

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 40A. Chemical Processes and Material Balances. 4 Units.
Introduction to chemical engineering and the industries where chemical engineers play vital roles. Problem-solving skills and techniques. Quantitative calculations and applications using mass and energy balances. Stoichiometric equations, multiple bypasses, and others in process industries.

Prerequisite: MATH 2B and PHYS 7C and (CHEM 1B or CHEM H2B)

Restriction: Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

CBE 40B. Process Thermodynamics. 3 Units.
Principles of thermodynamics: definitions, basic concepts, and laws; property relationships; construction of thermodynamic charts and tables; energy balances; phase and chemical equilibria; combined mass and energy balances.

Prerequisite: CBE 40A and (MATH 3A or ICS 6N). CBE 40A with a grade of C- or better

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 40C. Chemical Engineering Thermodynamics. 4 Units.
Elements of chemical engineering thermodynamics, including equilibrium and stability; equations of state; generalized correlations of properties of materials; properties of ideal and non-ideal mixtures; thermodynamics of real solutions; ideal and non-ideal phase equilibria; chemical equilibria for ideal and non-ideal solutions.

Corequisite: ENGRMAE 10
Prerequisite: MAE 10 and MATH 2D and CBE 40B. CBE 40B with a grade of C- or better

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 100. Introduction to Numerical Methods in Engineering. 3 Units.
An introduction to the fundamentals of numerical analysis and the computer algorithms in MATLAB for the solution of engineering problems, with emphasis on problems arising in chemical engineering thermodynamics, transport phenomena, and reaction engineering.

Prerequisite: CBE 40C

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 105. Engineering Physical Chemistry. 4 Units.
Provides an integrated view of both classical and molecular perspectives on thermodynamics, thermodynamic potentials, entropy, and the second law. Students learn how to use statistical mechanics to create a bridge between the quantum mechanical world and the familiar macroscopic one.

Prerequisite: CHEM 1C and CBE 40C and (PHYS 7D or PHYS 7E)

Overlaps with CHEM 132A, CHEM 132B, CHEM 132C.

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 110. Reaction Kinetics and Reactor Design. 4 Units.
Introduction to quantitative analysis of chemical reactions and chemical reactor design. Reactor operations including batch, continuous stirred tank, and tubular reactor. Homogeneous and heterogeneous reactions.

Prerequisite: CHEM 1C and MATH 3D and CBE 40B and CBE 40C and CBE 100. CBE 40B with a grade of C- or better. CBE 40C with a grade of C- or better

Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science and Engineering majors have second consideration for enrollment.

CBE 120A. Momentum Transfer. 4 Units.
Fluid statics, surface tension, Newton's law of viscosity, non-Newtonian and complex flows, momentum equations, laminar and turbulent flow, velocity profiles, flow in pipes and around objects, piping systems design, pumps and mixing, and other applications to chemical and related industries.

Prerequisite: CBE 40C and MATH 3D. CBE 40C with a grade of C- or better

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 120B. Heat Transfer. 3 Units.
Principles of conduction, radiation, and convection of heat; phenomenological rate laws, differential and macroscopic energy balances; heat transfer rates, steady state and unsteady state conduction, convection; applications to chemical and related industries.

Prerequisite: CBE 120A. CBE 120A with a grade of C- or better

Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science and Engineering majors have second consideration for enrollment.

CBE 120C. Mass Transfer. 3 Units.
Molecular and continuum approaches to diffusion and convection in multi-component mixtures; steady state, quasi-steady state and transient mass transfer; effect of reactions on mass transfer; convective mass transfer; simultaneous mass, heat and momentum transfer; applications to chemical and related industries.

Prerequisite: CBE 120B and CBE 100

Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science and Engineering majors have second consideration for enrollment.

CBE 130. Separation Processes. 4 Units.
Application of equilibria and mass and energy balances for design of separation processes. Use of equilibrium laws for design of distillation, absorption, stripping, and extraction equipment. Design of multicomponent separators.

Prerequisite: CBE 40B and CBE 40C. CBE 40B with a grade of C- or better. CBE 40C with a grade of C- or better

Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science and Engineering majors have second consideration for enrollment.

