CHEMICAL ENGINEERING

Emeriti: (Professors) Andreas Acrivos, Michel Boudart, George M. Homsy
Chair: Curtis W. Frank
Professors: Curtis W. Frank, Gerald G. Fuller, Chaitan Khosla, Robert J. Madix, Channing R. Robertson, Eric S. G. Shaqfeh, James R. Swartz
Associate Professor: Stacey F. Bent
Assistant Professors: Camilla M. Kao, Charles B. Musgrave
Courtesy Professors: Steven Chu, Daniel Herschlag, Franklin M. Orr, Jr., Robert M. Waymouth
Lecturers: Shari Libicki, Anthony Pavone, Howard Rosen
Consulting Professors: Charles R. Hutchinson, Kay Kanazawa, Wolfgang Knoll, Jaan Noolandi, Jürgen Rühe, Conrad Schadt, Robert Schwaar, Do Yeung Yoon
Visiting Professors: Alice P. Gast, Subhash Risbud

Department Office: Stauffer III, Room 113
Student Services Office: Keck, Room 189
Mail Code: 94305-5025
Department Phone: (650) 723-4906; *Student Services:* (650) 723-1302
Email: information@chemeng.stanford.edu; *Graduate Admissions:* apply@chemeng.stanford.edu
Web site: http://chemeng.stanford.edu

Courses given in Chemical Engineering have the subject code CHEMENG. For a complete list of subject codes, see Appendix B.

UNDERGRADUATE PROGRAM

BACHELOR OF SCIENCE

The Chemical Engineering depth sequence required for the B.S. degree provides training in applied chemical kinetics, biochemical engineering, electronic materials, engineering thermodynamics, plant design, polymers, process analysis and control, separation processes, and transport phenomena. The B.S. program in Chemical Engineering additionally requires basic courses in biology, chemistry, engineering, mathematics, and physics. Also see the "School of Engineering" section of this bulletin.

There are several B.S. plans for Chemical Engineering students to follow. Sample programs are available from the department's advisers, the Dean's Office in the School of Engineering, and in the *Handbook for Undergraduate Engineering Programs*, which is also found at http://ughb.stanford.edu/index-js.html. It is recommended that the student discuss the prospective program with his or her adviser, especially if transferring from biology, chemistry, physics, or another field in engineering. With some advanced planning, the student can usually arrange to attend one of the overseas campuses.

For information about a Chemical Engineering minor, see the "School of Engineering" section of this bulletin.

GRADUATE PROGRAMS

The University's requirements for the M.S., Engineer, and Ph.D. degrees are outlined in the "Graduate Degrees" section of this bulletin.

MASTER OF SCIENCE

An M.S. program comprising appropriate course work is available to accommodate students wishing to obtain further academic preparation, after receiving a B.S. degree, before pursuing a professional chemical engineering career. This degree is not a prerequisite for nor does it lead directly into the department's Ph.D. program. For conferral of an M.S. degree, a formal thesis is not required, but the following departmental requirements must be met.

Unit and Course Requirements—For students terminating their graduate work with the M.S. degree in Chemical Engineering, a graduate level, thematic program consisting of a minimum of 45 units of academic work is required, including (1) four or more Chemical Engineering lecture courses selected from the 200, 300, and 400 series; (2) 3 units of 699 Colloquia; (3) an additional 30 or more units, selected from graduate level science or engineering courses in any department and, by petition to the Chair of the Department of Chemical Engineering, from upper-division undergraduate courses in science and engineering; (4) credit toward the 45-unit minimum for degree for up to 6 units of research work (or for a combination of up to 6 units of 1, 2, or 3 units of 459 and 1-5 units of research work). Credit toward the M.S. degree is not given for Chemical Engineering Special Topics courses numbered 500 through 513 or similar courses in other departments.

