Department of Chemical & Petroleum Engineering

Chemical and Petroleum Engineering

Chemical engineering has grown out of a combination of chemistry and engineering associated with industrial processes. Today, it comprises knowledge used in processes that change the physical state or composition of materials. Chemical engineers hold key roles in the design, development, production, and purification of materials that are considered essential to human life and well-being, such as food products, fuels and lubricants, pharmaceuticals, fertilizers, synthetic fibers, microelectronic components, and plastics. Chemical engineers are involved in reducing the use of energy to make these products in safe and sustainable ways. They are responsible for minimizing environmental effects of chemical production on the environment.

Petroleum engineering is concerned with the drilling, recovery, production, and distribution of petroleum and natural gas. Petroleum engineers use knowledge of fluid and rock properties in subsurface environments with methods of producing oil and gas safely and economically. At the University of Kansas, the focus is on reservoir engineering to improve production from oil and gas reservoirs. Reservoir engineers use geological detection with computerized mathematical analysis to produce these valuable raw materials. Through such techniques, petroleum engineers continue to extract oil and gas from reservoirs that were considered uneconomical only a few years ago. Petroleum engineering is uniquely challenging in that the raw product must be recovered far from observation.

Undergraduate Programs

The Department of Chemical and Petroleum Engineering offers a Bachelor of Science degree in chemical engineering and a Bachelor of Science degree in petroleum engineering and is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

The B.S. program in chemical engineering offers a General Program, a Biomedical emphasis, an Environmental emphasis, a Materials Science emphasis, a Petroleum emphasis, and a Premedical emphasis.

Graduate Programs

C&PE graduate programs provide an in-depth academic understanding of chemical engineering and petroleum engineering for students who plan careers in academia, research, or development. The department offers the M.S. degree in chemical engineering and petroleum engineering and the Ph.D. degree in chemical and petroleum engineering. See the Graduate Studies (http://catalog.ku.edu/graduate-studies) section of the online catalog for requirements for admission and degrees.

In the master's programs, the primary emphasis is on formal course work in engineering and related subjects. Students take a sequence of core courses in heat, mass and momentum transport, thermodynamics, reaction kinetics, applied mathematics, reservoir engineering, and petroleum recovery.

In the doctoral program, the student completes an independent and novel research project in a significant engineering area. Specific Ph.D. course work depends on the research area and the specific education needed by the student for the project The general research area reflects the research interests of the faculty. In addition to specialized courses in the department, advanced courses in mathematics and computer science, life sciences, physical sciences, and other branches of engineering may be used to prepare the Ph.D. student for the research project.

These guidelines include departmental requirements and are intended to assist the student and advisory committee in preparing a Plan of Study for the graduate degree.

Courses

C&PE 111. Introduction to the Chemical Engineering Profession. 2 Hours.
An introduction to the University of Kansas and work done by professional engineers. Students are introduced to the resources available to them at KU, in the School of Engineering, and in the Chemical and petroleum Engineering Department. They are introduced to the curricula requirements and expectations of chemical engineering students. The career opportunities for chemical engineers are described. Students are introduced to engineering ethics, basic safety considerations, teamwork, and technical writing. The course includes fundamental calculations of material and energy balances and fluid flow. Prerequistie: Corequisite: CHEM 130 or CHEM 170 or CHEM 190. LEC.

C&PE 117. Energy in the Modern World. 1 Hour.
A survey course on global energy supply and demand, production methods and energy economics. Course begins with the matrix of energy supply and demand focusing on fossil fuels and nuclear energy and includes transportation/ distribution patterns and issues and current production technologies. We then analyze alternate energy realities and potentials such as solar energy, wind energy, biomass utilization, hydrogen, fuel cells, hydroelectric, geothermal, wave/tidal, and others based on thermodynamic principles and economics. Course is also open to non-engineering students. LEC.

C&PE 127. Introduction to Petroleum Engineering Profession. 1 Hour.
An introduction to principles of reservoir engineering and an application of economic principles will be introduced along with the use of computer spreadsheets. A mini petroleum engineering design project will be assigned to illustrate the integration of petroleum engineering principles and the use of computers. CPE 127 is required of all Petroleum Engineering freshmen but is optional for others. Course is also open to non-engineering students. LEC.

C&PE 211. Material and Energy Balances. 4 Hours.
The application of the laws of chemistry, physics, and mathematics to the solution of material and energy balance problems occurring in the process industries. Prerequisite: MATH 125 or MATH 145; CHEM 135 or CHEM 175 or CHEM 195; or consent of instructor. LEC.

