Chemical and Biomolecular Engineering

At Berkeley, graduate work in chemical and biomolecular engineering emphasizes the excitement of original research in frontier areas of applied science. Graduate students may pursue a PhD in Chemical Engineering, or they may apply to our Product Development Program (PDP) to obtain an MS in Chemical Engineering. While formal courses are necessary to provide scientific fundamentals and intellectual breadth, the primary characteristic of Berkeley's graduate experience is to participate in the quest for new knowledge. Graduate students and faculty collaborate as partners in scholarship, in learning, and in intellectual discovery.

Product Development Program (MS)

In Fall 2006, the Department of Chemical and Biomolecular Engineering at U.C. Berkeley initiated a new and innovative Product Development Program (PDP). The PDP is a graduate-level degree program whose central aim is to fill the unmet need at national and international levels for graduates of chemical engineering and related disciplines who have knowledge and field experience in the complex process of transforming technical innovations into commercially successful products. In the space of one calendar year, PDP graduates will gain exposure to real-world product development practices in a range of chemical process-intensive industries including biotechnology, microelectronics , nanoscience and consumer products (concentrations within the program). The PDP does not require a research thesis, but students will find completing the extensive coursework and field study assignment challenging. By combining elements of advanced technical knowledge with focused business-related training, the PDP aims to fill a specific niche in the "choice space" of graduate education options for engineering graduates.

The academic content of the program is the result of a careful design process using as input the results of extensive interviews with industry, faculty and students. Each component of the program has been thoroughly vetted with several representatives from each one of these stakeholder groups. As currently structured, the program will offer a one calendar year course of study that will result in the award of a Master's of Science Degree in Chemical Engineering with an emphasis in product development.

PhD Program

The PhD program is designed to enlarge the body of knowledge of the student and, more importantly, to discover and develop talent for original, productive, and creative work in chemical and biomolecular engineering. Breadth of knowledge and professional training are achieved through advanced course work. To develop the creative talents of the student, a paramount emphasis in the Ph.D. program is placed on intensive research, a project on which students work closely with one or more members of the faculty.

PhD students may choose to add a designated emphasis (DE) to their program. A designated emphasis is a specialization, such as a new method of inquiry or an important field of application, which is relevant to two or more existing doctoral degree programs. Designated emphases open to students in this PhD program include: Nanoscale Science and Engineering (NSE); Energy Sciences and Technology (DEEST); Communication, Computation and Statistic; Computational and Genomic Biology; and New Media.

Admission to the University

Uniform minimum requirements for admission

The following minimum requirements apply to all programs and will be verified by the Graduate Division:

1. A bachelor's degree or recognized equivalent from an accredited institution;
2. A minimum grade-point average of B or better (3.0);
3. If the applicant comes from a country or political entity (e.g. Quebec) where English is not the official language, adequate proficiency in English to do graduate work, as evidenced by a TOEFL score of at least 570 on the paper-and-pencil test, 230 on the computer-based test, 90 on the iBT test, or an IELTS Band score of at least 7 (note that individual programs may set higher levels for any of these); and
4. Enough undergraduate training to do graduate work in the given field.

Applicants who already hold a graduate degree

The Graduate Council views academic degrees as evidence of broad research training, not as vocational training certificates; therefore, applicants who already have academic graduate degrees should be able to take up new subject matter on a serious level without undertaking a graduate program, unless the fields are completely dissimilar.

Programs may consider students for an additional academic master's or professional master's degree if the additional degree is in a distinctly different field.

Applicants admitted to a doctoral program that requires a master's degree to be earned at Berkeley as a prerequisite (even though the applicant already has a master's degree from another institution in the same or a closely allied field of study) will be permitted to undertake the second master's degree, despite the overlap in field.

The Graduate Division will admit students for a second doctoral degree only if they meet the following guidelines:

1. Applicants with doctoral degrees may be admitted for an additional doctoral degree only if that degree program is in a general area of knowledge distinctly different from the field in which they earned their original degree. For example, a physics PhD could be admitted to a doctoral degree program in music or history; however, a student with a doctoral degree in mathematics would not be permitted to add a PhD in statistics.
2. Applicants who hold the PhD degree may be admitted to a professional doctorate or professional master's degree program if there is no duplication of training involved.