To ensure that an appropriate Chemical Engineering graduate program is pursued by all M.S. candidates, students who first matriculate at Stanford at the graduate level must (a) submit an adviser approved "Program Proposal for a Master's Degree" form to departmental student services by the end of the first quarter for review by the department chair, and (b) obtain faculty approval for any subsequent program change or changes. Stanford undergraduates admitted to the coterminal master's program must (a) submit an adviser approved "Program Proposal for a Master's Degree" (a graduate degree progress form), either during their first quarter of graduate standing or upon the completion of 15 units of graduate work (whichever occurs first) and (b) document with student services their M.S. adviser's review and approval of their graduate program when they have accrued 30 units toward the degree in Chemical Engineering. All M.S. programs must be reviewed and given final approval by the Chemical Engineering faculty *no later than the quarter prior to degree conferral*, to permit amendment of the final quarter's study list if indicated. Students with questions should contact departmental student services.

Research Experience—Students in the M.S. program wishing to obtain research experience should work with the graduate adviser on the choice of research adviser in advance of the quarter(s) of research, and, upon approval, enroll in the appropriate section of 600. A written report describing the results of the research undertaken must be submitted to and approved by the research adviser. CHEMENG 600 may not be taken in lieu of any of the required four lecture courses.

Residency Requirement—See General Requirements in the "Graduate Degrees" section of this bulletin. As of 2001-02, a new University residency policy was implemented. Graduate students who first matriculated before 2001-02 may petition to change to the new university requirement.

Minimum Grade Requirement—Any course used to satisfy the 45-unit minimum for the M.S. degree must be taken for a letter grade, if offered. An overall grade point average (GPA) of 3.0 must be maintained for these courses.

ENGINEER

The degree of Engineer is awarded after completion of a minimum of 90 units of graduate work beyond the B.S. degree and satisfactory completion of all University requirements plus the following departmental requirements. (This degree is not required to enter the Ph.D. program.)

Unit and Course Requirements—A minimum of 90 total units (including research) and 45 units of course work is required for the Engineer degree, including (1) 300, 310A, 340, 345, 350, 355 and (2) 3 units of 699. The remaining courses, to total at least 45 units, may be chosen from the basic sciences and engineering according to the guidelines given in the Master of Science section and with the consent of the graduate adviser and chair. An aggregate of 6 units maximum of the required 45 units may include such courses as 459 and 699. Students seeking the Engineer degree may apply for the M.S. degree once the requirements for that degree have been fulfilled (see above Master of Science section).

Residency Requirement—See General Requirements in the "Graduate Degrees" section of this bulletin and the Master of Science section above.

Minimum Grade Requirement—Any course intended to satisfy the degree requirements must be taken for a letter grade, if offered. An overall grade point average (GPA) of 3.0 must be maintained for these courses.

Reading Committee Requirement—All candidates are required to have an initial meeting with their committees by the end of their seventh quarter. Following this initial meeting, additional committee meetings must occur no less than once a year until all the requirements for the degree are satisfied. Students are encouraged to hold meetings on a more frequent basis, to help focus and guide the thesis project. It is each student's responsibility to schedule meetings and to inform departmental student services of meeting dates.

Thesis Requirement—The thesis must represent a substantial piece of research equivalent to nine months of full-time effort and must be approved by a reading committee consisting of two members of the Chemical Engineering faculty.

Qualification for the Ph.D. Program by Students Ready to Receive the Degree of Engineer—After completing all the requirements for the Engineer degree, a student may request to be examined on the Engineer research work for the purpose of qualifying for the Ph.D. degree. If the request is granted, the student's thesis must have been approved by the reading committee and be available in its final form for inspection by the entire faculty at least two weeks prior to the scheduled date of the examination.

DOCTOR OF PHILOSOPHY

The Ph.D. degree is awarded after the completion of a minimum of 135 units of graduate work as well as satisfactory completion of any additional University requirements and the following departmental requirements. Completion of an M.S. degree is not a prerequisite for beginning or pursuing doctoral work.

