CHEMICAL ENGINEERING

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

Chemical Engineering is a discipline that relates to numerous areas of technology. In broad terms, chemical engineers are responsible for the conception and design of processes involved in the production, transformation, and transport of materials. This activity begins with experimentation in the laboratory and is followed by implementation of the technology into full-scale production. The mission of the Department of Chemical Engineering at Stanford is to provide professional training, development, and education for the next generation of leaders in the chemical sciences and engineering. A large number of industries depend on the synthesis and processing of chemicals and materials. In addition to traditional examples such as the chemical and energy industries, there are increasing opportunities in biotechnology, pharmaceuticals, electronic device fabrication and materials, and environmental engineering. Chemical engineering is essential in these and other fields whenever processes involve the chemical or physical transformation of matter.

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. Sample programs are available from the department's student services and faculty advisers for undergraduates, the Office of Student Affairs in the School of Engineering, and in the *Handbook for Undergraduate Engineering Programs,* available at http://ughb.stanford.edu/. It is recommended that the student discuss a prospective program with a chemical engineering 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 the requirements for a Chemical Engineering minor, see the "School of Engineering" section of this bulletin.

HONORS PROGRAM

The Department of Chemical Engineering offers a program leading to a Bachelor of Science in Chemical Engineering with honors. Qualified undergraduate majors conduct independent study and research at an advanced level with a faculty mentor, graduate students, and fellow undergraduates. This three quarter sequential program involves research study in an area proposed to and agreed to by a Department of Chemical Engineering faculty adviser, completion of a faculty-approved thesis, and participation in the Chemical Engineering Honors Symposium held annually during Spring Quarter. The last requirement may also be fulfilled through an alternative, public, oral presentation with the approval of the department chair.

Admission to the honors program is by application. Declared Chemical Engineering students with a grade point average (GPA) of 3.5 or higher in Chemical Engineering courses are eligible to submit an application. Applications must be submitted no later than the second week of Autumn Quarter of the senior year, include an honors proposal, and be sponsored by both a thesis adviser and a second reader. The adviser, or alternatively the sponsor, must be a member of the Chemical Engineering faculty. Students should take advantage of university programs that support undergraduate research such as those sponsored by Undergraduate Research Programs; see http://urp.stanford.edu/StudentGrants/introstudentgrants.html. Students should start their honors research in their junior year and incorporate Summer Quarter research opportunities into their three quarter honors research proposal. Subject to faculty approval, it is recommended that students include a writing course in the second quarter of their honors project.

In order to receive departmental honors, students admitted to the honors program must:

1. Maintain an overall grade point average (GPA) of at least 3.5 as calculated on the unofficial transcript.
2. Complete at least three quarters of research with a minimum total of 9 units of CHEMENG 190H for a letter grade. All quarters must focus on the same topic. The same faculty adviser and faculty reader should be maintained throughout if feasible.
3. Participate in the Chemical Engineering Honors Symposium held during Spring Quarter with a poster and oral presentation of thesis work or, at the faculty's discretion, in a comparable public event.
4. Submit a completed draft of thesis simultaneously to the adviser and reader, and if appropriate to the Chemical Engineering faculty sponsor, no later than May 1, or the first day of the second month of the quarter in which the degree is to be conferred.
5. Complete all work and thesis revisions and obtain indicated faculty approvals on the Certificate of Final Reading of Thesis form by the end of the third week of May, or the second month of the graduation quarter.
6. Submit to Chemical Engineering student services two final copies of the honors thesis as approved by the appropriate faculty and with a certificate form for each copy. The deadline is May 22, 2006, or the Monday at the beginning of the fourth week of the second month of the graduation quarter.