C&PE 217. Introduction to Petroleum Drilling Engineering. 2 Hours.
An introduction to modern rotary drilling. Topics covered include: rig systems/hardware, management practices, cost analysis, drilling fluid function formulations and testing, well control systems, cement formulation and placement, drilling bits. LEC.

C&PE 219. Drilling Fluids Laboratory. 1 Hour.
Laboratory study of formulation and properties of drilling fluids. "Mud" measurements covered include density, solids content, filtration control and viscosity. Other measurements include compressive strength of cement and cuttings transport properties. Prerequisite: Corequisite: CPE 217. LAB.

C&PE 221. Chemical Engineering Thermodynamics. 3 Hours.
Fundamentals and applications of the First and Second Laws of Thermodynamics with strong emphasis on material, energy and entropy balances to solve engineering problems involving pure components. Topics include: Cycles (Rankine, Brayton, refrigeration, etc.), the calculus of thermodynamics, equations of state for realistic thermodynamic properties, departure functions, equilibrium and stability criteria, fugacity, and single component phase equilibrium (vaporization, melting, sublimation). Prerequisite: MATH 122 or MATH 142 or MATH 126 or MATH 146; and CPE 211. Prerequisite or Corequisite: PHSX 210 or PHSX 211 or PHSX 213; or consent of instructor. LEC.

C&PE 325. Numerical Methods and Statistics for Engineers. 3 Hours.
An introduction to numerical methods and statistics and their application to engineering problems. Numerical methods topics include finding roots of a single nonlinear equation, numerical solution of ordinary differential equations, numerical integration, and solutions of ordinary differential equations. Statistical topics include regression and curve fitting, probability and probability distributions, expected value and hypothesis testing, and optimization of single and multiple-variable systems. Implementing numerical algorithms using computer programming will be emphasized, along with the fundamentals of programming, including data typing, branching, and iteration. Applications specific to chemical and petroleum engineering systems will be considered. Prerequisite: MATH 126 or MATH 146; and CHEM 135 or CHEM 175 or CHEM 195. Corequisite: MATH 220 or MATH 221 or MATH 320 or MATH 321; and MATH 290 or MATH 291; or consent of instructor. LEC.

C&PE 327. Reservoir Engineering. 4 Hours.
Properties of porous rocks, reservoir fluids, and fluid saturated rocks. Introduction to multiphase flow in porous media including concepts of wettability, capillary pressure and relative permeability. Prerequisite: CHEM 135 or CHEM 175 or CHEM 195. LEC.

C&PE 511. Momentum Transfer. 3 Hours.
Solutions of continuity, momentum, and energy equations applied to fluids in confined flow or flowing past submerged objects. Laminar and turbulent flows of both incompressible and compressible fluids are considered. Engineering applications include pressure drop and network analysis of piping lines, flow measurements, fluid moving equipment including the performance of pumps. Prerequisite: CPE 221 or ME 312; CPE 121 or CPE 325; MATH 122 or MATH 142 or MATH 127 or MATH 147; and MATH 220 or MATH 221 or MATH 320 or MATH 321; or consent of instructor. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 512. Chemical Engineering Thermodynamics II. 3 Hours.
Further application of the laws of thermodynamics to multi-component mixtures and in multi-phase equilibria with focus on vapor-liquid, liquid-liquid, and solid-liquid equilibria. Mixture Fugacity expressions are developed using equations of state with mixing rules or Excess Gibbs Free Energy/activity coefficient models for data correlation or prediction. Chemical equilibrium of reactions is also discussed. Prerequisite: CPE 121 or CPE 325; CPE 211; CPE 221; and CHEM 330 or CHEM 380; or consent of instructor. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 521. Heat Transfer. 3 Hours.
An applied study of the various (conductive, convective, and radiative) heat transfer mechanisms in solid and fluid systems both transient and steady-state. Engineering applications include: conduction in solids and fluids, free and forced convection in fluids, radiation, boiling and condensing fluids, and design of heat exchangers. Prerequisite: CPE 121 or CPE 325; CPE 221 or ME 312; CPE 511 or ME 510; MATH 122 or MATH 142 or MATH 127 or MATH 147; and MATH 220 or MATH 221 or MATH 320 or MATH 321; or consent of instructor. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 522. Economic Appraisal of Chemical and Petroleum Projects. 2 Hours AE51.
Consideration of the economic factors important in the development of the chemical or petroleum enterprise. Applications of economic evaluation methods to engineering project development. Consideration of risk and uncertainty in project development. Prerequisite: MATH 122 or MATH 142 or MATH 126 or MATH 146; PHSX 210 or PHSX 211 or PHSX 213; and CPE 121 or CPE 325; or consent of instructor. LEC.

