

# CHEMICAL ENGINEERING (CHEM ENG)

## **CHEM ENG 1100 Computers And Chemical Engineering** (LAB 1.0 and LEC 2.0)

Introduction to chemical engineering, both its intellectual and professional opportunities. Students are introduced to computer programming and software packages while performing meaningful chemical engineering calculations.

## **CHEM ENG 2001 Special Topics** (LEC 0.0 and LAB 0.0)

This course is designed to give the department an opportunity to test a new course.

## **CHEM ENG 2100 Chemical Engineering Material & Energy Balances** (LAB 1.0 and LEC 2.0)

The application of mathematics, physics and chemistry to industrial chemical processes. The use of equations of state, chemical reaction stoichiometry, and the conservation of mass and energy to solve chemical engineering problems. Prerequisites: Chem 1320 or Geology 3410; Math 1215 or Math 1221; preceded or accompanied by Physics 1135.

## **CHEM ENG 2110 Chemical Engineering Thermodynamics I** (LEC 3.0)

Development and application of the laws and fundamental relationships of thermodynamics to industrial chemical processes. Emphasis is placed on the estimation of thermophysical property values for applications in chemical process engineering. Prerequisites: Preceded by Math 2222; Preceded or accompanied by Chem Eng 2100.

## **CHEM ENG 2300 Chemical Process Materials** (LEC 3.0)

Fundamentals of the chemistry of materials. Classification, properties, selection, and processing of engineering materials. Introduction to polymers, electronic materials, biomaterials, and nanomaterials. Prerequisites: Physics 1135.

## **CHEM ENG 2310 Professional Practice And Ethics** (LEC 1.0)

Preparation for post-graduate activities including resume writing and job searching. Professional attitudes, practice, licensure, and ethics in the chemical engineering profession. Discussions led by visiting industrialists and other invited speakers. Discussion of professional development including professional and graduate programs. Generally offered fall semester only. Prerequisite: At least sophomore standing.

## **CHEM ENG 3000 Special Problems** (IND 0.0-6.0)

Problems or readings on specific subjects or projects in the department. Consent of instructor required.

## **CHEM ENG 3001 Special Topics** (IND 0.0-6.0)

This course is designed to give the department an opportunity to test a new course.

## **CHEM ENG 3002 Cooperative Engineering Training** (IND 0.0-6.0)

On-the-job experience gained through cooperative education with industry, with credit arranged through departmental cooperative advisor. Grade received depends on quality of reports submitted and work supervisors evaluation.

## **CHEM ENG 3100 Chemical Engineering Fluid Flow** (LEC 3.0)

Mass, energy, and momentum balance concepts in fluid flow are studied to provide a basis for study of flow measurement, fluid behavior, turbulent flow, dimensional analysis of fluid flows, and the study of some practical flow processes such as: filtration, fluidization, compressible flow, pipe networks. Prerequisites: Chem Eng 2100 and Math 3304; Chem Eng majors only.

## **CHEM ENG 3101 Fundamentals of Transport in Chemical and Biochemical Engineering** (LEC 4.0)

This course covers the fundamentals of momentum, energy, and mass transport. Phenomenological mechanisms of molecular transport, fluid static, analysis of a fluid in motion laminar and turbulent flow are covered. The general differential equations for momentum, energy and mass transfer are presented and solved for a variety of chemical engineering problems. Prerequisites: Math 3304 and Chem Eng 2110. Admitted to the Chemical Engineering Program.

## **CHEM ENG 3110 Chemical Engineering Heat Transfer** (LEC 2.0)

Process principles of heat transfer in the chemical process industry. Steady and unsteady state heat conduction and radiation heat transfer. Free and forced convection and condensation and boiling heat transfer. Practical heat exchanger design. Prerequisites: Math 2222 and preceded or accompanied by Chem Eng 3100. Chem Eng majors only.

## **CHEM ENG 3111 Numerical Computing in Chemical and Biochemical Engineering** (LAB 1.0 and LEC 2.0)

The students are introduced to the concepts of engineering problem formulation, model building, and multi scale models. Matlab, spreadsheet and polymath computing are used to solve chemical engineering problems involving systems of linear and non linear algebraic equations, and ordinary and partial differential equations. Prerequisites: Math 3304 and either both Comp Sci 1971 and Comp Sci 1981 or both Comp Sci 1972 and Comp Sci 1982. Admitted to the Chemical Engineering Program.

