CHEMICAL ENGINEERING

The Department of Chemical and Biological Engineering (https://www.colorado.edu/chbe/graduate-program/prospective-graduate-students/) (ChBE) offers an innovative graduate program and emphasizes the doctoral degree. ChBE's outstanding national and international students take advantage of the high level of faculty-student collaboration and benefit from access to three interdisciplinary research centers. Department faculty and students have won numerous awards both nationally and internationally.

General research areas within the Department of Chemical and Biological Engineering include: biomaterials, biopharmaceutical engineering, catalysis, surface science and reaction engineering, complex fluids and microfluidic devices, computational science; energy and environmental applications, membranes and separations, metabolic engineering and directed evolution, nanostructured films and devices, polymer chemistry and engineering, and tissue engineering.

ChBE is one of the top research departments in the nation and maintains sophisticated facilities to support research endeavors. Although research in the department spans many diverse fields, there is a particular emphasis on research in biological engineering, functional materials, and renewable energy.

Biological engineering research includes a broad collection of focal areas spanning from the molecular scale (metabolites, genes, proteins) to the cellular and multicellular scales. Biological engineering projects account for a significant portion of the research activity within the ChBE Department. This research is supported in a variety of manners: federal grants (NIH, NSF, DOD, etc.), national foundations (Howard Hughes, Cystic Fibrosis, etc.), and industrial collaborators.

Functional Materials research in the ChBE Department is concentrated in a diverse group of research areas including polymers, nanostructured materials, photovoltaic materials, ultrathin films, catalytic materials, computational materials science, self-assembled monolayers, and liquid crystalline materials. The department has strength in studying materials problems at the nanometer and sub-nanometer length scales. Such fundamental investigations are directed toward technological applications.

Finally, the ChBE Department has an active program in renewable energy research. Studies range from the production and utilization of hydrogen to materials for photovoltaics to biorefining and biofuels research. A number of efforts focus on developing catalysts for converting water to hydrogen and CO^2 into fuels such as CO and methanol. Another area of focus is the study of novel photovoltaic materials and structures involving organic, inorganic, and hybrid structures for efficient solar energy harvesting.

Course code for this program is CHEN.

Master's Degree

- Chemical Engineering - Master of Science (MS) (https://catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/chemical-engineering/chemical-engineering-master-science-ms/)

Doctoral Degree

- Chemical Engineering - Doctor of Philosophy (PhD) (https://catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/chemical-engineering/chemical-engineering-doctor-philosophy-phd/)
- Biological Engineering - Doctor of Philosophy (PhD) (https://catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/chemical-engineering/biological-engineering-doctor-philosophy-phd/)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Anseth, Kristi S. (https://experts.colorado.edu/display/fisid_103471/)
Distinguished Professor; PhD, University of Colorado Boulder

Bay, R. Kōnane (https://experts.colorado.edu/display/fisid_172688/)
Assistant Professor; PhD, University of Massachusetts at Amherst

Bowman, Christopher N. (https://experts.colorado.edu/display/fisid_102043/)
Distinguished Professor; PhD, Purdue University

Bryant, Stephanie J. (https://experts.colorado.edu/display/fisid_111810/)
Professor; PhD, University of Colorado Boulder

Burdick, A. Jason (https://experts.colorado.edu/display/fisid_168868/)
Professor; PhD, University of Colorado Boulder

Cha, Jennifer N. (https://experts.colorado.edu/display/fisid_151746/)
Professor; PhD, University of California, Santa Barbara

Chatterjee, Anushree
Associate Professor; PhD, University of Minnesota

Clough, David Edwards (https://experts.colorado.edu/display/fisid_102332/)
Professor Emeritus; PhD, University of Colorado Boulder

Davis, Robert H. (https://experts.colorado.edu/individual/fisid_113653/)
Distinguished Professor; PhD, Stanford University

deGrazia, Janet (https://experts.colorado.edu/display/fisid_107661/)
Professor Emeritus; PhD, University of Colorado Boulder

Falconer, John L. (https://experts.colorado.edu/display/fisid_101426/)
Professor Emeritus; PhD, Stanford University