Applicants may only apply to one single degree program or one concurrent degree program per admission cycle.

Any applicant who was previously registered at Berkeley as a graduate student, no matter how briefly, must apply for readmission, not admission, even if the new application is to a different program.

Required documents for admissions applications

1. **Transcripts:** Upload unofficial transcripts with the application for the departmental initial review. Official transcripts of all college-level work will be required **if admitted**. Official transcripts must be in sealed envelopes as issued by the school(s) you have attended. Request a current transcript from every post-secondary school that you have attended, including community colleges, summer sessions, and extension programs.
   If you have attended Berkeley, upload unofficial transcript with the application for the departmental initial review. Official transcript with evidence of degree conferral ***will not*** be required if admitted.
2. **Letters of recommendation:** Applicants can request online letters of recommendation through the online application system. Hard copies of recommendation letters must be sent directly to the program, not the Graduate Division.
3. **Evidence of English language proficiency:** All applicants from countries in which the official language is not English are required to submit official evidence of English language proficiency. This requirement applies to applicants from Bangladesh, Burma, Nepal, India, Pakistan, Latin America, the Middle East, the People's Republic of China, Taiwan, Japan, Korea, Southeast Asia, and most European countries. However, applicants who, at the time of application, have already completed at least one year of full-time academic course work with grades of B or better at a U.S. university may submit an official transcript from the U.S. university to fulfill this requirement. The following courses will not fulfill this requirement: 1) courses in English as a Second Language, 2) courses conducted in a language other than English, 3) courses that will be completed after the application is submitted, and 4) courses of a non-academic nature. If applicants have previously been denied admission to Berkeley on the basis of their English language proficiency, they must submit new test scores that meet the current minimum from one of the standardized tests.

Admission to the Program

Admission is granted by the University's Graduate Division on the recommendation of the department. Applicants generally are required to provide the following: evidence of superior performance in the last two years of undergraduate studies; test scores for the aptitude portion of the Graduate Record Examination (the advanced GRE or subject test is not required); and 3 letters of recommendation from professors or colleagues familiar with the applicant's academic and professional aptitudes. International students whose native language is not English must provide evidence of English language proficiency. The weight of evidence from all sources determines admission. Students do not need a master's degree to apply for a doctoral degree. Most applicants will have completed a typical undergraduate program in chemical engineering. However, admission may be granted to students with undergraduate degrees in a related discipline. In this case, necessary background courses in chemical engineering are taken as part of the program for the first year.

Curriculum

Approved individualized study list which must include the following:

- 9-12 units: Chemical Engineering graduate courses
- 9-12 units: Graduate or upper-division electives
- 9-unit technical sequence in an outside specialty

Additional breadth courses per guidance of head graduate adviser

Curriculum

Biotechnology/Drug Development/Medical Device Concentration

CHM ENG 295P	Special Topics in Chemical Engineering: Introduction to New Product Development	3
CHM ENG 295Q	Special Topics in Chemical Engineering: Advanced Topics in New Product Development	3
CHM ENG 170A	Biochemical Engineering	3
MCELLBI 102	Survey of the Principles of Biochemistry and Molecular Biology	4
MCELLBI 150	Molecular Immunology	4
MCELLBI 200A	Fundamentals of Molecular and Cell Biology	3
MCELLBI 200B	Fundamentals of Molecular and Cell Biology	3
BIO ENG 290H	Course Not Available (Biomedical Device Development)	1-3
BIO ENG 290I	Course Not Available (Ethical and Social Issues in Translational Medicine)	1-3
PB HLTH 260A	Principles of Infectious Diseases	4
MBA 248A	Supply Chain Management	3