C&PE 523. Mass Transfer. 4 Hours.
Includes one credit hour of calculations laboratory. Treatment of mass transfer phenomena with application to analysis and design of unit operations equipment such as distillation, extraction, absorption, and adsorption. Prerequisite: CPE 211; CPE 511; and CPE 512; or consent of instructor. Corequisite: CPE 521. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 524. Chemical Engineering Kinetics and Reactor Design. 3 Hours.
Development and solution of the material and energy balance equations for continuous and batch reactors. These balance equations are applied in (a) the determination of intrinsic kinetics, (b) the design of reactors and (c) the analysis of reactor behavior. Both homogeneous and heterogeneous reaction systems are considered. Prerequisite: CPE 511; CPE 512; and MATH 220 or MATH 221 or MATH 320 or MATH 321; or consent of instructor. Corequisite: CPE 521. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 525. Heat and Mass Transfer. 4 Hours.
An applied study of the various heat and mass transfer mechanisms in solid and fluid systems. Heat transfer mechanisms include conduction and the concept of conductivity at the molecular level, convection, and radiation. Mass transfer fundamentals include diffusion and the concepts of diffusivity at the molecular level and shell mass balances including diffusion, convention, and consumption or generation source terms. Steady state and transient heat and mass transfer engineering applications will be considered. Prerequisite: MATH 220; MATH 127; CPE 221 or ME 312; CPE 325; CPE 511 or ME 510; or consent of instructor. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 527. Reservoir Engineering II. 4 Hours.
Lectures on single phase flow and pressure distribution in reservoirs. Calculations in drawdown, buildup, multiple rate, fractured systems, gas and injection well testing. Material balance calculations for gas, gas-condensate, undersaturated, and saturated reservoirs. Prerequisite: CPE 327; ME 312 or CPE 221; MATH 220 or MATH 221 or MATH 320 or MATH 321; or consent of instructor. The Petroleum major has a GPA requirement for specific courses to progress to junior year courses. Details can be found in the catalog. LEC.

C&PE 528. Well Logging. 3 Hours.
Analysis of well logs to determine properties of reservoir rocks, fluid saturations and lithology, and production logging. Prerequisite: CPE 327 or consent of instructor. The Petroleum major has a GPA requirement for specific courses to progress to the Junior year courses. Details can be found in the catalog. LEC.

C&PE 601. Undergraduate Topics in Chemical and Petroleum Engineering. 1-4 Hours.
Undergraduate study in various branches of Chemical and Petroleum Engineering on topics that may vary from year to year. Prerequisite: Varies. LEC.

C&PE 611. Design of Unit Operations. 3 Hours.
Application of chemical engineering principles to design pumps, heat exchangers, and separation equipment. Staged separation processes including distillation, extraction and absorption, membrane separations, and modes of operation will be considered. Sizing of equipment, energy consumption and materials of construction will also be addressed. Prerequisite: CPE 211; CPE 511; CPE 512; CPE 521 or CPE 525; CPE 523 or CPE 525; CPE 524; or consent of instructor. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 612. Environmental Assessment of Chemical Processes. 3 Hours.
A discussion and project-based survey of environmental issues in chemical engineering, including environmentally conscious design, environmental fate and transport, green chemistry, and life cycle analysis. Focus will be on the design, implementation and management of comprehensive environmental assessments for existing and new industrial facilities with an emphasis on the technical and economic impacts of catalytic systems on pollution control strategies. LEC.

C&PE 613. Chemical Engineering Design I. 4 Hours AE61.
Synthesis, design and economic analysis of petrochemical, and chemical plants. Applications in computer aided engineering applied to these topics. Prerequisite: CPE 511; CPE 512; CPE 521; CPE 522; CPE 523; and CPE 524; or consent of instructor. Corequisite: CPE 615. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 614. Reaction Engineering for Environmentally Benign Processes. 3 Hours.
Principles of reaction engineering and green chemistry applied to processes of the future. With a case-based introduction to the design and optimization of catalytic processes and reaction systems, focus will be on key reaction engineering concepts, including catalysis, mechanisms, reaction kinetics, heterogeneous reactions, reactor types and economic evaluation. Students will develop a multidisciplinary understanding of chemical, biological and molecular concepts and of the multiscale character of developing and designing processes from the micro level to the macro level. Prerequisite: Senior standing in engineering or the physical/biological sciences. LEC.