Unit and Course Requirements—A minimum of 135 total units, including 45 units of course work is required for the Ph.D. degree. The following courses are required: 300, 310A, 340, 345, 350, and 355, plus two courses from one of the areas of concentration in the 440, 450, or 460 series. The remaining courses may be chosen from the basic sciences and engineering, according to the guidelines given in the Master of Science section and with the approval of the faculty advisers. An aggregate of 6 units maximum of the required minimum of 45 units of course work may include such courses as 459 and 699. Students admitted to Ph.D. candidacy should enroll each quarter in the 500 series, 600, and 699 as appropriate and as study list unit maximums permit. Students seeking the Ph.D. degree may apply for the M.S. degree once the requirements for that degree have been fulfilled (see Master of Science section). The conferral of the M.S. degree must be made within the University's time limit for completion of a master's degree.

Residency Requirement—See General Requirements in the Graduate Degrees section of this bulletin.

Minimum Grade Requirement—Any course intended to satisfy the degree requirements must be taken for a letter grade, if offered. An overall grade point average (GPA) of 3.0 must be maintained for these courses.

Qualifying Examination—To be advanced to candidacy for the Ph.D. degree, the student must pass both parts of the qualifying examination. The first part is held at the beginning of Spring Quarter, or the third quarter of study, and the first-year student is asked to make an oral presentation to the faculty of a critical review of a published paper. This preliminary examination assists the faculty in their deliberations as to whether or not a first-year student will be allowed to choose a research adviser and to begin doctoral research work immediately. Failure of this examination leads to termination of a student's study towards the Ph.D. degree. It also precludes any financial aid beyond that already pledged; however, the student may continue to work toward an M.S. degree (see Master of Science section above). Students who pass the preliminary examination take the second part of the qualifying examination at the beginning of their second year, or fifth quarter. This second examination before the faculty is an oral presentation and defense of their current research work. Students who successfully pass both examinations submit applications for candidacy for a doctoral degree and form reading committees.

Reading Committee Requirement—All Ph.D. candidates are required to assemble reading committees and to have an initial committee meeting by the end of their seventh quarter. Following this initial meeting, additional meetings must take place no less than once per year until all the requirements for the Ph.D. degree are satisfied. The department encourages students to hold reading committee meetings on a more frequent basis, to help focus and guide the dissertation project. It is the students responsibility to schedule committee meetings and to report the meeting dates to the department's student services administrator.

Teaching Requirement—Teaching experience is considered an essential component of doctoral training. All Ph.D. candidates, regardless of the source of their financial support, are required to assist in the teaching of chemical engineering courses for a minimum of two courses.

Dissertation and Oral Defense Requirements—A dissertation based on a successful investigation of a fundamental problem in chemical engineering is required. Within four to five calendar years after enrolling in the department, students are expected to have fulfilled all the requirements for this degree, including the completion of dissertations approved by their research adviser. Upon adviser approval, copies must be distributed to each Reading Committee member. No sooner than four weeks after this distribution, students may schedule University oral examinations. The examination, based on the candidate's dissertation research, is in the form of a public seminar followed by a private examination by faculty committee. Satisfactory performance in the oral examination, and acceptance of an approved dissertation by the University Registrar's Office of Graduate Degree Progress, leads to Ph.D. degree conferral.

RESEARCH ACTIVITIES

Research investigations are currently being carried out in the following fields: applied statistical mechanics, biocatalysis, bioengineering, colloid science, computational materials science, electronic materials, hydrodynamic stability, kinetics and catalysis, Newtonian and non-Newtonian fluid mechanics, polymer science, rheo-optics of polymeric systems, and surface and interface science. Additional information may be found on the Department of Chemical Engineering's web site at http://chemeng.stanford.edu.