Advanced Materials/Microelectrics/Nanscience Concentration

CHM ENG 295P	Special Topics in Chemical Engineering: Introduction to New Product Development	3
CHM ENG 295Q	Special Topics in Chemical Engineering: Advanced Topics in New Product Development	3
MEC ENG 119	Introduction to MEMS (Microelectromechanical Systems)	3
EL ENG 143	Microfabrication Technology	4
MAT SCI 223	Semiconductor Materials	3
MAT SCI C225	Thin-Film Science and Technology	3
MAT SCI 251	Polymer Surfaces and Interfaces	3
MAT SCI C261	Introduction to Nano-Science and Engineering	3
CHEM 253A	Materials Chemistry I	1
CHEM 253B	Materials Chemistry II	1
MBA 264	High Technology Marketing Management	3

Chemical and Biomolecular Engineering

CHM ENG 230 Mathematical Methods in Chemical Engineering 3 Units
Mathematical formulation and solution of problems drawn from the fields of heat and mass transfer, fluid mechanics, thermodynamics, and reaction kinetics employing ordinary and partial differential equations, variational calculus, and Fourier methods.
Rules & Requirements

Prerequisites: MATH 53 and 54 or equivalent; open to seniors with consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 240 Thermodynamics for Chemical Product and Process Design 3 Units
Topics covered include molecular thermodynamics of pure substances and mixtures, interfacial thermodynamics, statistical mechanics, and computer simulations.
Rules & Requirements

Prerequisites: MATH 53 and 54 or equivalent; 141 or equivalent; open to seniors with consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 244 Kinetics and Reaction Engineering 3 Units
Molecular processes in chemical systems, kinetics and catalysis. Interaction of mass and heat transfer in chemical processes. Performance of systems with chemical reactors.
Rules & Requirements

Prerequisites: 142 or equivalent; open to seniors with consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 245 Catalysis 3 Units
Adsorption and kinetics of surface reactions; catalyst preparation and characterization; poisoning, selectivity, and empirical activity patterns in catalysis; surface chemistry, catalytic mechanisms and modern experimental techniques in catalytic research; descriptive examples of industrial catalytic systems.
Rules & Requirements

Prerequisites: 244 or Chemistry 223, or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 246 Principles of Electrochemical Engineering 3 Units
Electrode processes in electrolysis and in galvanic cells. Charge and mass transfer in ionic media. Criteria of scale-up.
Rules & Requirements

Prerequisites: Graduate standing or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 248 Applied Surface and Colloid Chemistry 3 Units
Principles of surface and colloid chemistry with current applications; surface thermodynamics, wetting, adsorption from solution, disperse systems, association colloids, interacting electrical double layers and colloid stability, kinetics of coagulation, and electrokinetics.
Rules & Requirements

Prerequisites: Graduate standing or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 250 Transport Processes 3 Units
Basic differential relations of mass, momentum, and energy including creeping, laminar, and turbulent flow, boundary layers, convective-diffusion in heat and mass transfer, and simultaneous multicomponent mass and energy transport. Analytic mathematical solution of the equations of change using classical techniques including: separation of variables, similarity solutions, and Laplace and Fourier transforms.
Rules & Requirements

Prerequisites: Chemical & Biomolecular Engineering 150A, 150B; Mathematics 53 and 54, or equivalent; open to seniors with consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 256 Advanced Transport Phenomena 3 Units
Formulation and rigorous analysis of the laws governing the transport of momentum, heat, and mass, with special emphasis on chemical engineering applications. Detailed investigation of laminar flows complemented by treatments of turbulent flow systems and hydrodynamic stability.
Rules & Requirements

Prerequisites: 230

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG C268 Physicochemical Hydrodynamics 3 Units
An introduction to the hydrodynamics of capillarity and wetting. Balance laws and short-range forces. Dimensionless numbers, scaling and lubrication approximation. Rayleigh instability. Marangoni effect. The moving contact line. Wetting and short-range forces. The dynamic contact angle. Dewetting. Coating flows. Effect of surfactants and electric fields. Wetting of rough or porous surfaces. Contact angles for evaporating systems.
Rules & Requirements