C&PE 615. Introduction to Process Dynamics and Control. 3 Hours.
The behavior of chemical processing equipment in the presence of disturbances in operating conditions is analyzed. Control systems are designed based on the criteria of system stability and optimal system performance. Prerequisite: CPE 511; CPE 512; CPE 521; CPE 523; and CPE 524; or consent of instructor. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 616. Chemical Engineering Laboratory I. 3 Hours.
Laboratory study of chemical engineering concepts of thermodynamics, fluid flow, heat transfer, mass transfer, and reaction kinetics. Includes emphasis on technical communication skills. Prerequisite: CPE 511; CPE 512; CPE 521; CPE 523; CPE 524; and ENGL 102 or ENGL 105; or consent of instructor. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LAB.

C&PE 617. Drilling and Well Completion. 3 Hours.
Design and analysis of rotary drilling and well completion systems; casing design, cementing, and perforating. Safety and ethical considerations in drilling and fluid disposal operations. Prerequisite: CPE 217; CPE 219; CPE 327; CPE 511 or ME 510; or consent of instructor. The Petroleum major has a GPA requirement for specific courses to progress to the senior year courses. Details can be found in the catalog. LEC.

C&PE 618. Secondary Recovery. 4 Hours.
Study of waterflooding based upon linear displacement theory. Extension to two and three dimensions through correlations and stream tube models. Design of waterfloods including preparation of a reservoir description for waterflood evaluation. Prerequisite: CPE 527; or consent of the instructor. The Petroleum major has a GPA requirement for specific courses to progress to the Junior year courses. Details can be found in the catalog. LEC.

C&PE 619. Petroleum Engineering Laboratory I. 3 Hours.
Laboratory study of methods to determine rock and fluid properties related to petroleum engineering including phase behavior, viscosity, permeability, porosity, capillary pressure, oil recovery, water/oil displacement, fluid flow, and heat transfer coefficients. Analysis of experimental uncertainty. Oral and written presentations are required. Prerequisite: ENGL 203 (Writing for Engineers); CPE 219; CPE 327; CPE 511 or ME 510; or consent of instructor. The Petroleum major has a GPA requirement for specific courses to progress to junior year courses. Details can be found in the catalog. LAB.

C&PE 620. Enhanced Oil Recovery. 3 Hours.
Enhanced Oil Recovery processes such as primary, secondary, and tertiary oil recovery techniques will be presented. This includes miscible/immiscible displacement, chemical processes such as polymerflood, surfactant and micellar flood, and thermal recovery techniques such as steam flooding, in-situ combustion, and other EOR techniques. Prerequisite: CPE 527 and CPE 618 or consent of instructor. LEC.

C&PE 623. Chemical Engineering Design II. 2 Hours AE61.
A continuation of CPE 613 with emphasis on individual student process design development and analysis. Prerequisite: CPE 613; and CPE 615; or consent of instructor. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 624. Process Safety and Sustainability. 3 Hours AE51.
An introductory course designed to acquaint students with the necessary global aspects and ethics of risk-based process safety and sustainability. Topics will include elements of process safety, process safety management, historical and contemporary case studies of major accidents in the chemical and petroleum industry, overview of current government regulation (e.g. OSHA, EPA, etc.), and ethics. Students will receive an introduction to sustainable ("green") chemistry and engineering followed by more quantitative Life Cycle Analysis (LCA) to compare technologies and products. Prerequisite: CPE 511 or ME 510; and CPE 521 or ME 612; or consent of instructor. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LEC.

C&PE 625. Unconventional Reservoirs. 3 Hours.
Principles of unconventional reservoir engineering including properties and use of shale reservoirs, hydraulic fracturing, and relevant environmental and economic factors. Prerequisite: CPE 511; CPE 522; CPE 527; CPE 528; ME 211 or CE 201 and CE 310; GEOL 331 or GEOL 591: Geology for Petroleum Engineers; or consent of instructor. The Petroleum major has a GPA requirement for specific courses to progress to the senior year courses. Details can be found in the catalog. LEC.