FELLOWSHIPS AND ASSISTANTSHIPS

Fellowships are awarded each year, primarily to Ph.D. students. Fellowships for incoming students are awarded in the spring prior to enrollment at the beginning of the following academic year. Current students are encouraged to apply for external, competitive fellowships and may obtain information about various awarding agencies from faculty advisers and student services. Assistantships are awarded by the faculty for research work performed by graduate students.

FURTHER INFORMATION

Additional information about the department can be found on our web site at http://chemeng.stanford.edu. Current Stanford students interested in graduate work in Chemical Engineering are encouraged to contact the department and must use internal application forms. Other students can find information about graduate admissions at http://chemeng.stanford.edu/html/admissions.html. Potential applicants also can obtain information by emailing apply@chemeng.stanford.edu or by contacting the department's student services administrator.

COURSES

(WIM) indicates that the course satisfies the Writing in the Major requirements.

(AU) indicates that the course is subject to the University Activity Unit limitations for undergraduates (8 units maximum).

PRIMARILY FOR UNDERGRADUATES

CHEMENG 10. The Chemical Engineering Profession—Faculty and alumni of the Chemical Engineering Department present and discuss a variety of career paths available to chemical engineering graduates in an informal seminar setting. Examples of topics: preparing for graduate school (M.S. and Ph.D.) in chemical engineering; opportunities in areas related to the environment; opportunities in areas related to soft and hard materials; opportunities in areas related to biotechnology; preparing for graduate work in other professional schools (law, business, medicine, other engineering); non-traditional opportunities.

1 unit, Aut (Robertson)

CHEMENG 20. Introduction to Chemical Engineering—(Enroll in ENGR 20.)

3 units, Spr (Robertson)

CHEMENG 25. Biotechnology—(Enroll in ENGR 25.)

3 units, Aut (Khosla, Kao)

CHEMENG 50Q. Drug Delivery in the 21st Century—Stanford Introductory Seminar. Preference to sophomores. Highly engineered, controlled delivery systems for medication are currently available for motion sickness, heart pain, and high blood pressure; the future promises further advances developed by joining chemistry, biology, medicine, materials science, and engineering. Guest scientists and engineers describe products on the market and in the pipeline. One sophisticated drug delivery system, the cigarette, is studied, as the basis for a therapeutic delivery system. Field trips. Recommended: prior exposure to chemistry, physics, biology, mathematics, physiology.

3 units, Aut (Robertson, Rosen)

CHEMENG 60Q. Environmental Regulation and Policy—Stanford Introductory Seminar. Preference to sophomores. How environmental policy is formulated in the U.S. How and what type of scientific research is incorporated into decisions. How to determine acceptable risk, the public's right to know of chemical hazards, waste disposal and clean manufacturing, brownfield redevelopment, and new source review regulations. The proper use of science and engineering including media presentation and misrepresentation, public scientific and technical literacy, and emotional reactions. Alternative models to formulation of environmental policy. Each week focuses on the framing of an environmental issue, the application of science and engineering to it, political and economic forces, and stakeholder discussions.

3 units, Spr (Robertson, Libicki)

CHEMENG 100. Chemical Process Modeling, Dynamics, and Control—Mathematical methods are applied to engineering problems, using chemical engineering examples. The development of mathematical models to describe chemical process dynamic behavior. Analytical and computer simulation techniques for the solution of ordinary differential equations. Dynamic behavior of linear first- and second-order systems. Introduction to process control. Dynamics and stability of controlled systems. Prerequisites: MATH 53 or 130, or ENGR 155A, or equivalent; ENGR 20.

3 units, Aut (Fuller)

CHEMENG 110. Equilibrium Thermodynamics—Thermodynamic properties, equations of state, properties of non-ideal systems including mixtures, and phase and chemical equilibria. Prerequisite: CHEM 171.