Prerequisites: A first graduate course in fluid mechanics sucs as 260A-260B

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

Instructor: Morris

Also listed as: MEC ENG C268

CHM ENG C270 Protein Engineering 3 Units
An in-depth study of the current methods used to design and engineer proteins. Emphasis on how strategies can be applied in the laboratory. Relevant case studies presented to illustrate method variations and applications. Intended for graduate students.
Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

Instructor: Tullman-Ercek

Also listed as: BIO ENG C219

CHM ENG 274 Biomolecular Engineering 3 Units
Fundamentals in biomolecular engineering. Structures, dynamics, and functions of biomolecules. Molecular tools in biotechnology. Metabolic and signaling networks in cellular engineering. Synthetic biology and biomedical engineering applications.
Rules & Requirements

Prerequisites: Graduate standing or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 295B Special Topics in Chemical Engineering: Electrochemical, Hydrodynamic, and Interfacial Phenomena 2 Units
Current and advanced study in chemical engineering, primarily for advanced graduate students.
Rules & Requirements

Prerequisites: Open to properly qualified graduate students

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 295K Design of Functional Interfaces 3 Units
This course introduces students to the concepts and techniques involved in the design and physical characterization of advanced functional materials consisting of well-defined interfaces. Throughout the course, principles of supramolecular chemistry on solid surfaces are applied to functional systems. Materials with different connectivity and structure at the active site are compared for development of understanding. Specific topics include catalysis, separations, encapsulation, and biomedicine.
Rules & Requirements

Prerequisites: Graduate standing

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

Instructor: Katz

CHM ENG 295N Polymer Physics 3 Units
This course, which is based on Gert Strobl's book addresses the origin of some of the important physical properties of polymer liquids and solids. This includes phase transitions, crystallization, morphology of multiphase polymer systems, mechanical properties, response to mechanical and electric fields, and fracture. When possible, we will develop quantitative molecular models that predict macroscopic behavior. The course will address experimental data obtained by microscopy, light and neutron scattering, rheology, and dielectric relaxation.
Rules & Requirements

Prerequisites: 230 and 240

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 295P Special Topics in Chemical Engineering: Introduction to New Product Development 3 Units
This course is part of the product development initative sponsored by the department of chemical engineering. It focuses on real-life practices and challenges of translating scientific discovery into commercial products. Its scope is limited in most circumstances to situations where some knowledge of chemical engineering, chemistry, and related disciplines might prove to be particularly useful. The course primarily uses case studies of real-world new product development situations to simulate the managerial and technical challenges that will confront students in the field. We will cover a wide range of topics including basic financial, strategic and intellectual property concepts for products, managing risk and uncertainity, the effective new product development team, the evolving role of corporate R&D, the new venture product company and the ethics of post-launch product management.
Rules & Requirements

Prerequisites: Graduate standing or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

Instructor: Alexander

CHM ENG 295Q Special Topics in Chemical Engineering: Advanced Topics in New Product Development 3 Units
This course is a part of the product development initiative sponsored by the department of chemical engineering. The course builds on the coverage in 295P of real-life practices of translating scientific discovery into commercial products. We will cover a wide range of advanced product development concepts including technology road maps, decision analysis, six sigma, product portfolio optimization, and best practices for field project management.
Rules & Requirements

Prerequisites: Graduate standing or consent of instructor. 295P recommended

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

Instructor: Alexander

CHM ENG C295A The Berkeley Lectures on Energy: Energy from Biomass 3 Units
After an introduction to the different aspects of our global energy consumption, the course will focus on the role of biomass. The course will illustrate how the global scale of energy guides the biomass research. Emphasis will be places on the integration of the biological aspects (crop selection, harvesting, storage, and distribution, and chemical composition of biomass) with the chemical aspects to convert biomass to energy. The course aims to engage students in state-of-art research.
Rules & Requirements

Prerequisites: BIOLOGY 1A; Chemistry 1B or 4B, Mathematics 1B

Repeat rules: Repeatable when topic changes with consent of instructor.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

