

Chemical Engineering (CH E)

Courses primarily for undergraduates:

CH E 104. Chemical Engineering Learning Community.

(1-0) Cr. arr. F.S. *Prereq:* Enrollment in Chemical Engineering Learning Team
(1-0) Curriculum in career planning and academic course support for Freshmen learning team.

CH E 160. Chemical Engineering Problems with Computer Applications Laboratory.

(2-2) Cr. 3. F.S. *Prereq:* MATH 142 or satisfactory scores on mathematics placement examinations; credit or enrollment in MATH 165
Formulation and solution of engineering problems. Significant figures. Use of SI units. Graphing and curve-fitting. Flowcharting. Introduction to material balances, engineering economics, and design. Use of spreadsheet programs to solve and present engineering problems. Solution of engineering problems using computer programming languages. Chemical Engineering examples.

CH E 202. Chemical Engineering Seminar.

(1-0) Cr. 1. F.S. *Prereq:* Sophomore classification in chemical engineering
Professionalism in the context of the engineering/technical workplace. Introduction to chemical engineering career opportunities. Process and workplace safety. Development and demonstration of key workplace competencies: teamwork, professionalism and ethical responsibility, ability to engage in life-long learning, and knowledge of contemporary issues. Resumes; professional portfolios; preparation for internship experiences.

CH E 204. Chemical Engineering Continuing Learning Community.

Cr. R. F.S. *Prereq:* Corequisite-enrollment in Chemical Engineering Learning Team
(1-0) Curriculum and career planning, academic course support for learning community.

CH E 210. Material and Energy Balances.

(3-0) Cr. 3. F.S. *Prereq:* Chem 178, Math 166
Introduction to chemical processes. Physical behavior of gases, liquids, and solids. Application of material and energy balances to chemical engineering equipment and processes.

CH E 220. Introduction to Biomedical Engineering.

(Cross-listed with BIOE). (3-0) Cr. 3. S. *Prereq:* BIOL 212, ENGR 160 or equiv, MATH 166, CHEM 167 or 178, PHYS 222
Engineering analysis of basic biology and engineering problems associated with living systems and health care delivery. The course will illustrate biomedical engineering applications in such areas as: biotechnology, biomechanics, biomaterials and tissue engineering, and biosignal and image processing, and will introduce the basic life sciences and engineering concepts associated with these topics.

CH E 298. Cooperative Education.

Cr. R. F.S.SS. *Prereq:* Permission of department and Engineering Career Services
First professional work period in the cooperative education program. Students must register for this course before commencing work.

CH E 310. Computational Methods in Chemical Engineering.

(3-0) Cr. 3. F.S. *Prereq:* CH E 210 and ENGR 160
Numerical methods for solving systems of linear and nonlinear equations, ordinary differential equations, numerical differentiation and integration, and nonlinear regression using chemical engineering examples. Nonmajor graduate credit.

CH E 325. Chemical Engineering Laboratory I.

(0-4) Cr. 2. F.S. *Prereq:* CH E 357, credit or enrollment in CH E 381
Experiments covering fundamental material and energy balances, momentum and energy transport operations, and thermodynamics. Computer applications. Nonmajor graduate credit.

CH E 356. Transport Phenomena I.

(3-0) Cr. 3. F.S. *Prereq:* CH E 210, PHYS 221, credit or enrollment in MATH 267
Momentum and mechanical energy balances. Incompressible and compressible fluid flow. Applications to fluid drag, piping system design, filtration, packed beds and settling. Nonmajor graduate credit.

CH E 357. Transport Phenomena II.

(3-0) Cr. 3. F.S. *Prereq:* Credit or enrollment in CH E 310; CH E 356
Conduction and diffusion, convective heat and mass transfer, boiling and condensation, radiation, and design of heat exchange equipment. Introduction to diffusion. Nonmajor graduate credit.

CH E 358. Separations.