3 units, Win (Madix)

CHEMENG 120A. Fluid Mechanics—The flow of isothermal fluids from a momentum transport viewpoint. Continuum hypothesis, scalar and vector fields, fluid statics, non-Newtonian fluids, shell momentum balances, equations of motion and the Navier-Stokes equations, creeping and potential flow, parallel and nearly parallel flows, time-dependent parallel flows, boundary layer theory and separation, turbulence and drag correlations. Prerequisites: junior standing in Chemical Engineering or consent of instructor; 100 and MATH 53 or 130 or ENGR 155A, or equivalent.

4 units, Win (Robertson)

CHEMENG 120B. Energy and Mass Transport—Introduction to general diffusive transport, heat transport by conduction, Fourier's law, advection-diffusion equations, forced convection, boundary layer heat transport via forced convection in laminar flow, forced convection correlations, free convection, free convection boundary layers, free convection correlations and application to geophysical flows, melting and heat transfer at interfaces, radiation, diffusive transport of mass for dilute and non-dilute transfer, mass and heat transport analogies, mass transport with bulk chemical reaction, mass transport with interfacial chemical reaction, evaporation. Prerequisite 120A or consent of instructor.

4 units, Spr (Shaqfeh)

CHEMENG 130. Separation Processes—Analysis and design of equilibrium and non-equilibrium separation processes. Possible examples: distillation, liquid-liquid extraction, flash distillation, electrophoresis, centrifugation, membrane separations, chromatography, and reaction-assisted separation processes.

3 units, Spr (Musgrave)

CHEMENG 140. Microelectronics Processing Technology—(Same as 240.) The chemistry and transport of microelectronics device fabrication. Introduction to solid state materials and electronic devices. Chemical processes including crystal growth, chemical vapor deposition, etching, oxidation, doping, diffusion, metallization, and plasma processing with emphasis on chemical, kinetic, and transport considerations.

3 units (Staff) not given 2002-03

CHEMENG 150. Biochemical Engineering—(Same as 250.) The general principles used in the biological production of fine biochemicals, with emphasis on biopharmaceuticals as a fundamental paradigm. Basic and applied principles in enzyme kinetics, microbial physiology, recombinant DNA technology, metabolic engineering, fermentation process development and scale up, product isolation, protein purification, protein folding, and regulatory issues. Prerequisites: BIOSCI 41 or equivalent. Recommended: concurrent enrollment in 150A/250A.

3 units, Aut (Swartz)

CHEMENG 150A. BioProcess Design Laboratory—(Same as 250A.) Small groups design, evaluate, and optimize processes for the manufacture of products such as commodity biochemicals, industrial enzymes, and pharmaceutical proteins. Product cost and quality targets to satisfy market needs. Uses and reinforces concepts introduced in CHEMENG 150/250. Corequisite: 150/250 or with consent of instructor. Prerequisites: BIOSCI 41 or equivalent.

1 unit, Aut (Swartz)

CHEMENG 160. Polymer Science and Engineering—(Same as 260.) Introduction to polymer science, including morphology of amorphous and semicrystalline polymers, linear viscoelasticity, and rheology. Applications of polymers in biomedical devices, drug delivery, and microelectronics.

3 units, Win (Frank)

CHEMENG 170. Kinetics and Reactor Design—Chemical kinetics, elementary steps, mechanisms, rate-limiting steps, and quasi-steady state approximations. Ideal isothermal and non-isothermal reactors; design principles. Multiplicity, ignition, and extinction in stirred tank reactors; limitations of thermodynamic equilibrium. Catalysis and catalytic reaction mechanisms. Chemical reactor models of animal digestion. Prerequisites: 110, 120A, 120B; CHEM 171, 173.

3 units, Aut (Bent)

CHEMENG 180. Chemical Engineering Plant Design—Open to seniors in chemical engineering or by consent of instructor. Application of chemical engineering principles to the design of practical plants for the manufacture of chemicals and related materials. Topics: flow-sheet development from a conceptual design, equipment design for distillation, chemical reactions, heat transfer, pumping, and compression; estimation of capital expenditures and production costs; plant construction.