C&PE 626. Chemical Engineering Laboratory II. 3 Hours GE22.
Laboratory study of chemical engineering concepts of thermodynamics, fluid flow, heat transfer, mass transfer, reaction kinetics, and process control. Includes emphasis on technical communication skills. Prerequisite: ENGL 102 or ENGL 105; CPE 511; CPE 512; CPE 521; CPE 523; CPE 524; CPE 615; and CPE 616; or consent of instructor. The Department has a GPA requirement for progression in the program. Details can be found in the catalog. LAB.

C&PE 627. Petroleum Production. 3 Hours.
Design and analysis of natural production and artificial lift systems, including beam pumping, gas lift, and submersible pumps. Vertical and horizontal two phase flow, compression, metering, acidizing, fracturing, and pipe line flow systems. Treatment of ethics considerations in production contracts and leasing arrangements. Prerequisite: CPE 327; CPE 511 or ME 510; or consent of instructor. The Petroleum major has a GPA requirement for specific courses to progress to the senior year courses. Details can be found in the catalog. LEC.

C&PE 628. Petroleum Engineering Design. 3 Hours AE61.
Design problems related to petroleum reservoir development such as selection of optimum well spacing for a specified reservoir, evaluation of a producing property or installation of a waterflood. Designs consider economic, uncertainty analysis, as well as conservation, environmental, and professional ethics factors. Prerequisite: CPE 522; CPE 527; CPE 528; CPE 618; CPE 619; GEOL 535; or consent of instructor. The Petroleum major has a GPA requirement for specific courses to progress to the senior year courses. Details can be found in the catalog. LEC.

C&PE 651. Undergraduate Problems. 1-4 Hours.
Investigation of a particular problem in the field of chemical or petroleum engineering. The problem or research topic is identified jointly by the student and the faculty research supervisor. A final report is required. IND.

C&PE 654. Biocatalysis. 3 Hours.
Introductory and advanced topics in biocatalysis with focus on enzymatic reactions. Enzymology will provide the fundamental basis for discussion of kinetics and bio-process development. Advanced topics include: enzymes in non-aqueous solvents, immobilization techniques, whole-cell transformations, bio-reactors. LEC.

C&PE 655. Introduction to Semiconductor Processing. 3 Hours.
An overview of various processes to fabricate semiconductor devices and integrated circuits. Topics covered include crystal growth, oxidation, solid-state diffusion, ion implantation, photolithography, chemical vapor deposition, epitaxial growth, metalization, and plasma etching of thin films. (Same as EECS 670.) Prerequisite: Senior standing in CPE or EECS, or consent of instructor. LEC.

C&PE 656. Introduction to Biomedical Engineering. 3 Hours.
An interdisciplinary introduction to the field of biomedical engineering. This course covers a breadth of topics including biotransport, biomechanics, biomaterials, tissue engineering, drug delivery, biomedical imaging, computational biology, and biotechnology. Students are exposed to these broad topics, and go further in depth in a topic of their choice with the semester project. Prerequisite: Junior or Senior-level standing in Engineering or consent of instructor. LEC.

C&PE 657. Polymer Science and Technology. 3 Hours.
Polymer Science and Technology is a 3-hour introductory course to polymer chemistry, science, technology, and processing. The course targets junior, senior, and graduate chemical engineers and chemistry majors and is intended to provide a background which would allow young professionals to understand polymer chemistry and processes to which they would be exposed to in industry and literature. The course would also assist them in selecting polymers and polymer specifications. Prerequisite: Senior or graduate student standing in chemical or petroleum engineering, or consent of instructor. LEC.

C&PE 661. Undergraduate Honors Research. 1-3 Hours.
This course involves the investigation of a particular problem in the field of chemical or petroleum engineering. CPE 661 should be taken, rather than CPE 651, for students seeking Departmental Honors in Chemical Petroleum Engineering. CPE 661 may also be used by students in the Honors Program to help satisfy the course requirement of this program. The design or research topic is identified jointly by the student and faculty research supervisor. Prerequisite: CPE 121 or CPE 325; CPE 211; CPE 511; CPE 512; CPE 522; overall GPA >3.5; and engineering GPA >3.5; or consent of the instructor. IND.

C&PE 671. Senior Thesis. 3 Hours.
This course involves the investigation of a particular problem in the field of chemical or petroleum engineering as a continuation for students with previous research experience, by invitation. The design or research topic is identified jointly by the student and faculty research supervisor and faculty committee. Students will present periodically and receive instruction and feedback on their presentations. A written thesis and public oral defense with committee are also required. Prerequisite: CPE 651 or CPE 661; and invitation and permission of instructor, open to seniors only. THE.