## **CHEM ENG 3120 Chemical Engineering Thermodynamics II** (LEC 3.0)

Physical, chemical and reaction equilibrium. Study of the thermophysical relationships of multicomponent, multiphase equilibrium. Application of equilibrium relationships to the design and operation of chemical mixers, separators and reactors. Prerequisites: Grade of "C" or better in Chem Eng 2100 and Chem Eng 2110; Chem Eng majors only.

## **CHEM ENG 3130 Staged Mass Transfer** (LEC 3.0)

Principles of equilibrium stage operations applied to distillation, liquid-liquid extraction, absorption, and leaching. Methods for estimating pressure drop and stage efficiencies are also studied. Quantitative solutions to practical problems are stressed. Prerequisites: Chem Eng 3120, admitted to Chem Eng program.

## **CHEM ENG 3131 Separations in Chemical and Biochemical Engineering** (LEC 3.0)

Flash and column distillation. McCabe-Thiele method, plate efficiencies. Azeotropes. Batch distillation. Absorption and stripping. Washing and leaching. Prerequisites: Chem Eng 3101, Chem Eng 3111, and Chem Eng 3120. Admitted to the Chemical Engineering Program.

## **CHEM ENG 3140 Continuous Mass Transfer** (LEC 3.0)

Fundamentals of diffusion and mass transfer applied to absorption, extraction, humidification, drying and filtration. Design and rating of continuous chemical separators. Prerequisites: Preceded or accompanied by Chem Eng 3130. Chem Eng majors only.

## **CHEM ENG 3141 Process Operations in Chemical and Biochemical Engineering** (LEC 2.0)

Design and selection of pumps, fans, compressors, valves, and ejectors. Design and selection of heat exchangers, condensers and reboilers. Design of mixing equipment, sterilizers, sedimentation vessels, centrifuges, and filtration and ultrafiltration units. Prerequisites: Chem Eng 3101 and Chem Eng 3120. Admitted to the Chemical Engineering Program.

**CHEM ENG 3150 Chemical Engineering Reactor Design** (LEC 3.0)

The study of chemical reaction kinetics and their application to the design and operation of chemical and catalytic reactors. Prerequisites: Preceded or accompanied by either Chem Eng 3140 or Chem Eng 3200 or preceded by both Chem Eng 3111 and Chem Eng 3101. Admitted to Chem Eng program.

**CHEM ENG 3160 Molecular Chemical Engineering** (LEC 3.0)

Introduction to the molecular aspects of chemical thermodynamics, transport processes, reaction dynamics, and statistical and quantum mechanics. Prerequisites: Chem Eng 3120, admitted to Chem Eng program.

**CHEM ENG 3200 Biochemical Separations** (LEC 3.0)

The fundamentals of mass transfer are introduced and applied to various unit operations employed in the separation of chemical and biochemical compounds. Prerequisites: Chem Eng 3120. Chem Eng majors only.

**CHEM ENG 3210 Introduction to Biomedical Engineering** (LEC 3.0)

This course will provide an introduction to the interdisciplinary field of biomedical engineering. The molecular, cellular, physiological and engineering principles that govern the field will be covered. Applications will include biomaterials, tissue engineering, biomechanics, bioimaging, bioinstrumentation, bio-nanotechnology and artificial organs. Prerequisite: Junior standing or above. (Co-listed with Cer Eng 3110 and Bio Sci 3110).

**CHEM ENG 4000 Special Problems** (IND 0.0-6.0)

Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**CHEM ENG 4001 Special Topics** (LEC 3.0)

This course is designed to give the department an opportunity to test a new course. Variable title.

**CHEM ENG 4091 Chemical Process Design I** (LEC 1.0 and LAB 2.0)

Economic analysis of a chemical process including capital requirements, operating costs, earnings, and profits. The economic balance is applied to chemical engineering operations and processes. Optimization and scheduling techniques are applied to process evaluation. Preliminary process design and use of simulation software. Prerequisites: Either (Chem Eng 3150, Chem Eng 3131 and Chem Eng 3141) or (Chem Eng 3150 and preceded or accompanied by Chem Eng 5250).

**CHEM ENG 4096 Chemical Engineering Economics** (LEC 2.0)

Economic analysis of a chemical process including capital requirements, operating costs, earnings, and profits. The economic balance is applied to chemical engineering operations and processes. Optimization and scheduling techniques are applied to process evaluation. Prerequisite: Preceded or accompanied by Chem Eng 3130.

