Emphasis area at bachelor of science level in biochemical engineering

Chemical engineering is the branch of engineering which deals with changing the composition, energy content and state of aggregation of materials. As a chemical engineering student, you will consider the fundamental properties and nature of matter (chemistry), the forces that act on matter (physics) and the precise expressions of the relationships between them (mathematics). Extensive use is made of computers in the application of these sciences to engineering problems.

As a chemical engineer, you may study ways in which pure water can be obtained from the sea; design processes to provide fertilizers, rubber, fibers, and fuels; or team up with other engineers and scientists in biomedical engineering to develop specialized polymeric materials for use in artificial arms, legs and other human organs. You may be instrumental in finding supplemental food sources for man, such as protein from petroleum, wood, or the sea. You might help develop new processes for the application of biochemistry, energy conservation, or environmental control, such as reducing undesirable substances in the air. Or, you might have a hand in the creation of strong lightweight materials to be used in aircraft construction. Your opportunities will be unlimited.

At Missouri S&T, you will have laboratories available which offer training in qualitative and quantitative analysis, basic organic and physical chemistry, physics, unit operations, biochemical engineering, design and automatic process control.

Your studies will give you a broad technical basis with an emphasis on material balances, energy balances, separation processes, rate processes, unit operations, process economics safety and design.

Among its facilities, the department features digital data acquisition and control equipment for research and instruction which allows simultaneous utilization of the system by several people. A full complement of hardware exists for input and output of signals to and from process equipment and instrumentation. The campus computer network makes available a wide variety of professional software. Also included is equipment to measure thermodynamic and physical properties, study biochemical engineering processes, polymers, surface phenomena, fluid mechanics, membranes, chemical kinetics and diffusion.

Mission Statement

The chemical and biochemical engineering department:

1. Prepares chemical engineers for successful careers of leadership and innovators in chemical engineering and related fields
2. Expands the knowledge base of chemical engineering through its scholarly pursuits
3. Develops technology to serve societal needs
4. Benefits the public welfare through service to chemical engineering and related professions

BSChE Program Educational Objectives:

Program graduates:

1. Become successful in their chosen career path
2. Undertake responsibility or leadership roles in their industry, business and/or community
3. Work in teams to improve the economic environment of their industry sector and/or community
4. Maintain career skills through life-long learning

Bachelor of Science
Chemical Engineering

Entering freshmen desiring to study chemical engineering will be admitted to the Freshman Engineering Program. They will be permitted, if they wish, to state a chemical engineering preference, which will be used as a consideration for available freshman departmental scholarships. The focus of the Freshman Engineering Program is on enhanced advising and career counseling, with the goal of providing to the student the information necessary to make an informed decision regarding the choice of a major.

For the bachelor of science degree in chemical engineering a minimum of 129 credit hours is required. These requirements are in addition to credit received for algebra, trigonometry and basic ROTC courses. An average of at least two grade points per credit hour must be attained. At least two grade points per credit hour must also be attained in all courses taken in chemical engineering.

Each student's program of study must contain a minimum of 21 credit hours of course work in general education and must be chosen according to the following rules:

1. All students are required to take one American history course, one economics course, one humanities course, and ENGLISH 1120. The history course is to be selected from HISTORY 1200, HISTORY 1300, HISTORY 1310, or POL SCI 1200. The economics course may be either ECON 1100 or ECON 1200. The humanities course must be selected from the approved lists for art, English, foreign languages, music, philosophy, speech and media studies, or theater.
2. Depth requirement. Three credit hours must be taken in humanities or social sciences at the 1000 level or above and must be selected from the approved list. This course must have as a prerequisite one of the humanities or social sciences courses already taken. Foreign language courses numbered 1180 will be considered to satisfy this requirement. Students may receive humanities credit for foreign language courses in their native tongue only if the course is at the 3000 level or above. All courses taken to satisfy the depth requirement must be taken after graduating from high school.
3. The remaining two courses are to be chosen from the list of approved humanities/social sciences courses and may include one communications course in addition to ENGLISH 1120.
4. Any specific departmental requirements in the general studies area must be satisfied.
5. Special topics and special problems and honors seminars are allowed only by petition to and approval by the student’s department chairman.

The chemical engineering program at Missouri S&T is characterized by its focus on the scientific basics of engineering and its innovative application; indeed, the underlying theme of this educational program is the application of the scientific basics to engineering practice through attention to problems and needs of the public. The necessary
interrelations among the various topics, the engineering disciplines, and the other professions as they naturally come together in the solution of real world problems are emphasized as research, analysis, synthesis, and design are presented and discussed through classroom and laboratory instruction.

### Freshman Year

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<th>First Semester</th>
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<td>FR ENG 1100</td>
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### Sophomore Year

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### Junior Year

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### Senior Year\(^3\)

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<td>Chem Eng 5xxx-Chem Eng Elective(^6)</td>
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Total Credits: 129

**Note:** The minimum number of hours required for a degree in chemical engineering is 129.

A cumulative grade point average of 2.50 or better and a "C" or better in Chem 1310, Chem 1319, Chem 1320, Math 1214, Math 1215 and Physics 1135 are required to be admitted into the chemical engineering major.