C&PE 678. Applied Optimization Methods. 3 Hours.
Study of methods for solving optimization problems encountered in engineering and the natural sciences, with specific applications illustrating analytical and numerical techniques. Topics covered include methods, penalty functions, linear programming, nonlinear and integer programming, stochastic optimization approaches, and treatment of constrained problems. A semester project is required. Prerequisite: Senior standing or consent of instructor. LEC.

C&PE 701. Methods of Chemical and Petroleum Calculations. 3 Hours.
The utilization of advanced mathematical methods and computing techniques in the solution of problems in these fields. LEC.

C&PE 710. Subsurface Methods in Formation Evaluation. 3 Hours.
Study of subsurface methods and their applications to exploration, evaluation, and production of hydrocarbon reservoirs. Emphasis is on fundamentals of quantitative well log interpretations and the use of well log data in solving geologic and reservoir engineering problems, e.g., porosity, hydrocarbon saturation, permeable bed thickness, permeability, correlation, structural mapping, and stratigraphic and paleoenvironmental studies. Laboratory. Prerequisite: GEOL 535 or CPE 517 or consent of instructor. LEC.

C&PE 712. Environmental Assessment of Chemical Processes. 3 Hours.
A discussion and project-based survey of environmental issues in chemical engineering, including environmental conscious design, environmental fate and transport, green chemistry, and life cycle analysis. Focus will be on the design, implementation and management of comprehensive environmental assessments for existing and new industrial facilities with in-depth analysis of the technical and economic impacts of catalytic systems on pollution control strategies. A comprehensive research paper is required as a final project. LEC.

C&PE 714. Reaction Engineering for Environmentally Benign Processes. 3 Hours.
Principles of reaction engineering and green chemistry applied to processes of the future. With a case-based introduction to the design and optimization of catalytic processes and reaction systems, focus will be on key reaction engineering concepts, including catalysis, mechanisms,

reaction kinetics, heterogeneous reactions, reactor types and economic evaluation. Students will develop a multidisciplinary understanding of chemical, biological and molecular concepts, and will develop and design processes from the micro level to the macro level. A final research paper is required. LEC.

C&PE 715. Topics in Chemical and Petroleum Engineering: _____. 1-4 Hours.
Study in various branches of Chemical and Petroleum Engineering on topics that may vary from year to year. LEC.

C&PE 721. Chemical Engineering Thermodynamics. 3 Hours.
Chemical engineering applications of advanced thermodynamics and physical chemistry. Prerequisite: CPE 512. LEC.

C&PE 722. Kinetics and Catalysis. 3 Hours.
Modeling and analysis of chemical reactors with emphasis on heterogenous catalytic reaction systems. Prerequisite: CPE 524. LEC.

C&PE 725. Molecular Cell Biology. 3 Hours.
Fundamentals and advanced concepts in cell biology and the molecular interactions responsible for cell functions, homeostasis and disease will be presented. Current analytical methods for examining cells and their molecular components will be discussed. Emphasis will be placed on the chemical and physical properties of individual proteins, nucleic acids and lipids and their assembly into cellular and subcellular structures. (Same as PHCH 725.) Prerequisite: Graduate standing or consent of instructor. LEC.

C&PE 731. Convective Heat and Momentum Transfer. 3 Hours.
The formulation and solution of steady- and unsteady-state convective heat and momentum transfer problems. Applications of boundary layer equations to free and forced convection with study of similarity and integral methods of solution for laminar and turbulent flow; development of analogies; transport properties from kinetic theory of gases viewpoint; introduction to numerical methods. Prerequisite: ME 610/CPE 511 and ME 612/CPE 521 or equivalent. A concurrent course in partial differential equations is helpful. LEC.

C&PE 732. Advanced Transport Phenomena II. 3 Hours.
The formulation and solution of steady- and unsteady-state mass transfer problems (including those complicated by momentum and heat transfer). This course is the sequel to CPE 731 and relies upon much of the material treated there. The mathematical approach predominates and the methods available for determining suitable mass transfer coefficients are covered. LEC.

C&PE 751. Basic Rheology. 3 Hours.
Basic rheology including classification of classical bodies based on their stress and strain tensors, rheological equation of state, material functions, generalized Newtonian and general linear viscoelastic fluids, mechanical models such as those of Jeffreys and Maxwell. Prerequisite: CPE 511 or an equivalent course in fluid mechanics. LEC.