3 units, Spr (Pavone)

CHEMENG 185A,B. Chemical Engineering Laboratory—Investigation of the experimental aspects of chemical engineering science, emphasizing development of communications skills. Experiments illustrating lecture subjects are conducted by groups of students. Lab. (WIM)

3 units, **A:** *Aut (Frank),* **B:** *Win (Kao)*

CHEMENG 190. Undergraduate Research in Chemical Engineering—Lab or theoretical work for undergraduate students under the direct supervision of a faculty member. Research in one of the graduate research groups or other special projects in the undergraduate chemical engineering lab. Students should consult advisers for information on available projects.

1-6 units, Aut, Win, Spr (Staff)

PRIMARILY FOR GRADUATE STUDENTS

CHEMENG 240. Microelectronics Processing Technology—(Same as 140; see 140.)
3 units (Staff) not given 2002-03

CHEMENG 250. Biochemical Engineering—(Same as 150; see 150.)
3 units, Aut (Swartz)

CHEMENG 250A. BioProcess Design Laboratory—(Same as 150A; see 150A.)
1 unit, Aut (Swartz)

CHEMENG 260. Polymer Science and Engineering—(Same as 160; see 160.)
3 units, Win (Frank)

CHEMENG 300. Applied Mathematics in Chemical Engineering—Mathematical problems in transport phenomena, fluid mechanics, reactor design, quantum chemistry, and polymer science. Applications of tensor calculus, ordinary differential equations, linear eigenvalue problems, perturbation theory (regular and singular), topics in partial differential equations, Fourier transforms. Prerequisites: MATH 53, 113, 130; or ENGR 155A, MATH 131 or ENGR 155B, or equivalent.
3 units, Win (Fuller)

CHEMENG 310A. Microscale Transport in Chemical Engineering—Introduction to transport on small scales where macroscopic or bulk convective processes are unimportant. The basic equations of mass, momentum, and energy are derived for incompressible fluids. Local analysis based on the flow kinematics. Simplifications of these equations in the Stokes or creeping flow regime; solution techniques for these reduced sets of equations. Topics: Green's function on boundary integral solution methods, point particle solutions, rigid particulate motion in suspension, drop and bubble flows including thermocapillary motion, lubrication theory, and the effective properties of composite media and suspensions; slender body theory and Brownian motion. Prerequisites: 120A, 120B, 300, or equivalents. 300 may be taken concurrently in 2002-03.
3 units, Win (Fuller)

CHEMENG 310B. Convective Transport and Reaction Engineering—Continuation of 310A. Macroscale or convective transport of mass, momentum, and energy including chemical reaction from a fundamental perspective. Topics: inviscid flow theory and its coupling to mass, momentum, and energy boundary layers including free jets and wakes; boundary layers adjoining regions of constant circulation (e.g., drop flows) including Prandtl-Batchelor layers; convective mass transport with and without reaction, including Taylor-dispersion and generalized Graetz problems; the fundamentals for mass, momentum, and energy transport correlations. The concepts are applied to basic reaction engineering. Prerequisite: 310A or consent of the instructor.
3 units (Staff) not given 2002-03

CHEMENG 340. Molecular Thermodynamics—Review of classical thermodynamics. Introduction to statistical thermodynamics; ensembles and partition functions. Application to phase equilibrium of solids and liquids, phase diagrams, and molecular dynamics simulation. Intermolecular forces and introduction to distribution functions, liquid state theory, integral equations, and perturbation theory. CHEM 275 may be substituted.
3 units (Staff) not given 2002-03

CHEMENG 345. Applied Spectroscopy—Development of theoretical approaches to spectroscopy, including spectroscopic transitions, transition probabilities, and selection rules. Application to photon and electron spectroscopies of the gas and solid phases. Topics: rotational spectroscopy; infrared and Raman vibrational spectroscopies; fluorescence spectroscopy; Auger, x-ray and ultraviolet photoelectron spectroscopies. Prerequisite: CHEM 271 or quantum mechanics.
3 units, Win (Bent)