Fox, Jerome Michael (https://experts.colorado.edu/display/fisid_156682/)
Assistant Professor; PhD, University of California, Berkeley

Goodwin, Andrew Pratt (https://experts.colorado.edu/display/fisid_151595/)
Associate Professor; PhD, University of California, Berkeley

Heinz, Hendrik (https://experts.colorado.edu/display/fisid_156488/)
Professor; PhD, ETH Zurich (Switzerland)

Holewinski, Adam P. (https://experts.colorado.edu/display/fisid_155859/)
Assistant Professor; PhD, University of Michigan Ann Arbor

Hrenya, Christine M.
Professor; PhD, Carnegie Mellon University

Kaar, Joel L. (https://experts.colorado.edu/display/fisid_148491/)
Associate Professor; PhD, University of Pittsburgh

Keyvani, Ehsan
Teaching Assistant Professor; PhD, Northeastern University

Krantz, William
Professor Emeritus

Mahoney, Melissa J.
Teaching Professor; PhD, Cornell University

McGehee, Michael D. (https://experts.colorado.edu/display/fisid_163453/)
Professor; PhD, University of California, Santa Barbara

Medlin, James William (https://experts.colorado.edu/display/fisid_122699/)
Professor, Chair; PhD, University of Delaware

Musgrave, Charles Bruce (https://experts.colorado.edu/display/fisid_144977/)
Professor; PhD, California Institute of Technology

Nuttelman, Charles Raymond (https://experts.colorado.edu/display/fisid_142758/)
Teaching Professor; PhD, University of Colorado Boulder

Ramirez, Walter
Professor Emeritus

Randolph, Theodore W. (https://experts.colorado.edu/display/fisid_101768/)
Professor; PhD, University of California, Berkeley

Schwartz, Daniel K. (https://experts.colorado.edu/display/fisid_118479/)
Professor, Endowed Chair; PhD, Harvard University

Shields, C. Wyatt IV (https://experts.colorado.edu/individual/fisid_165173/)
Assistant Professor; PhD, Duke University

Shirts, Michael R. (https://experts.colorado.edu/display/fisid_156474/)
Professor; PhD, Stanford University

Stansbury, Jeffrey W.
Professor; PhD, University of Maryland

Weimer, Alan W. (https://experts.colorado.edu/display/fisid_109152/)
Professor; PhD, University of Colorado Boulder

White, Timothy J. (https://experts.colorado.edu/display/fisid_163899/)
Professor, Associate Chair; PhD, University of Iowa

Whitehead, Timothy Andrew (https://experts.colorado.edu/display/fisid_164364/)
Associate Professor; PhD, University of California-Berkeley

Young, Wendy Mores (https://experts.colorado.edu/display/fisid_146942/)
Teaching Professor, Associate Chair; PhD, University of Colorado Boulder

Courses

CHEN 5090 (1) Seminar in Chemical Engineering
Required of all chemical engineering graduate students. Includes reports on research activities and on special current topics.
Requisites: Restricted to graduate students only.

CHEN 5128 (3) Applied Statistics In Research and Development
Students learn current and emerging statistical methods that are appropriate to experimentation in research and development activities. Statistical design of experiments and model fitting is emphasized. Department enforced prereq.: one introductory probability/statistics course.

CHEN 5150 (3) Biomolecular Kinetics, Transport, and Thermodynamics
Required for the Biological Engineering PhD. This course covers aspects of kinetics, transport, and thermodynamics as they relate to interactions between biomolecules and cells. These core subjects will be introduced within concepts common to cell biology, protein/genetic engineering, and signaling, among others. Undergraduate enrollment with instructor consent only.
Recommended: Prerequisites Introductory biology and/or biochemistry, linear algebra, differential equations, thermodynamics, organic chemistry.

CHEN 5160 (3) Systems Analysis of Cells and Tissues
Required for the Biological Engineering PhD. This course explores how to describe signaling and regulation networks present at the cell and tissue level. Topics include gene expression, stem cell differentiation, homeostasis, and others.
Recommended: Prerequisite prior experience in introductory biology and/or biochemistry, linear algebra, differential equations, thermodynamics, and organic chemistry.