**CHEM ENG 4097 Chemical Process Design II** (LAB 2.0 and LEC 1.0)

Engineering principles involved in the design and layout of chemical process equipment. Material and energy balances, equipment selection and design, and preconstruction cost estimation are performed for a capstone design project. Communication emphasized course. Prerequisites: Chem Eng 3130 and Chem Eng 3150; preceded or accompanied by either Chem Eng 4091 or both Chem Eng 4110 and Chem Eng 4096.

**CHEM ENG 4099 Undergraduate Research** (IND 0.0-6.0)

Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

**CHEM ENG 4100 Chemical Engineering Laboratory I** (LAB 1.0 and LEC 1.0)

Experiments associated with unit operations involving fluid flow and heat transfer. Principles of data and uncertainty analysis are introduced with emphasis on model building. Communication skills are stressed. This is a communication emphasized course. Prerequisites: Chem Eng 3100 and Chem Eng 3110.

**CHEM ENG 4101 Chemical Engineering Laboratory I** (LEC 1.0 and LAB 2.0)

Experiments associated with unit operations involving fluid flow and heat transfer. Principles of data and uncertainty analysis are introduced with emphasis on model building. Communication skills are stressed. This is a communication emphasized course. Prerequisites: Chem Eng 3141.

**CHEM ENG 4110 Chemical Engineering Process Dynamics And Control** (LEC 3.0)

Study of the dynamics of chemical processes and the instruments and software used to measure and control temperature, pressure, liquid level, flow, and composition. Generally offered fall semester only. Prerequisites: Preceded or accompanied by any one of Chem Eng 4100 or Chem Eng 4130 or Chem Eng 4200; or preceded by Chem Eng 3150, Chem Eng 3131 and Chem Eng 3141; or preceded by Chem Eng 3150 and preceded or accompanied by Chem Eng 5250.

**CHEM ENG 4120 Process Dynamics And Control Laboratory** (LAB 1.0)

Application of concepts of industrial process dynamics and control using experiments that demonstrate different control and sensing devices and software. This is a communications emphasized course. Prerequisite: Preceded or accompanied by Chem Eng 4110.

**CHEM ENG 4130 Chemical Engineering Laboratory II** (LAB 2.0 and LEC 1.0)

Experiments illustrating the unit operations of continuous and staged separation. Experimental design methods are extended to include the principles of regression and model building. Communication skills are stressed. This is a communication emphasized course. Prerequisites: Chem Eng 3130 and Chem Eng 3140; or Chem Eng 3141 and Chem Eng 3131 and preceded or accompanied by Chem Eng 3150.

**CHEM ENG 4140 Chemical Process Safety** (LEC 3.0)

The identification and quantification of risks involved in the processing of hazardous and/or toxic materials are studied. Prerequisite: Preceded or accompanied by Chem Eng 3150.

**CHEM ENG 4150 Chemical Process Flowsheeting** (LEC 2.0 and LAB 1.0)

The development, implementation, and evaluation of methods for determining the mathematical model of a chemical process, ordering the equations in the mathematical model, and solving the model. Prerequisite: Math 3304 or graduate standing.

**CHEM ENG 4200 Biochemical Separations Laboratory** (LAB 2.0)

Introduction to the unit operations employed in the separation of chemicals and biochemicals. The experiments illustrate the staged and continuous separation systems that are involved. This is a communications emphasized course. Prerequisite: Chem Eng 3200.

**CHEM ENG 4201 Biochemical Separations and Control Laboratory** (LAB 2.0 and LEC 1.0)

Introduction to the unit operations employed in the separation of chemicals and biochemicals. The experiments illustrate the staged and continuous separation systems that are involved. Application of concepts of industrial process dynamics and control. Communications emphasized. Prerequisites: Chem Eng 5250.

**CHEM ENG 4210 Biochemical Reactors** (LEC 3.0)

Application of chemical engineering principles to biochemical reactors. Emphasis on cells as chemical reactors, enzyme catalysis and disposable technology. Prerequisite: Chem Eng 3150 or graduate standing.