CBE 140A. Chemical Engineering Laboratory I. 4 Units.
Experimental study of thermodynamics, fluid mechanics, and heat and mass transfer. Operation and evaluation of process equipment, data analysis. Materials fee.

Prerequisite: CBE 110 and CBE 120C

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 140B. Chemical Engineering Laboratory II. 4 Units.
Continuation of the CBE 140A covering mass transfer operations such as distillation, absorption, extraction, etc. Rate and equilibria studies in simple chemical systems with and without reaction. Study of chemical process. Materials fee.

Prerequisite: CBE 130 and CBE 145 and CBE 140A

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 145. Chemical Process Control. 4 Units.
Dynamic responses and control of chemical process equipment, dynamic modeling of chemical processes, linear system analysis, analyses and design of feedback loops and advanced control systems.

Prerequisite: CBE 110 and CBE 120B and CBE 120C

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 150A. Chemical Engineering Design I. 3 Units.
Introduction to process design; flow sheets for chemical processes; synthesis of multicomponent separation sequences and reaction paths; synthesis of heat exchange networks; computer-aided design and simulation of processes and components pacts.

Prerequisite: CBE 110 and CBE 120C and CBE 130

Restriction: Seniors only. Chemical Engineering Majors only.

CBE 150B. Chemical Engineering Design II. 3 Units.
Application of chemical engineering basics to practical design problems; process economics; process safety; environmental impacts; a major team design project with progress reports, oral presentation, and technical report with engineering drawings and economics.

Prerequisite: CBE 150A

Restriction: Seniors only. Chemical Engineering Majors only.

CBE 160. Engineering Biology. 3 Units.
First-principle introduction to the modern biochemistry, molecular biology, and cell biology with an engineering language. The goal is to demonstrate that the vastly diverse biological phenomena can be explained by a set of fundamental principles in chemistry, thermodynamics, and kinetics.

CBE 161. Introduction to Biochemical Engineering. 3 Units.
Application of engineering principles to biochemical processes. Topics include microbial pathways, energetics and control systems, enzyme and microbial kinetics, and the design and analysis of biological reactors.

Prerequisite: CBE 110 and CBE 160 and (CHEM 1C or CHEM H2C) and MATH 3D

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 163. Kinetics of Biochemical Networks. 4 Units.
Principles from statistical mechanics, thermodynamics, and chemical kinetics applied to biochemical systems, from fundamental processes such as receptor-ligand binding and enzyme catalysis, to complex cellular functions including signal transduction and gene regulation.

Prerequisite: CBE 120A and CBE 160

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 172. Applied Spectroscopy. 4 Units.
Designed to teach fundamental principles of spectroscopy and their application to photon and electron spectroscopies of the gas and condensed phases. Covers theoretical principles of rotational, vibrational, and electronic spectroscopies. Specific topics include infrared and Raman spectroscopies, Auger, X-ray, etc.

Prerequisite: CBE 40C and CBE 105 and MATH 3D

Concurrent with CBE 272.

CBE 175. Electrochemical Engineering. 4 Units.
Introduction to fundamentals of electrochemical engineering and its application to variety of energy conversion- and storage-technologies. Planned topics include: electric double layers, reaction kinetics, transport, batteries, fuel-cells.

CBE 176. Nuclear and Radiochemistry. 4 Units.
Advanced treatment of nuclear structure, nuclear reactions, and radioactive-decay processes. Introduction to nuclear activation analysis, isotope effects, radiation chemistry, hot-atom chemistry, nuclear age-dating methods, nuclear reactors, and nuclear power.

Prerequisite: (CHEM M3C or CHEM 1C or CHEM H2C or CHEM M2C) and MATH 2D

Same as CHEM 133.

Restriction: Chemistry Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment.

Concurrent with CHEM 233 and CBE 276.

CBE 181. Polymer Science and Engineering. 4 Units.
An introduction to physical aspects of polymers, including configuration and conformation of polymer chains and characterization techniques; crystallinity, viscoelasticity, mechanical properties, polymer alloys, processing, and application.