Instructors: Bell, Blanch, Clark, Smit, C. Somerville

Also listed as: BIO ENG C281/CHEM C238/PLANTBI C224

CHM ENG C295R Applied Spectroscopy 3 Units
After a brief review of quantum mechanics and semi-classical theories for the interaction of radiation with matter, this course will survey the various spectroscopies associated with the electromagnetic spectrum, from gamma rays to radio waves. Special emphasis is placed on application to research problems in applied and engineering sciences. Graduate researchers interested in systematic in situ process characterization, analysis, or discovery are best served by this course.
Rules & Requirements

Prerequisites: Graduate standing in engineering, physics, chemistry, or chemical engineering; courses: quantum mechanics, linear vector space theory

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

Instructor: Reimer

Also listed as: AST C295R

CHM ENG C295Z Energy Solutions: Carbon Capture and Sequestration 3 Units
After a brief overview of the chemistry of carbon dioxide in the land, ocean, and atmosphere, the course will survey the capture and sequestration of CO2 from anthropogenic sources. Emphasis will be placed on the integration of materials synthesis and unit operation design, including the chemistry and engineering aspects of sequestration. The course primarily addresses scientific and engineering challenges and aims to engage students in state-of-the-art research in global energy challenges.
Rules & Requirements

Prerequisites: Chemistry 4B or 1B, Mathematics 1B, and PHYSICS 7B, or equivalents

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

Instructors: Bourg, DePaolo, Long, Reimer, Smit

Also listed as: CHEM C236/EPS C295Z

CHM ENG 296 Special Study for Graduate Students in Chemical Engineering 1 - 6 Units
Special laboratory and theoretical studies.
Rules & Requirements

Prerequisites: Consent of instructor

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: The grading option will be decided by the instructor when the class is offered.

CHM ENG 298 Seminar in Chemical Engineering 1 Unit
Lectures, reports, and discussions on current research in chemical engineering. Sections are operated independently and directed toward different topics.
Rules & Requirements

Prerequisites: Open to properly qualified graduate students with consent of instructor

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of seminar per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

CHM ENG 299 Research in Chemical Engineering 1 - 12 Units
Research.
Rules & Requirements

Prerequisites: Consent of instructor

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1-12 hours of independent study per week

Summer:
6 weeks - 2.5-30 hours of independent study per week
8 weeks - 1.5-22.5 hours of independent study per week
10 weeks - 1.5-18 hours of independent study per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate

Grading: Letter grade.

CHM ENG 300 Professional Preparation: Supervised Teaching of Chemical Engineering 2 Units
Discussion, problem review and development, guidance of large scale laboratory experiments, course development, supervised practice teaching.
Rules & Requirements

Prerequisites: Graduate standing, appointment as a Graduate Student Instructor, or consent of instructor

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/ Professional course for teachers or prospective teachers

Grading: Offered for satisfactory/unsatisfactory grade only.

CHM ENG 375 Professional Preparation: Supervised Teaching of Chemical Engineering 2 Units
Discussion, problem review and development, guidance of large scale laboratory experiments, course development, supervised practice teaching.
Rules & Requirements

Prerequisites: Graduate standing, appointment as a Graduate Student Instructor, or consent of instructor

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/ Professional course for teachers or prospective teachers

Grading: Offered for satisfactory/unsatisfactory grade only.

CHM ENG 602 Individual Studies for Graduate Students 1 - 8 Units
Individual study in consultation with the major field adviser for qualified students to prepare themselves for the various examinations required of candidates for the Ph.D.

Rules & Requirements

Prerequisites: Graduate standing in Ph.D. program

Credit Restrictions: Course does not satisfy unit or residence requirements for doctoral degree.

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Summer:
6 weeks - 1-5 hours of independent study per week
8 weeks - 1-4 hours of independent study per week

Additional Details

Subject/Course Level: Chemical & Biomolecular Engineering/Graduate examination preparation

Grading: Offered for satisfactory/unsatisfactory grade only.