**CHEM ENG 4220 Biochemical Reactor Laboratory** (LEC 1.0 and LAB 2.0)  
Introduction to the unit operations involved with the production of biochemicals. The experiments emphasize the isolation of proteins and enzymes from tissue and bacteria cells. This is a communications emphasized course. Prerequisites: Chem Eng 3200 and preceded or accompanied by Chem Eng 4210; or preceded or accompanied by Chem Eng 5250 and Chem Eng 4210.

**CHEM ENG 4230 Bioprocess Safety** (LEC 1.0)  
This course covers a risk assessment, biohazard containment and inactivation practices, and other biosafety issues relevant to industrial bioprocessing. Considerations relating to the release of genetically modified organisms are also discussed. Prerequisites: Preceded or accompanied by Chem Eng 4210.

**CHEM ENG 4241 Process Safety in the Chemical and Biochemical Industries** (LEC 3.0)

This course covers risk assessment, biohazard containment and inactivation practices, and other biosafety issues relevant to industrial bioprocessing. Considerations relating to the release of genetically modified organisms are also discussed. Prerequisites: Preceded or accompanied by Chem Eng 4210.

**CHEM ENG 4300 Patent Law** (LEC 3.0)  
A presentation of the relationship between patent law and technology for students involved with developing and protecting new technology or pursuing a career in patent law. Course includes an intense study of patentability and preparation and prosecution of patent applications. Prerequisite: Senior or graduate standing. (Co-listed with Eng Mgt 5514).

**CHEM ENG 4310 Interdisciplinary Problems In Manufacturing Automation** (LAB 1.0 and LEC 2.0)  
The course will cover material necessary to design a product and the fixtures required to manufacture the product. Participants will gain experience with CAD/CAM software while carrying out an actual manufacturing design project. (Co-listed with Mech Eng 5644, Eng Mgt 5315).

**CHEM ENG 5000 Special Problems** (IND 0.0-6.0)  
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**CHEM ENG 5001 Special Topics** (LEC 0.0 and LAB 0.0)  
This course is designed to give the department an opportunity to test a new course. Variable title.

**CHEM ENG 5010 Seminar** (RSD 0.0-6.0)  
Discussion of current topics.

**CHEM ENG 5040 Oral Examination** (IND 0.0)  
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**CHEM ENG 5096 Industrial Chemical Processes** (LEC 3.0)  
Detailed study of various industrial chemical manufacturing processes including underlying chemistry, reaction pathways and separation processes. Prerequisite: Chem Eng 3130 or Chem 2210, or graduate standing. (Co-listed with Chem 5250).

**CHEM ENG 5097 Intermediate Process Design** (LEC 3.0)  
Study of newer unit operations, fluidization, chromatographic absorption, new developments in operations previously studied. Comparison of operations which might be selected for the same end result in an industrial process. Prerequisite: Chem Eng 3130 or graduate standing.

**CHEM ENG 5100 Intermediate Transport Phenomena** (LEC 3.0)  
The similarities of flow of momentum, heat and mass transfer and the applications of these underlying principles are stressed. Course is primarily for seniors and beginning graduate students. Prerequisite: Chem Eng 3140 or Chem Eng 3200 or graduate standing.

**CHEM ENG 5110 Intermediate Chemical Reactor Design** (LEC 3.0)  
A study of homogeneous and heterogeneous catalyzed and noncatalyzed reaction kinetics for flow and batch chemical reactors. Application to reactor design is stressed. Prerequisite: Chem Eng 3150 or graduate standing.

**CHEM ENG 5120 Interfacial Phenomena In Chemical Engineering** (LEC 3.0)  
The course deals with the effects of surfaces on transport phenomena and on the role of surface active agents. Topics include fundamentals of thermodynamics, momentum, heat and mass transfer at interfaces and of surfactants. Some applications are included. Prerequisite: Chem Eng 3140 or Chem Eng 3200 or graduate standing.

**CHEM ENG 5130 Risk Assessment and Reduction** (LEC 3.0)  
Safe, secure manufacturing facilities protect the health of employees and the public, preserve the environment, and increase profitability. Methods for systematically identifying hazards and estimating risk improve the safety performance and security of manufacturing facilities. Prerequisite: Senior or Graduate Standing. (Co-listed with Eng Mgt 4312).

**CHEM ENG 5140 Intermediate Chemical Process Safety** (LEC 3.0)  
The identification and quantification of risks involved in the processing of hazardous and/or toxic materials are studied. Methods to design safety systems or alter the chemical process to reduce or eliminate the risks are covered. Prerequisite: Graduate Standing.