(3-0) Cr. 3. F.S. *Prereq:* CH E 310, CH E 357
Diffusion and mass transfer in fluids. Analysis and design of continuous contacting and multistage separation processes. Binary and multicomponent distillation, absorption, extraction, evaporation, membrane processes, and simultaneous heat and mass transfer. Nonmajor graduate credit.

CH E 381. Chemical Engineering Thermodynamics.

(3-0) Cr. 3. F.S. *Prereq:* Credit or enrollment in CH E 310; MATH 267, PHYS 222, CHEM 325
Application of thermodynamic principles to chemical engineering problems. Thermodynamic properties of fluids, phase equilibria, and chemical reaction equilibria. Nonmajor graduate credit.

CH E 382. Chemical Reaction Engineering.

(3-0) Cr. 3. F.S. *Prereq:* Credit in CH E 310; CH E 381, credit or enrollment in CH E 357
Kinetics of chemical reactions. Design of homogeneous and heterogeneous chemical reactors. Nonmajor graduate credit.

CH E 391. Foreign Study Orientation.

(3-0) Cr. 3. *Prereq:* Credit or enrollment in CH E 357 and CH E 381 or permission of instructor
Offered on a satisfactory-fail basis only. Credit for graduation allowable only upon completion of Ch E 392.
Meets International Perspectives Requirement.

CH E 392. Foreign Study Program.

Cr. 4. SS. *Prereq:* CH E 391
Study of chemical engineering including laboratories and lectures at University College London or other collaborating international universities. Comparative study of U.S. and international manufacturing facilities. Expenses required. Meets International Perspectives Requirement.

CH E 396. Summer Internship.

Cr. R. Repeatable. SS. *Prereq:* Permission of department and Engineering Career Services
Summer professional work period. Students must register for this course prior to commencing work.

CH E 397. Engineering Internship.

Cr. R. Repeatable. F.S. *Prereq:* Permission of department and Engineering Career Services
One semester maximum per academic year professional work period. Students must register for this course prior to commencing work.

CH E 398. Cooperative Education.

Cr. R. F.S.SS. *Prereq:* CH E 298, permission of department and Engineering Career Services
Second professional work period in the cooperative education program. Students must register for this course before commencing work.

CH E 406. Environmental Chemodynamics.

(Dual-listed with CH E 506). (3-0) Cr. 3. Alt. F., offered 2013. *Prereq:* CH E 381, credit or enrollment in CH E 358
Examines the mechanisms and rates of chemical transport across air, water, and soil interfaces. Applications of transport and thermodynamic fundamentals to movement of chemicals in the environment. Nonmajor graduate credit.

CH E 408. Surface and Colloid Chemistry.

(Dual-listed with CH E 508). (3-0) Cr. 3. Alt. F., offered 2012. *Prereq:* CH E 381 or equivalent
Examines the factors underlying interfacial phenomena, with an emphasis on the thermodynamics of surfaces, structural aspects, and electrical phenomena. Application areas include emulsification, foaming, detergency, sedimentation, fluidization, nucleation, wetting, adhesion, flotation, and electrophoresis. Nonmajor graduate credit.

CH E 415. Biochemical Engineering.

(Dual-listed with CH E 515). (3-0) Cr. 3. S. *Prereq:* CH E 357, CH E 382 recommended, CHEM 331
Application of basic chemical engineering principles in biochemical and biological process industries such as enzyme technology and fermentation. Nonmajor graduate credit.

CH E 420. Chemical Process Safety.

(3-0) Cr. 3. S. Prereq: CH E 357, CH E 381 (or equivalents); junior classification
Application of transport phenomena, thermodynamics, and chemical kinetics to the study of safety, health, and loss prevention. Government regulations, industrial hygiene, relief sizing, runaway reactions, toxic release, and dispersion models will be used. Fires, explosions, risk assessment, hazard identification, case studies, accident investigations, and design considerations will be studied. Nonmajor graduate credit.

CH E 421. Process Control.

(3-0) Cr. 3. F.S. Prereq: CH E 358, CH E 382, Math 267
Control of industrial chemical processes. Device applications and limitations. Dynamics of chemical process components and process control systems. Nonmajor graduate credit.