CHEN 5210 (4) Transport Phenomena
Considers continuum mechanics, emphasizing fundamental relationships for fluid mechanics and heat and mass transfer and their applications to engineering problems. Department enforced prerequisites: undergraduate courses in fluid mechanics, heat transfer, and differential equations.
Requisites: Restricted to students with 87-180 credits (Seniors) or graduate students only.

CHEN 5360 (3) Catalysis and Kinetics
Studies principles of chemical kinetics and catalytic reactions, emphasizing heterogeneous catalysis.
Requisites: Requires corequisite course of CHEN 4330. Restricted to Chemistry (CHEM) or Chemical Engineering (CHEN) graduate students only.

CHEN 5370 (3) Intermediate Chemical Engineering Thermodynamics
Reviews fundamentals of thermodynamics, application to pure fluids and mixtures, and physical equilibrium and changes of state. Examines the equation of state and computation of fluid properties for pure fluids, mixtures and solutions. Also looks at relations between thermodynamics and statistical mechanics. Department enforced prerequisite: an undergraduate course in chemical thermodynamics.
Requisites: Restricted to graduate students only.

CHEN 5390 (3) Chemical Reactor Engineering
Studies ideal and nonideal chemical reactors, including unsteady state behavior, mixing effects, reactor stability, residence time distribution and diffusion effects. Department enforced prerequisite: undergraduate course in chemical reactor design/kinetics.
Requisites: Restricted to graduate students only.

CHEN 5420 (3) Physical Chemistry and Fluid Mechanics of Interfaces
Covers thermodynamics of interfaces and surface tension measurement; adsorption at liquid-gas, liquid-liquid, and solid-gas interfaces; monolayers; conservation equations for a fluid interface; rheology of interfaces; surface tension driven flows; contact angle and wettability; and double layer phenomena.
Requisites: Requires prerequisite course of CHEN 3200 (minimum grade D-).

CHEN 5440 (3-4) Design of Materials
The course content includes introduction and study of important concepts in solid state physics (particularly those relevant for design of materials); origin, characterization and design of mechanical, electronic, optical, magnetic, thermal and electrochemical properties of materials; design of bulk and nanostructured composites; introduction to polymers and soft materials; fundamentals of colloids and interfaces; and nanoscale chemistry and physics for design or desired material properties.
Grading Basis: Letter Grade

CHEN 5450 (3) Polymer Chemistry
Introduces polymer science with a focus on polymer chemistry and polymerization reactions. Focuses on polymerization reaction engineering and how polymer properties depend on structure.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4450
Requisites: Restricted to graduate students only.

CHEN 5460 (3) Polymer Engineering
Introductory polymer engineering course reviewing basic terminology and definitions; the properties and synthetic routes of important industrial polymers; and processing of polymers and their applications.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4460
Requisites: Restricted to graduate students only.

CHEN 5470 (3) Functional Materials Chemistry
The synthesis, organization, and processing of materials can enable functional performance. Curriculum will overview the synthesis and design of functional organic and inorganic materials. A particular emphasis will be placed on structure-performance correlations between chemistry and materials organization. Topical foci will include polymers, biomaterials, and materials for energy.
Recommended: Prerequisite Introductory course(s) in materials or organic chemistry.

CHEN 5480 (3) Solar Cells and Optical Devices for Sustainable Buildings
This course assumes no background in electronic materials and explains how silicon and cutting-edge metal halide perovskite solar cells are designed, fabricated and characterized. Topics will include optics, band diagrams, wafer fabrication, most thin film deposition techniques, module design and economics. Other optical devices that can help the world rapidly reduce its carbon emissions, such as light-emitting diodes and energy saving windows with dynamic tinting, will also be covered.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4480
Requisites: Restricted to graduate students only.
Recommended: Prerequisite a course in materials science (for example CHEN 4440), the physics of electromagnetism and optics at a very basic level.