**CHEM ENG 5150 Intermediate Chemical Process Flowsheeting** (LEC 2.0 and LAB 1.0)  
The development, implementation, and evaluation of methods for determining the mathematical model of a chemical process, ordering the equations in the mathematical model, and solving the model. Projects on special topics and presentations related to the course materials will be included. Prerequisite: graduate standing.

**CHEM ENG 5160 Introduction to Molecular Modeling and Simulation** (LEC 3.0)  
An introduction to the concepts of molecular-based modeling and simulations, their connections to other engineering approaches and their role in multiscale modeling. Major methodologies such as molecular dynamics and lattice and off-lattice Monte Carlo, and special case studies are discussed. Prerequisite: Chem Eng 3160.

**CHEM ENG 5161 Intermediate Molecular Engineering** (LEC 3.0)  
Molecular aspects of chemical thermodynamics, transport processes, reaction dynamics, and statistical and quantum mechanics. Prerequisites: Chem Eng 3120 or graduate standing.

**CHEM ENG 5170 Physical Property Estimation** (LEC 3.0)  
Study of techniques for estimating and correlating thermodynamic and transport properties of gases and liquids. Prerequisite: Chem Eng 3130 or graduate standing.

**CHEM ENG 5180 Industrial Pollution Control** (LEC 3.0)  
The study of water, air, and thermal pollution control methods and the application of these methods to the solution of pollution problems in the chemical industry. Prerequisite: Chem Eng 3130 or graduate standing.

**CHEM ENG 5190 Plantwide Process Control** (LEC 3.0)

Synthesis of control schemes for continuous and batch chemical plants from concept to implementation. Multiloop control, RGA, SVD, constraint control, multivariable model predictive control, control sequence descriptions. Design project involving a moderately complicated multivariable control problem. Prerequisites: Chem Eng 4110 or Elec Eng 3320 or Elec Eng 3340 or graduate standing. (Co-listed with Elec Eng 5350).

**CHEM ENG 5200 Biomaterials I** (LEC 3.0)

This course will introduce senior undergraduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. Prerequisite: Senior undergraduate standing. (Co-listed with Bio Sci 5210, MS&E 5310).

**CHEM ENG 5210 Intermediate Biochemical Reactors** (LEC 3.0)

Application of chemical engineering principles to biochemical reactors. Emphasis on cells as chemical reactors, enzyme catalysis and production of monoclonal antibodies. Projects on special topics and presentations related to the course materials will be included. Prerequisite: Preceded or accompanied by Chem Eng 3150 or graduate standing.

**CHEM ENG 5220 Intermediate Engineering Thermodynamics** (LEC 3.0)

Review thermodynamic principles for pure fluids and mixtures. Emphasis on applications for the chemical industry and use of fundamental relations and equations of state. Prerequisite: Senior or graduate standing.

**CHEM ENG 5230 Bioprocess Safety** (LEC 1.0)

This course covers a risk assessment, biohazard containment and inactivation practices, and other biosafety issues relevant to industrial bioprocessing. Considerations relating to the release of genetically modified organisms are also discussed. Prerequisites: Graduate standing.

**CHEM ENG 5241 Intermediate Process Safety in the Chemical and Biochemical Industries** (LEC 3.0)

This course covers risk assessment, biohazard containment and inactivation practices, and other biosafety issues relevant to industrial bioprocessing. Considerations relating to the release of genetically modified organisms are also discussed. Prerequisites: Chem Eng 3150 or graduate standing.

**CHEM ENG 5250 Isolation and Purification of Biologicals** (LEC 3.0)

Isolation and purification of biologicals with emphasis on biopharmaceuticals. Principles and applications of chromatography, lyophilization, and product formulation. Use of ultrafiltration and diafiltration in the processing of protein products. Disposable technology. Prerequisites: Chem Eng 3131 and Chem Eng 3141.

**CHEM ENG 5300 Principles Of Engineering Materials** (LEC 3.0)

Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Aero Eng 3877, Physics 4523, Met Eng 5810, Cer Eng 5810).

**CHEM ENG 5305 Hazardous Materials Management** (LAB 1.0 and LEC 2.0)

Major themes: hazard identification and characterization; safety, health and environmental management; and the protection of safety, health and environment. Students will have an understanding of work place and environmental hazards in order to be able to facilitate their management and control. The course will include an intensive 30 hour hands-on workshop. Prerequisite: Chem Eng 3130 or graduate standing.