CH E 426. Chemical Engineering Laboratory II.

(0-4) Cr. 2. F.S. Prereq: CH E 325, CH E 358, CH E 382
Experiments in heat and mass transfer, staged operations, chemical reactor performance, unit processes. Computer applications. Nonmajor graduate credit. Only one of CH E 426 or 427 may count toward graduation.

CH E 427. Biological Engineering Laboratory.

(0-4) Cr. 2. S. Prereq: Credit in CH E 325, CH E 358, CH E 382, and BBMB 301
Experiments on biological applications in chemical engineering. Nonmajor graduate credit. Only one of CH E 426 or CH E 427 may count toward graduation.

CH E 430. Process and Plant Design.

(2-6) Cr. 4. F.S. Prereq: CH E 358, CH E 382
Synthesis of chemical engineering processes, equipment and plants. Cost estimation and feasibility analysis. Nonmajor graduate credit.

CH E 440. Biomedical Applications of Chemical Engineering.

(Dual-listed with CH E 540). (Cross-listed with BIOE). (3-0) Cr. 3. Alt. F., offered 2013. Prereq: CH E 210, MATH 266, PHYS 222
Applications of material and energy balances, transport phenomena, chemical reaction engineering, and thermodynamics to problems in biomedical engineering and applied physiology; survey of biomedical engineering; biomaterials; biomedical imaging. Nonmajor graduate credit.

CH E 447. Polymers and Polymer Engineering.

(Dual-listed with CH E 547). (3-0) Cr. 3. S. Prereq: CH E 382 and CHEM 331 or MAT E 351
Chemistry of polymers, addition and condensation polymerization. Physical and mechanical properties, polymer rheology, production methods. Applications of polymers in the chemical industry. Nonmajor graduate credit.

CH E 490. Undergraduate Research/Independent Study.

(0-18) Cr. 1-6. Repeatable, maximum of 6 credits. Prereq: Permission of Department
Investigation of topics of special interest to student and faculty with a final written report. Election of course and topic must be approved in advance by Department with completion of Study Proposal. No more than 6 credits of ChE 490 may be counted towards technical electives.

CH E 490H. Undergraduate Research/Independent Study, Honors.

(0-18) Cr. 1-6. Repeatable, maximum of 6 credits. Prereq: Permission of Department
Investigation of topics of special interest to student and faculty with a final written report. Election of course and topic must be approved in advance by Department with completion of Study Proposal. No more than 6 credits of ChE 490 may be counted towards technical electives.

CH E 498. Cooperative Education.

Cr. R. Repeatable. F.S.SS. Prereq: CH E 398, permission of department and Engineering Career Services
Third and subsequent professional work periods in the cooperative education program. Students must register for this course before commencing work.

Courses primarily for graduate students, open to qualified undergraduates:**CH E 506. Environmental Chemodynamics.**

(Dual-listed with CH E 406). (3-0) Cr. 3. Alt. F., offered 2013. Prereq: CH E 381, credit or enrollment in CH E 358
Examines the mechanisms and rates of chemical transport across air, water, and soil interfaces. Applications of transport and thermodynamic fundamentals to movement of chemicals in the environment. Nonmajor graduate credit.

CH E 508. Surface and Colloid Chemistry.

(Dual-listed with CH E 408). (3-0) Cr. 3. Alt. F., offered 2012. Prereq: CH E 381 or equivalent

Examines the factors underlying interfacial phenomena, with an emphasis on the thermodynamics of surfaces, structural aspects, and electrical phenomena. Application areas include emulsification, foaming, detergency, sedimentation, fluidization, nucleation, wetting, adhesion, flotation, and electrophoresis. Nonmajor graduate credit.

CH E 515. Biochemical Engineering.

(Dual-listed with CH E 415). (3-0) Cr. 3. S. Prereq: CH E 357, CH E 382, CHEM 331
Application of basic chemical engineering principles in biochemical and biological process industries such as enzyme technology and fermentation. Term project required for graduate credit.

CH E 540. Biomedical Applications of Chemical Engineering.