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 Chemical Engineering lecture courses selected from the 300 series; (2) 3 units of 699 Colloquia; (3) an additional 30 units, selected from graduate-level science or engineering lecture courses in any department and, by petition to the Chair of the Department of Chemical Engineering, from upper-division undergraduate lecture courses in science and engineering. Alternatively, for terminal M.S. degree students, up to 6 units of research may be used in lieu of up to 6 units of the additional 30 lecture units to partially satisfy the 45-unit minimum requirement. Another option for fulfilling the M.S. degree unit requirement is an up-to-six-units combination of research units and no more than 3 units of 459 or other 1- or 2-unit seminar courses in other departments, used in lieu of up to 6 units of the required additional 30 lecture units. Credit toward the M.S. degree is not given for Chemical Engineering special topics courses numbered in the 500 series nor for 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 during the first quarter, no later than the ninth week, an adviser-approved Program Proposal for a Master's Degree form to departmental student services for review by the department chair, and (b) obtain approval from the M.S. adviser and the department chair 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 M.S. adviser and the department chair no later than the quarter before the quarter of M.S. degree conferral, in order to permit amendment of the final quarter's study list if the faculty deem this necessary. Students with questions should contact student services.

For University coterminal degree program rules and University application forms, see http://registrar.stanford.edu/publications/#Coterm.

Research Experience—Students in the M.S. program wishing to obtain research experience should work with the M.S. adviser on the choice of research adviser in advance of the quarter(s) of research, and, upon approval, then enroll in the appropriate section of CHEMENG 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 300-level lecture courses.

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

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) within which 45 units of lecture course work is required for the Engineer degree, including (1) 300, 310A, 345, 355 and (2) 3 units of 699. The remaining lecture 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-unit minimum of course work 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 General Requirements in the "Graduate Degrees" section of this bulletin and Chemical Engineering's "Master of Science" section above).

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 reading committees consisting of two members of the Chemical Engineering faculty, 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 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 the reading committee.

Qualification for the Ph.D. Program by Students Ready to Receive the Degree of Engineer—After completing 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, pursuing, or completing doctoral work.

Unit and Course Requirements—A minimum of 135 total units, including a minimum of 45 units of lecture course work, is required for the Ph.D. degree. The following course work is required: 300, 310A, 340, 345, and 355, plus two courses the 440, 450, or 460 series. These must be taken at Stanford, and any petition to substitute another graduate-level Stanford course for any of these core courses must be approved by the chair. The remaining lecture courses may be chosen from graduate-level science and engineering lecture courses in any department and, by petition to the chair, from upper-division undergraduate lecture courses in the sciences and engineering. 3 units of 699 may be included in the required 45 units of lecture courses. Alternatively, 1, 2, or 3 units of seminar courses such as 459 may be substituted for up to 3 units of the lecture course work requirement, but not for any of the specified CHEMENG courses above. All proposals for Ph.D. course work must be approved by the student's adviser and the department chair. Students admitted to Ph.D. candidacy should enroll each quarter in the 500 series, 600, and 699 as appropriate and as study list unit limits permit. Predoctoral students have the option of petitioning for a M.S. degree program to be added to their graduate record. When the petition is approved, students may apply for M.S. degree conferral once the requirements for that degree have been fulfilled (see the "Master of Science" section above). The M.S. degree must be awarded 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, in addition to performance in courses and during research rotations, is the basis for determining whether or not a first-year student may be allowed to choose a research adviser and to begin doctoral research work immediately. Failure in this first part of the qualifying 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 pass both examinations must promptly submit Application for Candidacy for Doctoral Degree forms approved by their research advisers and at the same time establish and meet with their doctoral dissertation 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. Reading committee meetings are not examinations; they are intended to be discussion sessions, to help focus and guide the dissertation project. Following the initial committee 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 take advantage of the benefits of more frequent meetings with their entire reading committee as a group. It is the student's responsibility to schedule committee meetings and to report the meeting dates to the student services manager.

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 a minimum of two chemical engineering courses.

Dissertation and Oral Defense Requirements—A dissertation based on a successful investigation of a fundamental problem in chemical engineering is required. Within approximately 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 advisers. Upon adviser approval, copies must be distributed to each reading committee member. No sooner than three weeks after this distribution, students may schedule University oral examinations. The examination is a dissertation defense, based on the candidate's dissertation research, and is in the form of a public seminar followed by a private examination by the faculty on the student's oral examination committee. Satisfactory performance in the oral examination and acceptance of an approved dissertation by Graduate Degree Progress, Office of the University Registrar, leads to Ph.D. degree conferral.

