

# CHEMICAL ENGINEERING (CHEM ENG)

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**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.

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**CHEM ENG 2100 Chemical Engineering Material & Energy Balances** (LEC 4.0)

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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**CHEM ENG 3111 Numerical Computing in Chemical and Biochemical Engineering** (LEC 3.0)

Students will add to their programming skills by exploring numerical computational techniques for solving and analyzing algebraic and calculus-based equations and systems of equations that describe chemical engineering processes. Prerequisites: Math 3304 and either Comp Sci 1500, or both Comp Sci 1570 and Comp Sci 1580, or both Comp Sci 1971 and Comp Sci 1981, or both Comp Sci 1972 and Comp Sci 1982; preceded or accompanied by Chem Eng 2100.

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**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.

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**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.

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**CHEM ENG 3141 Process Operations in Chemical and Biochemical Engineering** (LEC 3.0)

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.

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**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 both Chem Eng 3111 and Chem Eng 3101.

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**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.

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**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).

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**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.

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**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.

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**CHEM ENG 4091 Chemical Process Design I** (LEC 3.0)

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: Chem Eng 3131 and Chem Eng 3141; preceded or accompanied by either Chem Eng 3150 or Chem Eng 5250; preceded or accompanied by either English 3560 or English 1160.

**CHEM ENG 4097 Chemical Process Design II** (LEC 3.0)

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 3150 and Chem Eng 4091; preceded or accompanied by Chem Eng 4110.

**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 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: Stat 3113 and Chem Eng 3141; Preceded or accompanied by ChemEng 4110.

**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: Chem Eng 3150, Chem Eng 3131 and Chem Eng 3141.

**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: Stat 3113, Chem Eng 3141 and Chem Eng 3131; preceded or accompanied by Chem Eng 3150 and either English 3560 or English 1160.

**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: Stat 3113; Preceded or accompanied by 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** (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: Stat 3113; 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, hazardous and/or toxic materials containment, environmental impact, safety regulations, and other safety issues relevant to chemical and biochemical industries. Prerequisites: Preceded or accompanied by Chem Eng 3150.

**CHEM ENG 4301 Chemical Process Materials** (LEC 1.0)

Seminar to highlight the classification, properties, selection, and processing of engineering materials that may include polymers, electronic materials, biomaterials, and nanomaterials. Students will research related topics for presentation and discussion. Prerequisites: Physics 1135.

**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 4311 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. Prerequisite: Senior standing.

**CHEM ENG 4540 Energy Economics** (LEC 3.0)

For students interested in both economic and engineering issues of energy policy. Provides an assessment of economics and technology issues related to traditional and renewable energy resources. Presented in a framework that allows for analysis of the economic trade-offs between energy sources and the technologies associated with their use and extraction. Prerequisite: Econ 1100 or Econ 1200. (Co-listed with Econ 4540 and Min Eng 4524).

**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. Prerequisite: Consent of Instructor Required.

**CHEM ENG 5001 Special Topics** (LAB 0.0 and LEC 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 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 3101 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 3131 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 5150 Intermediate Process Computing** (LAB 1.0 and LEC 2.0)

Analysis of chemical processes from model development to solution. Emphasis on numerical computational techniques and tools appropriate for ordinary and partial differential equation solution. Prerequisite: Graduate standing.

**CHEM ENG 5161 Intermediate Molecular Engineering** (LEC 3.0)

Molecular aspects of chemical thermodynamics, transport processes, reaction dynamics, and statistical and quantum mechanics, and their treatments in molecular-based modeling and simulation approaches. 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 3131 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: Chem Eng 3120 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** (LEC 3.0)

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 3131 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 3131 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 2110 or Cer Eng 3230. (Co-listed with Met Eng 5310).

**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 5325 Carbon Capture Process Engineering** (LEC 3.0)

An introduction to the process technologies and material design associated with capturing carbon in industrial operations to reduce carbon emission, reutilizing captured carbon in oil and chemical process industries, and extracting carbon from the atmosphere to mitigate greenhouse effect and climate change. Prerequisites: Chem Eng 3150 or graduate standing.

**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 3131 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 3101 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 3131 or graduate standing.

**CHEM ENG 5355 Process Control System Safety, Security and Alarms** (LEC 3.0)

Lifecycle approach for industrial automation in the context of IEC 61511 (safety) and IEC 62443 (IACS cybersecurity) standards. Functional safety and cybersecurity fundamentals for risk analysis, safety/cybersecurity requirements, inherently safer/secure design techniques, SIL/SL verification, operations, real-world cybersecurity attacks, alarm management. Prerequisites: Elec Eng 3320, Elec Eng 3340, or Chem Eng 4110. (Co-listed with Elec Eng 5355).

**CHEM ENG 5810 Introduction to Polymeric Materials** (LEC 3.0)

A basic study of the organic chemistry of natural and synthetic high polymers, their inherent properties and their uses in plastic, fiber, rubber, resin, food, paper and soap industries. Credit may not be given for both Chem 5810 and Chem 4810. Prerequisites: Chem 1320. (Co-listed with Chem 5810 and MS&E 5810).

**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** (LEC 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.

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**CHEM ENG 6085 Internship** (IND 1.0-15)

Students working toward a graduate (M.S. or Ph.D.) degree will select, with the advice of their committees, appropriate work experience 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 degree.

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**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.

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**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.

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**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.

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

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.

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**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.

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**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.

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**CHEM ENG 6180 Advanced Applications of Computational Fluid Dynamics** (LEC 3.0)

Advanced applications of CFD analyses is presented to investigate mass, momentum and heat transport in complex geometries with general initial and boundary conditions. Students will gain practical experience using commercial CFD codes and learn and apply a general algorithm for solving challenging industrial problems using tutorials. Prerequisites: Chem Eng 5100 and either Chem Eng 3111 or Chem Eng 5150.

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**CHEM ENG 6241 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.

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**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).

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**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).

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**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).

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