1. A grade of "C" or better is required in Chem Eng 2100 & Chem Eng 2110 in order to enroll in Chem Eng 3120.
2. Communications emphasized course (See bachelor of science degree, general education communications requirement).
3. Prior to graduation, all chemical engineering majors must take the fundamentals of engineering exam (See assessment requirements, major field). A passing grade is not required to earn a degree, however it is the first step toward becoming a registered professional engineer.
4. From approved list published on the website of Undergraduate Studies. The prerequisites for the upper level course must be completed with a passing grade.
5. CHEM 2510 (Analytical Chemistry Lec 3 Lab 1) or CHEM 4610 (Biochem. Lec 3) and CHEM 4619 (Biochem Lab 2) or BIO SCI 2213 (Cell Biology Lec 3) and BIO SCI 2219 (Cell Biology Lab 1) or CHEM 2220 (Organic Chemistry II, Lect 4) and CHEM 2289 (Lab 1) or Bio Sci 3313 (Microbiology Lec 3) and Bio Sci 3319 (Microbiology Lab 2) or CHEM 3420. (Quantum Chemistry Lec 3) and CHEM 3419 (Physical Chem. Lab 1).
6. Any Chem Eng 5xxx and any class from the approved list published in the Chemical Engineering web site but only 3 cr. hr. of Chem. Eng. 4000, Chem Eng 4099 or Chem Eng 4099. Students may have no more than three hours from approved, out-of-department elective.

### Chemical Engineering

#### Biochemical Engineering Emphasis

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Total Credits: 15

### 2016-2017
Honors in Chemical and Biochemical Engineering

CBE requires the student to complete a three semester long project with 6 or 9 credit hours of CHEM ENG 4099H-Undergraduate Research Honors, three hours counting towards the technical elective and up to 6 towards free electives. CHEM ENG 4099H cannot be taken without a GPA of 3.5. It is necessary to start and finish with the same advisor. The report has to be validated by a committee consisting of at least the project advisor and the CBE honors program advisor. A form has to be sent to the department chair to start and another to complete the process.

Honors projects have no known solutions and in that, the successful completion of the project shows the ability of the candidates to solve problems. The three semesters make the study in-depth. And the report will contribute towards building good technical writing abilities. This report can be shown to all technical people to make a point about the lasting skills that have been achieved along with the B.S. degree.

Muthanna Hikmat Al Dahhan, Professor
DSc Washington University

Baojun Bai, Associate Professor
PHD New Mexico Institute of Mining

Dipak Barua, Assistant Professor
PHD North Carolina State University

Sutapa Barua, Assistant Professor
PHD Arizona State University

Neil L Book, Associate Professor Emeritus
PHD University of Colorado-Boulder

Hank Foley, Joint Appointment with University of Missouri-Columbia
PHD Penn State University

Daniel Forciniti, Professor
PHD North Carolina State University

Chang-Soo Kim, Associate Professor
PHD Kyungpook National University

Xinhua Liang, Assistant Professor
PHD University of Colorado-Boulder

Athanasios I Liapis, Professor
PHD Swiss Federal Institute of Technology

Douglas K Ludlow, Professor
PHD Arizona State University

Christi Luks, Associate Teaching Professor
PHD University of Tulsa

Parthasakha Neogi, Professor
PHD Carnegie Mellon University

Joontaek Park, Assistant Professor
PHD University of Florida

Fateme Rezaei, Assistant Professor
PHD Monash University - Melbourne, Australia

Ali Rownaghi, Assistant Research Professor
PHD University Putra - Malaysia

Michael Stephen Schmidt, Adjunct Professor
MS University of Missouri-Rolla

Oliver Clifford Sitton, Associate Professor
PHD University of Missouri-Rolla

Joseph D Smith, Professor
PHD Brigham Young University

Jee-Ching Wang, Associate Professor
PHD Pennsylvania State University

David J Westenberg, Associate Professor
PHD University of California-Los Angeles

Silviya Petrova Zustiak, Joint Appointment with St. Louis University
PHD University of Maryland Baltimore County
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 (LAB 0.0 and LEC 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; Math 1215 (or 1221); preceded or accompanied by Phys 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 both Comp Sci 1971 and Comp Sci 1981. 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)

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 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 Process Design I (LAB 2.0 and LEC 1.0)
Prerequisite: Chem Eng 3120. Process design and use of simulations
software. This course covers a risk assessment, biohazard containment and
deployment of genetically modified organisms are also discussed. Prerequisites:
Preceded or accompanied by Chem Eng 4210 or 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. Preliminary
process design and use of simulations 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 4097 Chemical Process Design (LAB 2.0 and LEC 1.0)
Prerequisite: Chem Eng 3130 or preceded or accompanied by Chem Eng 4100.
Chapters 1-26 of Cengel, Y. and Boles, S. 2010. Thermodynamics: An

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
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 (LAB 2.0 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 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 communications 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 (LAB 1.0 and LEC 2.0)
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. Prerequisites: Chem Eng 3150 or graduate standing.

CHEM ENG 4220 Biochemical Reactor Laboratory (LAB 2.0 and LEC 1.0)
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 either Chem Eng 4210 or Chem Eng 5250.

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

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

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

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

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

CHEM ENG 5001 Special Topics

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

CHEM ENG 5010 Seminar

Discussion of current topics.

CHEM ENG 5040 Oral Examination

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

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

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

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

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

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

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

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

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

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

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

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

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

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 Biocatalysis

This course will introduce senior undergraduate students to a broad array of topics in biocatalysis, including fermentation, enzymatic reactions, and applications in biotechnology. 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 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 indentification 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: "C" or better grade in either Chem 3430 or Cer Eng 3230. (Co-listed with Met Eng 4220).

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 3100 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.