PH.D. MINOR

A Ph.D. minor is a program outside a student's Ph.D. department. The University's general requirements for the Ph.D. minor are specified in the "Graduate Degrees" section of this bulletin. An application for a Ph.D. minor must be approved by both the major and minor departments.

A student desiring a Ph.D. minor in Chemical Engineering must have a minor program adviser who is a regular Chemical Engineering faculty member. At a minimum, this adviser must be a member of the student's reading committee for the doctoral dissertation, and the entire reading committee must meet at least once and at least one year prior to the scheduling of the student's oral examination. The department strongly prefers that regular reading committee meetings start in the second year of graduate study. In addition, the minor adviser must be a member of the student's University oral examination committee.

The Ph.D. minor program must include at least 20 units of graduate-level course work (that is, courses numbered at the 200 level or above), but may not include in the 20-unit minimum any 1-2 unit courses in Chemical Engineering, with the exception of 250A if it is taken in conjunction with 250. The list of courses must form a coherent program and must be approved by the minor program adviser and the chair of the department. All courses for the minor must be taken for a letter grade, and a GPA of at least 3.0 earned for these courses.

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 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 matriculation 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 paid positions for graduate students that, in addition to a salary, provide the benefit of a tuition allocation. Individual faculty appoint students to research assistantships; the department chair appoints doctoral students to teaching assistantships. Contact student services for further information.

FURTHER INFORMATION

More information about the department can be found on our web site at http://chemeng.stanford.edu. Any students interested in graduate admissions should click on the admissions link. Current Stanford students interested in graduate work in Chemical Engineering are encouraged to contact the department and must follow an internal application process. All other students should go to http://gradadmissions.stanford.edu/ for additional guidelines regarding application requirements and processes. Potential applicants also can obtain the essentials by first emailing inquire@chemeng.stanford.edu and then contacting the department's student services office in Keck, room 189, or sending email to cosby@stanford.edu.

GRADUATE COURSES IN BIOLOGICAL INTERDISCIPLINARY SCIENCES AND ENGINEERING

The Chemical Engineering Department offers a number opportunities for students to pursue course work in interdisciplinary biosciences which include the chemical, physical, mathematical, and engineering sciences. These include CHEMENG 250, 250A, 288, 289, 350, 355, 450, 452, and 454. In addition, students seeking a broad introduction to current topics in the interdisciplinary biosciences and engineering should consider CHEMENG 459, Frontiers in Interdisciplinary Biosciences, which covers emerging technologies and other subject matter at the intersection of engineering and biology ranging from molecular to complex systems. Students are encouraged to review course offerings in all departments of the School of Engineering.

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—Open to all undergraduates; most useful for juniors and seniors in the major. Seminar. Faculty and alumni of the Chemical Engineering department present career paths and post-graduation opportunities available to Chemical Engineering graduates. Possible topics: preparing for graduate school (M.S. and Ph.D., and in law, business, medicine, other engineering fields); opportunities in areas related to the environment, soft and hard materials, and biotechnology; and non-traditional opportunities.

1 unit, Aut (Frank)

CHEMENG 20. Introduction to Chemical Engineering—(Enroll in ENGR 20.)
3 units, Spr (Robertson)

CHEMENG 25. Biotechnology—(Enroll in ENGR 25.)
3 units, Spr (Kao)

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. Political and economic forces, and stakeholder discussions. GER:DB-EngrAppSci
3 units, Aut (Robertson, Libicki)

CHEMENG 70Q. Masters of Disaster—Stanford Introductory Seminar. Preference to sophomores. For students interested in science, engineering, politics, and the law. Learn from past disasters to avoid future ones. How disasters can be tracked to failures in the design process. The roles of engineers, artisans, politicans, lawyers, and scientists in the design of products. Failure as rooted in oversight in adhering to the design process. Student teams analyze real disasters and design new products presumably free from the potential for disastrous outcomes. GER:DB-EngrAppSci
3 units, Aut (Robertson, Moalli)