C&PE 752. Tissue Engineering. 3 Hours.
An introduction to the rapidly growing and continuously evolving field of tissue engineering. Tissue engineering applies principles and methods of engineering and life sciences toward understanding and development of biological substitutes to restore, maintain and improve tissues functions. In this course, students study the basic science, engineering and medicine required for tissue engineering, learn state-of-the-art technology and practice, and create a literature-based proposal for a tissue engineered medical product. Prerequisite: Senior or graduate standing in engineering; or consent of instructor. LEC.

C&PE 753. Introduction to Electrochemical Engineering. 3 Hours.
Basic principles of electrochemical engineering as they are applied to energy conversion and storage devices, industrial electrolytic processes and corrosion. Areas covered range from electrochemical thermodynamics, ionic phase equilibria, electro-kinetics and ionic mass transport to mathematical modeling of electrochemical systems. Prerequisite: Graduate standing; CPE 511, CPE 512, CPE 524 or equivalent; knowledge of a programming language. LEC.

C&PE 754. Biocatalysis. 3 Hours.
Introductory and advanced topics in biocatalysis with focus on enzymatic reactions. Enzymology will provide the fundamental basis for discussion of kinetics and bio-process development. Advanced topics include: enzymes in non-aqueous solvents, immobilization techniques, whole-cell transformations, bio-reactors. Knowledge of the theoretical basis for these techniques and processes will be demonstrated within a class project. LEC.

C&PE 755. Introduction to Semiconductor Processing. 3 Hours.
An overview of various processes to fabricate semiconductor devices and integrated circuits. Topics covered include crystal growth, oxidation, solid-state diffusion, ion implantation, photolithography, chemical vapor deposition, eqitaxial growth, metallization, and plasma etching of thin films. A term paper on an approved topic of fabrication referencing current peer reviewed literature is required. LEC.

C&PE 756. Introduction to Biomedical Engineering. 3 Hours.
The graduate elective form of CPE 656. Additional assignments commensurate with the graduate-level course designation are required for this section. Prerequisite: Graduate-level standing in Engineering, or consent of instructor. LEC.

C&PE 765. Corrosion Engineering. 3 Hours.
Electrochemical basis of corrosion. Types of corrosion and corrosive atmospheres. Corrosion control measures and industrial problems. Prerequisite: ME 306 or CHEM 135 or CHEM 175 or CHEM 195. LEC.

C&PE 771. Advanced Reservoir Engineering. 2-3 Hours.
Physical principles of petroleum production; gas drive performance; partial water drive performance; pressure maintenance through gas and water injection. Prerequisite: CPE 527. LEC.

C&PE 778. Applied Optimization Methods. 3 Hours.
Study of methods for solving optimization problems encountered in engineering and the natural sciences, with specific applications illustrating analytical and numerical techniques. Topics covered include gradient methods, penalty functions, linear programming, nonlinear and integer programming, stochastic optimization approaches, and treatment of constrained problems. Homework problems involving theoretical concepts and a theoretically-based semester project are required. LEC.

C&PE 790. Introduction to Flow in Porous Media. 3 Hours.
Generalized Darcy's law, vector equations, solutions of partial differential equations with various boundary conditions as applied to the flow of fluids in porous media. Prerequisite: CPE 527. LEC.

C&PE 795. Enhanced Petroleum Recovery. 3 Hours.
A study of improved oil recovery processes such as miscible displacement, microemulsion displacement, and thermal methods. Prerequisite: CPE 618 or permission of instructor. LEC.

C&PE 798. Phase Equilibrium. 3 Hours.
A study of phase behavior and equilibrium from a molecular perspective. Focus will be on vapor-liquid, liquid-liquid and solid-liquid equilibrium with advanced topics in compressed and supercritical fluids, petroleum applications, ionic solutions and others. LEC.

C&PE 800. Seminar. 0.5-1 Hours.
Every fall, five to six seminar sessions will be devoted to providing incoming students information on available thesis/dissertation research projects, library resources, computing environment and topics related to the issues of responsible scholarship in the fields of Chemical and Petroleum Engineering. For the remainder of the year, the seminar will involve presentation of current research and other topics of interest to chemical and petroleum engineers. These presentations will be made by invited guests, faculty, and advanced graduate students. Student attendance is required. Graded on a satisfactory/unsatisfactory basis. LEC.