CHEMENG 350. Principles of Cellular Systems—Biochemistry and cell biology for engineering students with no previous training in biology. Chemical Engineering Ph.D. students with previous training in biology may substitute other graduate-level biology courses with consent of instructor. Recommended: undergraduate physical and organic chemistry.
3 units, Aut (Kao)

CHEMENG 355. Advanced Biochemical Engineering—The technological tools for exploiting the power offered by modern biology. Review of relevant biochemistry. How a cell interacts with and influences its environment, how a production organism is optimized, what technology is used for large scale production, how products are isolated and purified, how proteins can be made without living cells, how a biopharmaceutical is formulated and delivered, and what the regulatory requirements are for drug approval and sale. Prerequisite: 350 or equivalent.
3 units, Spr (Swartz)

CHEMENG 442. Structure and Reactivity of Solid Surfaces—The structure of solid surfaces, including a description of experimental methods for determining the structures of single crystal surfaces. The adsorption of molecules on these surfaces, including the thermodynamics of adsorption processes, surface diffusion, and the molecular structure of the adsorbates. Surface mediated reactions, that is heterogeneous catalysis, including descriptions of catalytic mechanisms and surface kinetics.
3 units, Win (Madix) alternate years, not given 2003-04

CHEMENG 444A. Quantum Simulations of Molecules and Materials—Molecules and surfaces: quantum atomistic simulations of molecules and surfaces to predict atomic structure, properties, reaction mechanisms, and kinetics. Review of quantum mechanics. Electronic structure calculations: Hartree Fock, configuration interaction, many body perturbation theory, and density functional theory. Property calculations: energy, forces, structure, and electronic and vibrational spectra. Applications to semiconductor processing, surface science, biochemistry, catalysis, polymers, environmental chemistry, and combustion. Prerequisite: undergraduate level quantum mechanics.
3 units, Win (Musgrave)

CHEMENG 444B. Quantum Simulations: Materials Micro Mechanics—(Enroll in ME 444B.)
3 units, Spr (Cho)

CHEMENG 450. Introduction to Biotechnology—(Same as BIOC 450.) Stanford faculty from the schools of Medicine, Humanities and Sciences, Engineering and invited industrial speakers review the interrelated elements of modern biotechnology. Topics: development of recombinant protein pharmaceuticals, bacterial fermentation and scale-up, mammalian cell culture and scale-up, transgenic animals, transgenic protein production in plants, isolation and purification of protein pharmaceuticals, formulation and delivery of pharmaceutical proteins, environmental biotechnology, metabolic engineering, industrial enzymes, diagnostic devices, transciptomics and proteomics, drug delivery systems. Prerequisite: graduate student or upper-division undergraduate in the sciences or engineering.
3 units, Spr (Robertson, Swartz)

CHEMENG 452. Protein Science and Engineering—(Same as CHEM 232.) The physio-chemical interactions that govern the structure and function of proteins. Topics: protein function and structure, techniques for probing protein structure and function, mechanisms of protein function, design of proteins with novel properties. Examples from literature on enzymes. Recommended: background in physical and organic chemistry.
3 units, Win (Khosla)

CHEMENG 454. Metabolic Engineering Methods and Applications—The analysis and optimization of industrial organisms. Applications illustrate the basic principles of metabolic pathway regulation, metabolic flux analysis, and traditional and new methods for genetic engineering. Examples: production of amino acids, protein synthesis and post-translational modification, and the production of isoprenoids, peptides, and polyketides. Prerequisites: 250, 355 or equivalent.