CHEMENG 100. Chemical Process Modeling, Dynamics, and Control—Mathematical methods 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: ENGR 20; CME 102, or MATH 53 or 130, or equivalent.
3 units, Aut (Kao)

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 (Bao)

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, introduction to drag correlations. Prerequisites: junior in Chemical Engineering or consent of instructor; 100 and CME 102 (formerly ENGR 155A), or equivalent.
4 units, Aut (Fuller)

CHEMENG 120B. Energy and Mass Transport—General diffusive transport, heat transport by conduction, Fourier's law, conduction in composites with analogies to electrical circuits, 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, Win (Fuller)

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. Recommended: CHEM 33, 171, and PHYSICS 55.
3 units, Spr (Bao)

CHEMENG 150. Biochemical Engineering—(Same as 250.) Principles used in the biological production of fine biochemicals emphasizing protein pharmaceuticals as a fundamental paradigm. Basic and applied principles in applied biochemistry, enzyme kinetics, cellular physiology, recombinant DNA technology, metabolic engineering, fermentation development and scale up, product isolation and purification, protein folding and formulation, and biobusiness and regulatory issues. Prerequisite: BIOSCI 41 or equivalent.
3 units, Aut (Swartz)

CHEMENG 150A. BioProcess Design Laboratory—(Same as 250A.) Small groups use a commercial software package to design, evaluate, and optimize processes for the manufacture of products such as commodity biochemicals, industrial enzymes, and pharmaceutical proteins. Product cost and quality targets developed to satisfy market needs. Uses and reinforces concepts introduced in 150/250. Prerequisite: BIOSCI 41 or equivalent. Corequisite: 150/250 or consent of instructor.
1 unit (Swartz) not given 2005-06

CHEMENG 160. Polymer Science and Engineering—(Same as 260.) Introduction to polymer science, including morphology of amorphous and semicrystalline polymers, linear viscoelasticity, and rheology. Selected applications of polymers in biomedical devices and microelectronics. Recommended: CHEM 33, 171, or equivalent.
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. Prerequisites: 110, 120A, 120B.
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 185. Chemical Engineering Laboratory—Experimental aspects of chemical engineering science emphasizing development of communication skills. Experiments illustrating lecture subjects conducted by student groups. WIM
4 units, Aut (Frank)

CHEMENG 188. Biochemistry I—(Same as 288, BIOSCI 188/288, CHEM 188.) Chemistry of major families of biomolecules including proteins, nucleic acids, carbohydrates, lipids, and cofactors. Structural and mechanistic analysis of properties of proteins including molecular recognition, catalysis, signal transduction, membrane transport, and harvesting of energy from light. Molecular evolution. Pre- or corequisites: BIOSCI 41, CHEM 131, and CHEM 135 or 171. GER:DB-NatSci
3 units, Aut (Kohler)

CHEMENG 189. Biochemistry II—(Same as 289, BIOSCI 189/289, CHEM 189.) Metabolism. Glycolysis, gluconeogenesis, citric acid cycle, oxidative phosphorylation, pentose phosphate pathway, glycogen metabolism, fatty acid metabolism, protein degradation and amino acid catabolism, protein translation and amino acid biosynthesis, nucleotide biosynthesis, DNA replication, recombination and repair, lipid and steroid biosythesis. Medical consequences of impaired metabolism. Therapeutic intervention of metabolism. Prerequisite: 188/288. GER:DB-NatSci

3 units, Win (Khosla)

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, Sum (Staff)

CHEMENG 190H. Undergraduate Honors Research in Chemical Engineering—For declared Chemical Engineering B.S. with honors majors who have obtained faculty approval for a research topic. Research proposal, written thesis, and oral presentation of thesis work.

2-5 units, Aut, Win, Spr, Sum (Staff)

PRIMARILY FOR GRADUATE STUDENTS

CHEMENG 240. Microelectronics Processing Technology—(Same as 140; see 140.)

3 units, Spr (Bao)

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 (Swartz) not given 2005-06

CHEMENG 260. Polymer Science and Engineering—(Same as 160; see 160.)