(Dual-listed with CH E 440). (Cross-listed with BIOE). (3-0) Cr. 3. Alt. F., offered 2013. Prereq: CH E 210, MATH 266, PHYS 222
Applications of material and energy balances, transport phenomena, chemical reaction engineering, and thermodynamics to problems in biomedical engineering and applied physiology; survey of biomedical engineering; biomaterials; biomedical imaging. Nonmajor graduate credit.

CH E 542. Polymeric Biomaterials.

(3-0) Cr. 3. Prereq: CHEM 331 or a polymers class
Polymeric biomaterials, overview of biomaterial requirements, different classes of polymers used as biomaterials, specific bioapplications of polymers.

CH E 545. Analytical and Numerical Methods.

(3-0) Cr. 3. F. Prereq: CH E 358, MATH 267
Analysis of equipment and processes by analytic and/or numerical solution of descriptive differential equations. Operational and series techniques, boundary value problems, numerical interpolation and approximation, integration techniques.

CH E 547. Polymers and Polymer Engineering.

(Dual-listed with CH E 447). (3-0) Cr. 3. S. Prereq: CH E 382 and CHEM 331 or MAT E 351
Chemistry of polymers, addition and condensation polymerization. Physical and mechanical properties, polymer rheology, production methods. Applications of polymers in the chemical industry.

CH E 554. Integrated Transport Phenomena.

(4-0) Cr. 4. F. Prereq: CH E 357, CH E 381, Math 267, credit or enrollment in CH E 545
Conservation equations governing diffusive and convective transport of momentum, thermal energy and chemical species. Transport during laminar flow in conduits, boundary layer flow, creeping flow. Heat and mass transport coupled with chemical reactions and phase change. Scaling and approximation methods for mathematical solution of transport models. Diffusive fluxes; conservation equations for heat and mass transfer; scaling and approximation techniques; fundamentals of fluid mechanics; unidirectional flow; creeping flow; laminar flow at high Reynolds number; forced-convection heat and mass transfer in confined and unconfined laminar flows.

CH E 562. Bioseparations.

(3-0) Cr. 3. Prereq: CH E 357 or advanced standing in a science major
Principles and techniques for separation and recovery of biologically-produced molecules, especially proteins. Relationship between the chemistry of biological molecules and efficient separation and preservation of biological activity. Includes centrifugation and filtration, membrane processing, extraction, precipitation and crystallization, chromatography, and electrophoresis.

CH E 572. Turbulence.

(Cross-listed with AER E). (3-0) Cr. 3. Alt. S., offered 2012. Prereq: AER E 543 or ME 538
Qualitative features of turbulence. Statistical representation of turbulent velocity fields: averages, moments, correlations, length and time scales and the energy cascade. Averaged equations of motion, closure requirements, Reynolds averaged models. Homogeneous shear flows, free shear flows, boundary layers. Numerical simulation of turbulence: DNS, LES, DES.

CH E 583. Advanced Thermodynamics.

(3-0) Cr. 3. F. Prereq: CH E 381
Application of the thermodynamic principles to chemical engineering problems. Thermodynamic properties of non-ideal fluids and solutions; phase and chemical-reaction equilibria/stability.

CH E 587. Advanced Chemical Reactor Design.(3-0) Cr. 3. S. *Prereq:* CH E 382

Analysis of complex reactions and kinetics. Fixed bed, fluidized bed, and other industrial reactors. Analysis and design of non-ideal flow mixing, and residence times. Heterogeneous reactors.

CH E 590. Independent Study.

Cr. 2-6. Repeatable.

Investigation of an approved topic on an individual basis.

CH E 595. Special Topics.

Cr. 2-3. Repeatable.

CH E 595A. Special Topics: Separations.

Cr. 2-3. Repeatable.

CH E 595B. Special Topics: Advanced Control Theory.

Cr. 2-3. Repeatable.

CH E 595C. Special Topics: Crystallization.

Cr. 2-3. Repeatable.

CH E 595D. Special Topics: Thermodynamics.