3 units, Spr (J. Swartz)

CHEMENG 459. Frontiers in Interdisciplinary Biosciences—(Cross-listed in multiple departments in the schools of Humanities and Sciences, Engineering, and Medicine.) An introduction to cutting-edge research involving interdisciplinary approaches to bioscience and biotechnology; for specialists and non-specialists. Organized and sponsored by the Stanford BioX Program. Three seminars each quarter address a broad set of scientific and technical themes related to interdisciplinary approaches to important issues in bioengineering, medicine, and the chemical, physical, and biological sciences. Leading investigators from Stanford and throughout the world present the latest breakthroughs and endeavors that cut broadly across many core disciplines. Pre-seminars introduce basic concepts and provide background for non-experts. Registered students attend all pre-seminars in advance of the primary seminars, others welcome. Prerequisite: keen interest in all of science, engineering, and medicine with particular interest in life itself. Recommended: basic knowledge of mathematics, biology, chemistry, and physics.

1 unit, Aut, Win, Spr (Robertson)

CHEMENG 460. Polymer Surfaces and Interfaces—The principles of polymer physics in the context of developing an understanding of polymer surfaces and interfaces, critical to technological applications in lubrication, adhesion, polymer phase behavior, and biocompatibility. Treatments of intermolecular forces; conformational statistics of macromolecular structure; models for polymer dynamics; tethering of polymers at a variety of different interfaces; techniques for chemical modification of surfaces; methods for physical characterization of polymer surfaces and interfaces.

3 units, Spr (Frank) alternate years, not given 2003-04

CHEMENG 462. Dynamics of Complex Liquids—The connection between the microstructural dynamics of complex liquids and their rheology, i.e., stress-strain rate relationship, developed sequentially from non-Brownian suspensions, to colloidal suspensions, to polymer solutions and melts. The fundamental concepts of rheology, the origins of stress in complex liquids, how Brownian motion can create stress, and how rheometric measurements can elucidate stress producing mechanisms in complex fluids. A spectrum of microstructural and molecular models are examined including those for dilute and concentrated polymer solutions and melts, and, if time permits, liquid crystals and surfactants. Prerequisites: 300, 310A.

3 units, Spr (Shaqfeh) alternate years, given 2003-04

CHEMENG 500-512. Special Topics in Chemical Engineering—Discussion of recent developments and current research in specialized fields. Prerequisites: graduate standing and consent of instructor.

CHEMENG 500. Special Topics in Protein Biotechnology

1 unit, Aut, Win, Spr, Sum (Swartz)

CHEMENG 501. Special Topics in Semiconductor Processing

1 unit, Aut, Win, Spr, Sum (Bent)

CHEMENG 502. Special Topics in Computational Materials Science

1 unit, Aut, Win, Spr, Sum (Musgrave)

CHEMENG 503. Special Topics in Biocatalysis

1 unit, Aut, Win, Spr, Sum (Khosla)

CHEMENG 504. Special Topics in Bioengineering

1 unit, Aut, Win, Spr, Sum (Robertson)

CHEMENG 505. Special Topics in Microrheology

1 unit, Aut, Win, Spr, Sum (Fuller)

CHEMENG 506. Special Topics in Surface and Interface Science

1 unit, Aut, Win, Spr, Sum (Madix)

CHEMENG 507. Special Topics in Polymer Physics and Molecular Assemblies

1 unit, Aut, Win, Spr, Sum (Frank)

CHEMENG 509. Special Topics in Statistical Mechanics of Dispersed Systems

1 unit, Aut, Win, Spr, Sum (Gast)

CHEMENG 510. Special Topics in Transport Mechanics

1 unit, Aut, Win, Spr, Sum (Shaqfeh)

CHEMENG 512. Special Topics in Functional Genomics

1 unit, Aut, Win, Spr, Sum (Kao)

CHEMENG 600. Graduate Research in Chemical Engineering—Laboratory and theoretical work for graduate students on chemical engineering problems leading to partial fulfillment of requirements for an advanced degree.

1-12 units (Staff)

CHEMENG 699. Colloquium—Weekly lectures by experts from academia and industry in the field of chemical engineering. (AU)

1 unit, Aut, Win, Spr (Staff)