3 units, Win (Frank)

CHEMENG 288. Biochemistry I—(Same as 188, BIOSCI 188/288, CHEM 188; see 188.)

3 units, Aut (Kohler)

CHEMENG 289. Biochemistry II—(Same as 189, BIOSCI 189/289, CHEM 189; see 189.)

3 units, Win (Khosla)

CHEMENG 300. Applied Mathematics in the Chemical and Biological Sciences—(Enroll in CME 330.)

3 units, Aut (Shaqfeh)

CHEMENG 310A. Microscale Transport in Chemical Engineering—Transport phenomena on small-length scales appropriate to applications in microfluidics, complex fluids, and biology. The basic equations of mass, momentum, and energy, derived for incompressible fluids and simplified to the slow-flow limit. Topics: solution techniques utilizing expansions of harmonic and Green's functions; singularity solutions; flows involving rigid particles and fluid droplets; applications to suspensions; lubrication theory for flows in confined geometries; slender body theory; and capillarity and wetting. Prerequisites: 120A,B, 300, or equivalents.

3 units, Win (Wiyatno)

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 distribution functions, liquid state theory, integral equations, and perturbation theory.

3 units, Aut (Musgrave)

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 course in quantum mechanics.

3 units, Win (Bent)

CHEMENG 350. Principles of Cellular Systems—Biochemistry and cell biology for engineering students with no training in biology. Chemical engineering Ph.D. students with training in biology may substitute other graduate level biology courses with consent of instructor. Recommended: undergraduate physical and organic chemistry.

3 units, Win (Kao)

CHEMENG 355. Advanced Biochemical Engineering—(Same as BIOE 355.) Quantitative biological concepts and the technological tools used to exploit the power of modern biology. How a cell interacts with and influences its environment, and how a production organism is produced and optimized. Concepts for large-scale bioproduct production, isolation, and purification. How proteins are manufactured without living cells, how biopharmaceuticals are formulated and delivered, and the regulatory requirements for drug approval and sale. Prerequisite: 350 or BIOSCI 41 or equivalent.

3 units, Spr (Swartz)

CHEMENG 442. Structure and Reactivity of Solid Surfaces—The structure of solid surfaces including experimental methods for determining the structure 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 or heterogeneous catalysis including catalytic mechanisms and surface kinetics.

3 units (Bent) alternate years, given 2006-07

CHEMENG 444A. Quantum Simulations of Molecules and Materials—Quantum atomistic simulations to predict atomic structure, properties, reaction mechanisms, and kinetics. Review of quantum mechanics. Quantum chemical theory and electronic structure methods including Hartree Fock, configuration interaction, many body perturbation theory, and density functional theory. Property calculations: energy, forces, structure, and electronic and vibrational spectra. Student designed simulation projects involve applications to semiconductor processing, surface science, biochemistry, catalysis, polymers, environmental chemistry, and combustion. Prerequisite: undergraduate quantum mechanics.

3 units, Win (Musgrave)

CHEMENG 444B. Quantum Simulations: Materials Micro Mechanics—(Enroll in ME 444B.)

3 units (Staff) not given 2005-06

CHEMENG 450. Introduction to Biotechnology—Faculty from the schools of Medicine, Humanities and Sciences, and Engineering, and industrial speakers review the interrelated elements of modern biotechnology. Topics: life-cycle of a biotechnology company, therapeutic proteins, small molecule therapeutics, non-therapeutic protein products, small molecule products from biotechnology, manufacturing and formulation of therapeutic products, drug delivery systems, medical devices, diagnostics, intellectual property in biotechnology. Prerequisite: graduate student or upper-division undergraduate in sciences or engineering.