Cr. 2-3. Repeatable.

CH E 595E. Special Topics: Protein Engineering/Bioseparations.

Cr. 2-3. Repeatable.

CH E 595F. Special Topics: Biological Engineering.

Cr. 2-3. Repeatable.

CH E 595G. Special Topics: Materials and Biomaterials.

Cr. 2-3. Repeatable.

CH E 595H. Special Topics: Surfaces.

Cr. 2-3. Repeatable.

CH E 595I. Special Topics: Combinatorial Design.

Cr. 2-3. Repeatable.

CH E 599. Creative Component.

Cr. arr. Repeatable.

Courses for graduate students:**CH E 601. Seminar.**

Cr. R. Repeatable. F.S.

Offered on a satisfactory-fail basis only.

CH E 625. Metabolic Engineering.(3-0) Cr. 3. *Prereq:* CH E 382, CHEM 331

Principles of metabolic engineering. Emphasis on emerging examples in biorenewables and plant metabolic engineering. Overview of biochemical pathways, determination of flux distributions by stoichiometric and labeling techniques; kinetics and thermodynamics of metabolic networks; metabolic control analysis; genetic engineering for overexpression, deregulation, or inhibition of enzymes; directed evolution; application of bioinformatics, genomics, and proteomics.

CH E 632. Multiphase Flow.(Cross-listed with M E). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq:* M E 538

Single particle, multiparticle and two-phase fluid flow phenomena (gas-solid, liquid-solid and gas-liquid mixtures); particle interactions, transport phenomena, wall effects; bubbles, equations of multiphase flow. Dense phase (fluidized and packed beds) and ducted flows; momentum, heat and mass transfer. Computer solutions.

CH E 642. Principles and Applications of Molecular Simulation.(3-0) Cr. 3. *Prereq:* CH E 545

Principles of statistical physics. General features of molecular simulations including Monte Carlo (MC) methods, molecular mechanics (MM), and molecular dynamics (MD). Overview of intermolecular and interatomic potentials. Evaluation of phase equilibria, free energies, and surface/interfacial properties. Coarse-grained methods.

CH E 652. Advanced Transport.(3-0) Cr. 3. *Prereq:* CH E 552 and CH E 553

Advanced topics in momentum transport, fluid mechanics, and mass transport including study of recent literature.

CH E 688. Catalysis and Catalytic Processes.(Cross-listed with BR C). (3-0) Cr. 3. *Prereq:* CH E 382

Principles and applications of heterogeneous and homogeneous catalysis. Adsorption. Reaction kinetics and mass transfer effects. Catalyst characterization. Industrial catalytic processes.

CH E 692. Independent Study.

Cr. 2-6. Repeatable.

Investigation of an approved topic on an individual basis. Election of course and topic must be approved in advance by Program of Study Committee.

CH E 695. Advanced Topics.

Cr. arr. Repeatable.

CH E 695A. Advanced Topics: Separations.

Cr. arr. Repeatable.

CH E 695B. Advanced Topics: Advanced Statistical Modeling and Control.

Cr. arr. Repeatable.

CH E 695C. Advanced Topics: Crystallization.

Cr. arr. Repeatable.

CH E 695D. Advanced Topics: Thermodynamics.

Cr. arr. Repeatable.

CH E 695E. Advanced Topics: Protein Engineering/Bioseparations.

Cr. arr. Repeatable.

CH E 695F. Advanced Topics: Biological Engineering.

Cr. arr. Repeatable.

CH E 695G. Advanced Topics: Materials and Biomaterials.

Cr. arr. Repeatable.

CH E 695H. Advanced Topics: Surfaces.

Cr. arr. Repeatable.

CH E 695I. Advanced Topics: Combinatorial Design.

Cr. arr. Repeatable.

CH E 697. Engineering Internship.Cr. R. Repeatable. F.S.SS. *Prereq:* Permission of major professor, graduate classification

One semester and one summer maximum per academic year professional work period.

CH E 699. Research.

Cr. arr. Repeatable.

Advanced topic for thesis/dissertation.