**CHEM ENG 5310 Structure And Properties Of Polymers** (LEC 3.0)

A study of the parameters affecting structure and properties of polymers. Syntheses, mechanisms, and kinetic factors are emphasized from the standpoint of structural properties. Prerequisite: Chem Eng 3130 or graduate standing.

**CHEM ENG 5315 Corrosion And Its Prevention** (LEC 3.0)

A study of the theories of corrosion and its application to corrosion and its prevention. Prerequisite: A grade of "C" or better in either Chem Eng 3120 or Cer Eng 3230. (Co-listed with Met Eng 4230).

**CHEM ENG 5320 Introduction to Nanomaterials** (LEC 3.0)

Introduction to the fundamentals of nanomaterials and recent developments on nanomaterials. Topics include physical and chemical properties, synthesis, processing, and applications of nanomaterials. Example nanomaterials include nanoparticles, nanotubes, and nanowires. Prerequisite: Chem Eng 2300, or Met Eng 1210 or Chem 1320.

**CHEM ENG 5330 Alternative Fuels** (LEC 3.0)

Global energy outlook and available resources are discussed. Alternative energy options and their technologies are covered. Associated environmental concerns and technology are assessed. Special emphases are placed on renewable energies, transportation fuels, energy efficiencies, and clean technologies. Prerequisite: Chem Eng 3130 or senior or graduate standing.

**CHEM ENG 5340 Principles Of Environmental Monitoring** (LEC 3.0)

This course introduces the fundamentals of particle technology, including particle characterization, transport, sampling, and processing. In addition, students will learn about the basic design of some industrial particulate systems and environmental and safety issues related to particulate handling. Prerequisites: Chem Eng 3100 and Physics 2135, or graduate standing.

**CHEM ENG 5350 Environmental Chemodynamics** (LEC 3.0)

Interphase transport of chemicals and energy in the environment. Application of the process oriented aspects of chemical engineering and science to situations found in the environment. Prerequisite: Chem Eng 3140 or Chem Eng 3200 or graduate standing.

**CHEM ENG 5360 Pollution Prevention Via Process Engineering** (LEC 3.0)

To arrive at environmentally benign process design, each processing system will be considered as an inter-connection of elementary units. Systematic methods capitalizing on synergistic process integrations will be employed. Linear, nonlinear and integer optimization, mass/heat exchange networks, and reactor and reaction networks will be used. Prerequisite: Chem Eng 3130 or graduate standing.

**CHEM ENG 5370 Intermediate Process Dynamics And Control** (LEC 3.0)

A study of the dynamic properties of engineering operations and the interrelationships which result when these operations are combined into processes. Formulation of equations to describe open-loop and closed-loop systems. Prerequisite: Chem Eng 3130 or graduate standing.

**CHEM ENG 5380 Intermediate Separation Processes** (LEC 3.0)

Fundamentals of separation operations such as extraction and distillation; rates of diffusion in equilibrium stages and continuous contactors; efficiencies; multistage contactors; performance of equipment; phase equilibrium data; multicomponent separation. Prerequisite: Chem Eng 3130 or graduate standing.

**CHEM ENG 6000 Special Problems** (IND 0.0-6.0)

Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**CHEM ENG 6001 Special Topics** (IND 0.0-6.0)

This course is designed to give the department an opportunity to test a new course. Variable title.

**CHEM ENG 6010 Graduate Seminar** (RSD 1.0-3.0)

Discussion of current topics. One of these topics will be expanded to write an in depth report. Prerequisites: Graduate standing.

**CHEM ENG 6015 Lecture Series** (LEC 1.0)

Attendance of lecture series and submission of in-depth report on one of the covered topics is required for a grade. The course can be taken multiple times for a grade, with the same requirement each time, and up to three times to be counted for 6000 level course requirement. Prerequisites: Graduate standing.