CHEN 5490 (3) Electrochemical Engineering
This course discusses fundamentals and applications of electrochemical systems from an engineering perspective. Aspects of thermodynamics, reaction kinetics, and transport phenomena relevant to the description of electrode/electrolyte interfaces and charge transfer reactions are covered. Topics include cell equilibrium (Nernst equation), reactions rates within Butler-Volmer and Marcus theory, electrochemical double layer structure, ion transport (Poisson-Nernst-Planck equation), potential and current distributions in electrochemical cells, and experimental electroanalytical techniques. Applications include fuel cells, electrolyzers, batteries, sensors, and corrosion. Contact instructor to request to take prerequisites as corequisites.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4490
Requisites: Requires prerequisite courses of (CHEN 4330 or CHEN 4830) and PHYS 1120 (minimum grade D-). Restricted to graduate students only.
Grading Basis: Letter Grade

CHEN 5630 (1) Intellectual Property Law and Engineering
Learn the fundamentals of the various types of intellectual property, obtain the ability to search the USPTO database for patents, learn the difference between provisional patents, utility patents and foreign patents and learn the timing requirements related to the filing of patents and public disclosure, use, and/or sale of an invention.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4630
Requisites: Restricted to graduate students only.

CHEN 5650 (3) Particle Technology
Aims to identify the important physical mechanisms occurring in processes involving particles, formulate and solve mathematical descriptions of such processes, and analyze experimental and theoretical results in both a qualitative and quantitative manner. Teaches students to apply this knowledge to the design of particulate systems. Conveys the breadth and depth of natural and industrial applications involving particulates. Extra work required for graduate course.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4650
Requisites: Restricted to graduate students only.

CHEN 5670 (3) Environmental Separations
Lect. Covers traditional, as well as new, chemical separations processes that have environmental applications. Includes chemically benign processing (pollution prevention) as well as approaches to address existing pollution problems.

CHEN 5730 (1) Mathematical Methods Short Course for Chemical Engineers
Determine and apply appropriate analytical methods, which may include linear and nonlinear algebraic equations, ordinary differential equations and partial differential equations, to solve an array of chemical engineering problems. Identify and interpret the differences between model predictions and experimental results.
Grading Basis: Letter Grade

CHEN 5740 (3) Analytical Methods in Chemical Engineering
Presents applied analytical and numerical mathematical methods in the context of chemical engineering problems. Topics include modeling techniques, algebraic equations, and ordinary and partial differential equations. Department enforced requisite: working knowledge of computing, calculus, differential equations, linear algebra, and vector operations; and undergraduate courses in physics, fluid mechanics, heat transfer, and reaction engineering.
Requisites: Restricted to students with 87-180 credits (Seniors) or graduate students only.

CHEN 5750 (3) Numerical Methods in Chemical Engineering
Covers numerical methods for solving ordinary differential, partial differential, and integral equations. These principles are employed to develop, test, and assess computer programs for solving problems of interest to chemical engineers.
Requisites: Restricted to graduate students only.

CHEN 5800 (3) Bioprocess Engineering
Reviews the recent developments in the fields of microbiology, molecular genetics, and genetic engineering that are of commercial value and benefit to mankind. Covers engineering implementation of such biological processes.

CHEN 5803 (3) Metabolic Engineering
Introduces basic concepts in metabolic engineering and explores modern approaches in metabolic and strain engineering. Application areas that will be discussed will include the use of metabolic engineering approaches in biofuels and biorefining as well as biopharmaceutical production.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4803
Requisites: Requires prerequisite courses of APPM 2360 and BCHM 4611 (all minimum grade C-). Restricted to graduate students only.

CHEN 5804 (3) Protein and Enzyme Engineering
This course reviews various applications of protein and enzyme engineering and covers key concepts in protein and enzyme design, including protein structure-function relationships; rational and evolutionary engineering approaches; genetic code expansion; cell-free protein synthesis; computational design; and biophysical methods for protein characterization. Additionally, students gain valuable experience reading, analyzing, and interpreting research results from scientific literature, as well as drafting an original research proposal.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4804
Requisites: Requires prerequisite courses of CHEN 3320 and CHEN 2810 and BCHM 4611 (minimum grade D-). Restricted to graduate students only.
Grading Basis: Letter Grade

CHEN 5805 (3) Biological Interactions to Biomaterials
Covers major classes of materials used in medical applications. Provide an in-depth view of advanced biomaterial concepts with a focus on biological interactions with materials that relate to protein and cell interactions, the innate and acquired immune response, blood interactions and infection.
Requisites: Restricted to graduate students only.