C&PE 801. Introduction to Research. 1 Hour.
One hour per week in which the staff introduces entering graduate students to research. Topics include discussion of research methods, methods of effectively tapping library resources, preparation of literature surveys, and presentation of results. Faculty members of the department will make presentations of their current research interests. Offered fall only. Prerequisite: Corequisite: CPE 800. LEC.

C&PE 802. CEBC Colloquium. 0.5-1 Hours.
A forum in which graduate and postdoctoral students, and faculty present the results of CEBC research and literature surveys that support the mission of CEBC. LEC.

C&PE 803. Research. 1-6 Hours.
For M.S. candidates. THE.

C&PE 804. Petroleum Management Seminar. 1 Hour.
Structure, operation, and problems of the petroleum industry from a management viewpoint. Presentations will be made by faculty, advanced students, and invited guests. Prerequisite: Permission of instructor. LEC.

C&PE 825. Graduate Problems in Chemical and Petroleum Engineering. 1-5 Hours.
Advanced laboratory problems, special research problems, or library reading problems. Three hours maximum acceptable for master's degree. RSH.

C&PE 902. Preparation for the Ph.D. Comprehensive Examination. 3 Hours.
Preparation of a research proposal in an area assigned by the student's advisory committee. The grade received on the Ph.D. comprehensive examination will apply to this credit. RSH.

C&PE 904. Research. 1-12 Hours.
For Ph.D. candidates. THE.

C&PE 910. Industrial Development of Catalytic Processes. 3 Hours.
Students adopt an interdisciplinary team approach to developing strategies for the design and optimization of catalytic processes. Examples of case studies will be derived from industry or from research testbeds. Students collaborate in multiscale process development involving catalyst and reactor design, reaction system design, modeling and optimization, economic analysis and environmental assessment needed for the development of a catalytic process at either the pilot or production scale. LEC.

C&PE 911. Industrial Practicum. 1-3 Hours.
Graduate students engage in an industrial research internship experience with collaborators in industry. FLD.

C&PE 912. Teaching College Level Engineering and Science Practicum. 1 Hour.
Future university instructors learn how to critically examine course content and teaching strategies, and prepare courses that will address the learning needs of the diverse student populations of the future. Students participate in weekly in-class workshops and symposia, as well as a teaching practicum experience during this course. LEC.

C&PE 919. Advanced Topics in Process Modeling Simulation or Control: _____. 1-4 Hours.
Advanced study in process modeling, simulation or control on topics which may vary from year to year. LEC.

C&PE 929. Advanced Topics in Chemical and Petroleum Engineering: _____. 1-4 Hours.
Advanced study in various branches of chemical and petroleum engineering on topics which may vary from year to year. LEC.

C&PE 933. Heat and Mass Transport in Porous Media. 3 Hours.
A study of industrial problems involving heat and mass transport in porous media such as packed columns, catalyst beds, chemical reactors, and petroleum reservoirs. Mechanisms of interphase and intraphase transport, diffusion, and dispersion. Included are methods of solution of the describing differential equations. LEC.

C&PE 934. Heat Transport with Phase Change. 3 Hours.
A fundamental treatment of heat transfer occurring during boiling and condensation. Included are nucleate and film boiling, film and dropwise condensation, and two-phase flow. LEC.

C&PE 936. Industrial Separation Processes. 3 Hours.
Determination and treatment of vapor-liquid separations, including methods for obtaining and treating equilibrium data, procedures for calculating multi-component separations by distillation, absorption, extraction, and adsorption. LEC.

C&PE 937. Applied Rheology. 3 Hours.
Industrial applications of fluid mechanics including compressible flow, flow of non-Newtonian fluids, flow of drag reducing systems all to be considered in laminar and turbulent flow regimes, and within conduits, and porous media. LEC.

C&PE 939. Advanced Topics in the Transport Phenomena: _____. 1-4 Hours.
Advanced study in various branches of transport phenomena on topics which may vary from year to year. LEC.

C&PE 940. Data Analysis in Engineering and Natural Sciences. 3 Hours.
Statistical inference and data analysis, emphasizing interpretation of observations from areas of engineering and natural sciences where controlled experimentation is not possible. The basics of elementary statistics and matrix algebra are covered, followed by topics in time, series analysis, map analysis, including automatic contouring, and multivariate procedures such as principal components, discrimination and factor analysis. A suite of computer programs is provided. Students are encouraged to use data from their own graduate research in class projects. LEC.