Prerequisite: ENGR 54 and (CBE 110 or MSE 165)

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 183. Surface and Adhesion Science. 4 Units.
Structure, thermodynamics of, kinetics, and reactions on surfaces. Surface electronic and mechanical properties and characterization of all classes of materials including metals, semiconductors, ceramics, polymers, and soft materials. Adhesion between different materials is also addressed.

Prerequisite: (CBE 110 or MSE 165C) and (MSE 141 or MSE 69)

Same as MSE 176.

Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

Concurrent with MSE 276 and CBE 283.

CBE 187. Semiconductor Device Packaging. 3 Units.
Introduction to the semiconductor device packaging and assembly process. Electrical, thermal, optical, and mechanical aspects of package design and reliability. Special topics on optoelectronics packaging are covered.

Prerequisite: CBE 40B

Restriction: Chemical Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment.

CBE 195. Special Topics in Chemical Engineering. 1-4 Units.
Studies in selected areas of Chemical Engineering. Topics addressed vary each quarter.

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

CBE 197. Chemical and Biomolecular Engineering Internship. 2-12 Units.
Students majoring in CBE may receive credit for an approved internship, working at a company under the supervision of an industry mentor and a faculty advisor. Enables students to gain valuable experience in a professional setting and enhance their skills.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 3 times.

CBE 198. Group Study. 1-4 Units.
Group study of selected topics in engineering.

Repeatability: May be repeated for credit unlimited times.

Restriction: Upper-division students only.

CBE 199. Individual Study. 1-4 Units.
For undergraduate engineering majors in supervised but independent readings, research, or design. Students taking individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

Repeatability: May be taken for credit for 8 units.

Restriction: Chemical Engineering Majors have first consideration for enrollment.

CBE 199P. Individual Study. 1-4 Units.
For undergraduate Engineering majors in supervised but independent reading, research, or design. Students taking individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in The School of Engineering.

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

CBE 200. Applied Engineering Mathematics I. 4 Units.
Analytical techniques applied to engineering problems in transport phenomena, process dynamics and control, and thermodynamics.

Restriction: Graduate students only.

CBE 210. Reaction Engineering. 4 Units.
Advanced topics in reaction engineering, reactor stability analysis, diffusional effect in heterogeneous catalysis, energy balance, optimization of reactor operation, dispersed in phase reactors.

Restriction: Graduate students only.

CBE 220A. Transport Phenomena I. 4 Units.
Continuum modeling and analysis of heat and mass transfer from an integrated viewpoint. Scaling concepts, relevance of characteristic time- and length-scales, steady- and unsteady-state processes, bounded and unbounded problems, and convective transport, with applications to chemical and biological processes.

Restriction: Graduate students only.

CBE 220B. Transport Phenomena II. 4 Units.
Introduces flow of isothermal fluids from a momentum transport viewpoint. Steady- and unsteady-state creeping and laminar flows; viscous and inviscid flows; Navier-Stokes equations; lubrication theory; boundary layer theory; with specific application to complex chemical and biological engineering processes.

Prerequisite: CBE 220A. CBE 220A with a grade of B- or better

Restriction: Graduate students only.

CBE 240. Advanced Engineering Thermodynamics. 4 Units.
Introduction to modern thermodynamics and applications, with a focus on aspects relevant to chemical and materials engineering. Mathematical tools; equilibrium and stability; microscope rigorous equations of state; molecular-level thermodynamics of real mixtures; and phase and chemical equilibrium.

Restriction: Graduate students only.

CBE 249. Special Topics in Chemical Engineering. 1-4 Units.
Studies in selected areas of Chemical Engineering. Topics addressed vary each quarter.

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

CBE 250. Research Methods and Technical Communication. 4 Units.
Intended for Ph.D. students to develop critical research skills in creating archival papers, intellectual property and technical proposals, and in analysis of the scientific literature.

Restriction: Graduate students only.

CBE 261. Molecular Biotechnology. 4 Units.
Engineering and biological principles important in recombinant cell technology. Host/vector selection; plasmid propagation; optimization of cloned gene expression; metabolic engineering; protein secretion; experimental techniques; modeling of recombinant cell systems.