**CHEM ENG 6040 Oral Examination** (IND 0.0)

After completion of all other program requirements, oral examinations for on-campus Ph.D. students may be processed during intersession. Off-campus Ph.D. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**CHEM ENG 6050 Continuous Registration** (IND 1.0)

Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

**CHEM ENG 6085 Internship** (IND 0.0-15)

Students working toward a doctor of engineering degree will select, with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

**CHEM ENG 6099 Research** (IND 0.0-15)

Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

**CHEM ENG 6100 Advanced Chemical Engineering Thermodynamics** (LEC 3.0)

Extension of thermodynamic principles as applied to nonideal systems. Use of existing thermodynamic data and correlations with emphasis on applications of chemical engineering problems in energy, mass and momentum transfer.

**CHEM ENG 6110 Advanced Transport Phenomena** (LEC 3.0)

Course is concerned with all aspects of transport phenomena. Complete expressions for heat, mass and momentum transfer in all three coordinate systems are applied under both laminar and turbulent conditions. Prerequisite: Chem Eng 5100.

**CHEM ENG 6120 Applied Mathematics In Chemical Engineering** (LEC 2.0 and LAB 1.0)

An introduction to numerical methods for ordinary and partial differential equations arising in chemical engineering, bioengineering, and environmental engineering applications. Topics include finite difference and finite element methods; other numerical and analytical methods if time permits.

**CHEM ENG 6130 Advanced Chemical Reactor Design** (LEC 3.0)

A study of homogeneous and heterogeneous reaction kinetics and catalysis with special emphasis on effects of mixing in design and scale-up of chemical reactors.

**CHEM ENG 6140 Applied Optimization In Chemical Engineering** (LEC 3.0)

An introduction to modern optimization techniques having applications in engineering economics, data analysis, process design and dynamics; methods such as Fibonacci, Partan, steep ascent, geometric, mathematical and dynamic programming.

**CHEM ENG 6150 Molecular Modeling and Simulation** (LEC 3.0)

Study of molecular-based modeling and simulation methodologies and their connections with each other and to multiscale modeling and other engineering approaches. Molecular Dynamics, Monte Carlo, Brownian Dynamics, statistical mechanics, and application cases in engineering and science are included. Prerequisite: Chem Eng 6100.

**CHEM ENG 6160 Advanced Chemical Process Design** (LEC 2.0 and LAB 1.0)

The use of advanced methods of economic, engineering, optimizing, and control techniques in planning, designing, and operating chemical process industries. Topics may be adjusted to include those of special interest or need in the above fields.

**CHEM ENG 6170 Advanced Fluid Flow** (LEC 3.0)

Fundamentals of Newtonian flow, non-Newtonian flow, flow through packed beds, two phase flow, flow around submerged objects and other related topics. Fundamentals of statistical theory of turbulence, turbulence modeling for transport processes. Theories of turbulent diffusion associated with mixing.

**CHEM ENG 6300 Biomaterials II** (LEC 3.0)

This course will introduce graduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. A term paper and oral presentation are required. Prerequisite: Graduate Standing. (Co-listed with BIO SCI 6210, MS&E 6310).

**CHEM ENG 6310 Nanomaterials** (LEC 3.0)

Introduction of the fundamentals of nanomaterials and recent developments on nanomaterials. Topics include physical and chemical properties, synthesis, processing, and applications of nanomaterials. Example nanomaterials include nanoparticles, nanotubes, and nanowires. Students will need to complete a project related to nanomaterials. Prerequisite: Graduate Standing. (Co-listed with MS&E 6230).

**CHEM ENG 6320 Plasma Polymerization** (LEC 3.0)

Fundamental aspects of polymer formation in plasma (weakly ionized gas), and properties of polymers formed by such a process are studied. Prerequisite: Chem Eng 4710.

***CHEM ENG 6330 Physicochemical Operations In Environmental Engineering Systems*** (LEC 3.0)

Course covers physicochemical operations and design in water, wastewater and aqueous hazardous waste treatment systems including coagulation, precipitation, sedimentation, filtration, gas transfer, chemical oxidation and disinfection, adsorption, ion exchange. Prerequisite: Civ Eng 3330 or equivalent. (Co-listed with Env Eng 6611 and Civ Eng 6611).

***CHEM ENG 6340 Philosophy of Scientific Research*** (LEC 3.0)

Organization and planning of research. Introduction to the philosophy and management of scientific research, particularly issues related to ethics, plagiarism, ownership of intellectual properties, research techniques, technical presentations and time management. The course will address these issues by integrating with case studies. (Co-listed with IDE 425, Civ Eng 6940, Env Eng 6940, Elec Eng 6810, Comp Eng 6810).