3 units, Spr (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 (Swartz)

CHEMENG 459. Frontiers in Interdisciplinary Biosciences—(Same as BIOSCI 459, CHEM 459, PSYCH 459, BIOC 459, BIOE 459.) For specialists and non-specialists. Sponsored by the Stanford BioX Program. Three seminars per quarter address scientific and technical themes related to interdisciplinary approaches in bioengineering, medicine, and the chemical, physical, and biological sciences. Leading investigators from Stanford and the world present breakthroughs and endeavors that cut across core disciplines. Pre-seminars introduce basic concepts and background for non-experts. Registered students attend all pre-seminars; others welcome. See http://www.stanford.edu/group/biox/courses/459.html. Recommended: basic mathematics, biology, chemistry, and physics.
1 unit, Aut, Win, Spr (Robertson)

CHEMENG 460. Polymer Surfaces and Interfaces— Principles of interfacial thermodynamics and polymer physics applied to polymer surfaces and interfaces. Treatments of intermolecular forces; conformational statistics of macromolecular structure; models for polymer dynamics; tethering of polymers at different interfaces; techniques for chemical modification of surfaces; methods for physical characterization of polymer surfaces and interfaces. Applications in adhesion and biocompatibility. Prerequisite: exposure to principles of polymer science or consent of instructor.
3 units (Frank) alternate years, given 2006-07

CHEMENG 462. Dynamics of Complex Liquids—The connection between the microstructural dynamics of complex liquids and their rheology such as stress-strain rate relationship, developed sequentially from non-Brownian suspensions, to colloidal suspensions, to polymer solutions and melts. Concepts of rheology, origins of stress in complex liquids, how Brownian motion can create stress, and how rheometric measurements can elucidate stress producing mechanisms in complex fluids. Microstructural and molecular models including those for dilute and concentrated polymer solutions and melts, and if time permits, liquid crystals and surfactants. For 2005-06, enroll in ME 455. Prerequisites: 300, 310A.
3 units (Shaqfeh) not given 2005-06

CHEMENG 463. Complex Fluids and Non-Newtonian Flows—(Enroll in ME 455.)
3 units, Spr (Shaqfeh)

CHEMENG 464. Polymer Chemistry—Polymer synthesis, characterization, and application. Topics include organic and kinetic aspects of polymerization, polymer characterization techniques, and structure and properties of bulk polymers for commercial applications and emerging technologies.
3 units, Aut (Bao)

CHEMENG 500. Special Topics in Protein Biotechnology—Recent developments and current research. May be repeated for credit.
1 unit, Aut, Win, Spr, Sum (Swartz)

CHEMENG 501. Special Topics in Semiconductor Processing—Recent developments and current research. May be repeated for credit.
1 unit, Aut, Win, Spr, Sum (Bent)

CHEMENG 502. Special Topics in Computational Materials Science—Recent developments and current research. May be repeated for credit.
1 unit, Aut, Win, Spr, Sum (Musgrave)

CHEMENG 503. Special Topics in Biocatalysis—Recent developments and current research. May be repeated for credit.
1 unit, Aut, Win, Spr, Sum (Khosla)

CHEMENG 504. Special Topics in Bioengineering—Recent developments and current research. May be repeated for credit.
1 unit, Aut, Win, Spr, Sum (Robertson)

CHEMENG 505. Special Topics in Microrheology—Recent developments and current research. May be repeated for credit.
1 unit, Aut, Win, Spr, Sum (Fuller)

CHEMENG 507. Special Topics in Polymer Physics and Molecular Assemblies—Recent developments and current research. May be repeated for credit.
1 unit, Aut, Win, Spr, Sum (Frank)

CHEMENG 510. Special Topics in Transport Mechanics—Recent developments and current research. May be repeated for credit.
1 unit, Aut, Win, Spr, Sum (Shaqfeh)

CHEMENG 512. Special Topics in Functional Genomics—Recent developments and current research. May be repeated for credit.
1 unit, Aut, Win, Spr, Sum (Kao)

CHEMENG 513. Special Topics in Functional Organic Materials for Electronic and Optical Devices—Recent developments and current research. May be repeated for credit.
1 unit, Aut, Win, Spr, Sum (Bao)

CHEMENG 600. Graduate Research in Chemical Engineering—Laboratory and theoretical work leading to partial fulfillment of requirements for an advanced degree.
1-12 units, Aut, Win, Spr, Sum (Staff)

CHEMENG 699. Colloquium—Weekly lectures by experts from academia and industry in the field of chemical engineering.
1 unit, Aut, Win, Spr (Staff)