Restriction: Graduate students only.

CBE 262. Metabolic Engineering and Synthetic Biology. 4 Units.
Synthesis of chemicals from renewable carbon and energy sources using.

Restriction: Graduate students only.

CBE 264. Drug Delivery. 4 Units.
Introduction to design of drug delivery systems. Includes physicochemical and pharmacokinetic considerations in drug formulations, types of therapeutics, routes of administration, biomaterials, and novel drug delivery systems.

CBE 266. Bioseparation Processes. 4 Units.
Introduction to design of bioseparation processes. The recovery and purification of biologically produced proteins, chemicals, and particulates are important. Focuses on the use of chemical engineering skills and principles in the analysis and design of biologically-based processes.

Restriction: Graduate students only.

CBE 271. Catalysis. 4 Units.
Establish the microscopic thermodynamics of rate constants and develop quantitative rate laws to model multistep reaction kinetics typical of catalyzed reactions. Common elementary chemical transformations and characteristics of catalytic materials are discussed, citing reactions from industry and current research.

Restriction: Graduate students only.

Concurrent with CBE 171.

CBE 272. Applied Spectroscopy. 4 Units.
Designed to teach fundamental principles of spectroscopy and their application to photon and electron spectroscopies of the gas and condensed phases. Covers theoretical principles of rotational, vibrational, and electronic spectroscopies. Specific topics include infrared and Raman spectroscopies, Auger, X-ray, etc.

Restriction: Graduate students only.

Concurrent with CBE 172.

CBE 276. Nuclear and Radiochemistry. 4 Units.
Advanced treatment of nuclear structure, nuclear reactions, and radioactive-decay processes. Introduction to nuclear activation analysis, isotope effects, radiation chemistry, hot-atom chemistry, nuclear age-dating methods, nuclear reactors, and nuclear power.

Same as CHEM 233.

Restriction: Graduate students only.

Concurrent with CHEM 133 and CBE 176.

CBE 277. Detection and Measurement of Radiation. 4 Units.
Basic principles of detection and measurement of ionizing radiation; both theory and practical aspects of measurement techniques for alpha, beta, gamma, and neutron radiation, properties of different detector materials, electronics and data treatments, and analysis.

Prerequisite: CHEM 233 or CBE 276. CHEM 233 with a grade of B- or better. CBE 276 with a grade of B- or better

Same as CHEM 244.

Restriction: Graduate students only.

CBE 280. Advanced Polymer Science and Engineering. 4 Units.
The synthesis, characterization, microstructure, rheology, and properties of polymer materials. Polymers in solution and in the liquid, crystalline and glassy states. Engineering and processing properties, including viscoelasticity and rheology. Forming and processing methods. Environmental issues.

Restriction: Graduate students only.

CBE 282. Colloid Science and Engineering. 4 Units.
An introduction to the basic foundations of colloid science, interfacial phenomena, suspensions and complex fluids, and engineering and assembly of colloidal materials.

Restriction: Graduate students only.

CBE 283. Surface and Adhesion Science. 4 Units.
Structure, thermodynamics of, kinetics, and reactions on surfaces. Surface electronic and mechanical properties and characterization of all classes of materials including metals, semiconductors, ceramics, polymers, and soft materials. Adhesion between different materials is also addressed.

Same as MSE 276.

Restriction: Graduate students only.

Concurrent with MSE 176 and CBE 183.

CBE 295. Seminars in Engineering. 1-4 Units.
Seminars scheduled each year by individual faculty in major field of interest.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

CBE 296. Master of Science Thesis Research. 1-16 Units.
Individual research or investigation conducted in preparation for the thesis required for the M.S. degree.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

CBE 297. Doctor of Philosophy Dissertation Research. 1-16 Units.
Individual research or investigation conducted in preparation for the dissertation required for the Ph.D. degree.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

CBE 298. Seminars in Engineering. 2 Units.
Presentation of advanced topics and reports of current research efforts in chemical engineering.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

CBE 299. Individual Research. 1-16 Units.
Individual research or investigation under the direction of an individual faculty member.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.