CHEN 5830 (1) Introduction to Modern Biotechnology
Introduces students to the biotechnology enterprise. Topics include the biotechnology industry and profession, the various academic disciplines of biotechnology, intellectual property, financing, and ethics.

CHEN 5831 (2) Biotechnology Case Studies
Capstone course required of all graduate students in the interdisciplinary graduate biotechnology certificate program. Reviews molecular genetics, product synthesis and purification, economics, intellectual property, and business planning. Working in teams, students present a biotechnology product plan.
Requisites: Requires prerequisite course of CHEN 5830 (minimum grade D-).

CHEN 5835 (3) Colloids and Interfaces
Provides a deep exploration of the fundamental principles of colloid and interface science and of related applications. Core topics include fundamental equations of interfacial science, capillary phenomena, interfacial thermodynamics interfaces, molecular monolayers, electrical surface properties, and interfacial a forces. Advanced topics include wetting phenomena, adsorption isotherms, dynamic interfacial behavior, surface modification, tribiology, surfactant self-assembly, and foams/emulsions among others.
Requisites: Requires prerequisite course of CHEN 3320 (minimum grade C-).

CHEN 5836 (3) Nanomaterials
Presents fundamental chemical and physical concepts that give rise to the unique optical, electronic and magnetic properties of nanoscale materials. Introduces important synthetic routes for producing nanomaterials, and interparticle forces governing colloidal behavior and self-assembly. Discusses current and potential applications in catalysis, biomedicine, renewable energy, and other fields.
Equivalent - Duplicate Degree Credit Not Granted: CHEN 4836
Requisites: Restricted to graduate students only.

CHEN 5838 (1-3) Special Topics in Chemical Engineering
Graduate-selected topics courses offered upon demand.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.

CHEN 5840 (1-4) Independent Study
Allows multiple enrollment in term.
Repeatable: Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.

CHEN 5900 (3) Pharmaceutical Biotechnology
Incorporates biochemistry, pharmaceutical science, and engineering for application in the pharmaceutical industry. Emphasizes microscale mechanisms affecting drug delivery, bioavailability, and stability. Specific topics include thermodynamics of macromolecular conformational stability, crystallization kinetics, interfacial phenomena, and industrial protein folding.
Requisites: Restricted to graduate students only.

CHEN 5919 (1-5) Special Topics in CHBE
Repeatable: Repeatable for up to 5.00 total credit hours.
Requisites: Restricted to graduate students only.

CHEN 5930 (1-3) Professional Internship
This class provides a structure for CHEN and BIEN graduate students to receive academic credit for participating in internship experiences with industry partners that have an academic component consistent with graduate-level education in the engineering arts and sciences. Participation in this class requires an internship agreement between the student and the employment (industry) partner, detailing the academic goals of the internship experience. Instructor participation will include facilitation of mid-term and final assessment of student performance as well as additional educational opportunities during the internship period. May be taken during any term following initial enrollment and participation in CHEN or BIEN graduate programs.
Requisites: Restricted to graduate students only.

CHEN 6210 (3) Microhydrodynamics of Suspensions and Colloids
Focuses on fluid mechanics and colloid science of suspensions of particles, cells, and drops. Covers fundamentals, applications, and research frontiers.
Requisites: Requires prerequisite course of CHEN 5210 (minimum grade D-).

CHEN 6820 (3) Biochemical Engineering Fundamentals
Covers design and operation of fermentation processes, microbial and enzyme kinetics, multiple substrate and multiple species of fermentation, regulation of enzyme activity, energetics of cellular growth, immobilized enzyme and cell reactors, and transport phenomenain microbial systems and downstream processing.
Requisites: Restricted to Chemistry (CHEM), Chemical Engineering (CHEN), Biological Engineering (BIEN), or Biological Sciences (MCDB) graduate students only.

CHEN 6940 (1) Master's Candidate for Degree
Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.

CHEN 6950 (1-6) Master's Thesis

CHEN 8990 (1-10) Doctoral Dissertation