The department of chemical and biochemical engineering offers M.S. and Ph.D. degrees in chemical engineering.

A baccalaureate degree in chemical engineering with a minimum undergraduate grade point average of 3.0/4.0 or equivalent is required for admission to the graduate program.

The department specializes in research in the areas of fluid mechanics, supercritical fluid technology, reaction engineering, biochemical engineering, mass and heat transfer in porous media, transport and interfacial phenomena, computer-aided design, particle characterization, catalysis, statistical mechanics and nanotechnology.

All students, except for those in their last semester of graduate study, need to register for 1 credit hour of CHEM ENG 5010 Seminar.

All students, except for those in their first semester and in their last semester for PhD candidates, need to register for 1 credit hour of CHEM ENG 6015 Lecture Series. Lecture Series can be used for a total of 3 hours towards the students 6000 level requirement.

The master of science thesis program consists of a minimum of 30 semester hours, including 18-24 hours of coursework, in which CHEM ENG 5100, CHEM ENG 5110, and CHEM ENG 6100 are required. In addition, a thesis from research that is equivalent to 6-12 credit hours in the major area must be prepared and defended.

A master of science non-thesis program consists of 30 semester hours of coursework, including CHEM ENG 5100, CHEM ENG 5150, CHEM ENG 5110, CHEM ENG 5220 and a minimum of 24 hours of coursework within the department. The program of study must include nine credit hours of 6000 level courses.

A candidate for the Ph.D. degree normally follows a program of 72 semester hours beyond the BS degree or 42 semester hours beyond the MS degree. Research for M.S. and Ph.D. may be coordinated, or a Ph.D. may be pursued without an M.S. degree. The Ph.D. coursework must satisfy the departmental core course requirements for the M.S. degree with an additional 6 credit hours of 6000-level coursework for a minimum of 12, 6000-level credit hours. In addition to these course requirements, a candidate must prepare and defend a dissertation based on analytical and/or experimental research.

All Ph.D. students must pass the qualifying exam which consists of written and oral assignments specified by the department.

At least three members of the advisory committee have to be ChE faculty. The comprehensive examination, consisting of a written and oral presentation of a research proposal, should be taken in the semester following the completion of their course work and no later than six months prior to the final examination. The final examination, consisting of the dissertation defense, is conducted according to the rules of the graduate faculty, College of Engineering and Computing, and the department.

Muthanna Hibmat Al Dahhan, Professor
DSc Washington University
Department Chair. Multiphase reaction and reactor engineering flow systems; transport-kinetic integration; advanced measurement and computational techniques; applications to green technology and sustainable development in energy, products, and environment.

Baojun Bai, Associate Professor
PHD New Mexico Institute of Mining
Enhanced oil recovery target, conformance control, surfactants, biosurfactants, carbon sequestration.

Dipak Barua, Assistant Professor
PHD North Carolina State University
Computational systems biology, cell singling systems.

Sutapa Barua, Assistant Professor
PHD Arizona State University
Nanoparticles for uniform drug delivery, early detection of cancer cells, treatment of devastating diseases.

Neil L Book, Associate Professor Emeritus
PHD University of Colorado-Boulder
Computer-aided chemical process design, electronic information management, and chemical process safety.

Hank Foley, Joint Appointment with University of Missouri-Columbia
PHD Penn State University
Catalysis and reaction engineering.

Daniel Forciniti, Professor
PHD North Carolina State University
Applications of molecular theories to problems in biochemical engineering and science. Bioseparation. Protein characterization and computer simulations of biological systems.

Chang-Soo Kim, Associate Professor
PHD Kyungpook National University
Functional integration and structural integration of advanced microsystems, biosensors.

Xinhua Liang, Assistant Professor
PHD University of Colorado-Boulder
Surface science and catalysis, nano-structured films and devices, energy and environmental applications.
Athanasios I Liapis, Professor
PHD Swiss Federal Institute of Technology
Modeling of mass and heat transfer mechanisms in separation processes and heterogeneous chemical reaction systems; adsorption/desorption; lyophilization; chromatography; affinity chromatography; perfusion chromatography; transport phenomena; biochemical engineering.

Douglas K Ludlow, Professor
PHD Arizona State University
Surface characterization, catalysts, adsorption.

Christi Luk, Associate Teaching Professor
PHD University of Tulsa
Engineering education pedagogy, sustainable engineering.

Parthasakha Neogi, Professor
PHD Carnegie Mellon University
Interfacial and transport phenomena.

Joontaek Park, Assistant Professor
PHD University of Florida
Dynamics and rheology of complex fluids/soft matters.

Fateme Rezai, Assistant Professor
PHD Monash University - Melbourne, Australia
Adsorption, energy efficient separation processes, process design, modeling and optimization; PSA/TSA; and hybrid materials and process for separation and reaction.

Ali Rownaghi, Assistant Research Professor
PHD University Putra - Malaysia
Sustainable energy; catalysis; separations.

Oliver Clifford Sitton, Associate Professor
PHD University of Missouri-Rolla
Modeling and scale-up of ultra-sonic systems, effect of ultrasonics on mass transport and chemical kinetics with emphasis on polymer reactions, phase transfer catalysis and oxidation; biotechnology and bioprocessing with emphasis on biochemical reactor design and operation.

Joseph D Smith, Professor
PHD Brigham Young University
Laufer Chair of Energy. Hybrid energy generation, gas flare design, process modeling, and control.

Jee-Ching Wang, Associate Professor
PHD Pennsylvania State University
Molecular modeling and simulation, nanofluid and nanoparticle technology, interfacial phenomena and dynamics, transport in porous media, parallel computing and new simulation techniques.

David J Westenberg, Associate Professor
PHD University of California-Los Angeles
Molecular microbiology, microbial diversity, microbial physiology.

Silviya Petrova Zustiak, Joint Appointment with St. Louis University
PHD University of Maryland Baltimore County
Tissue engineering, synthetic biomaterials.

**CHEM ENG 5001 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 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 adsorption, and 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 Flowsheating** (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. Projects on special topics and presentations related to the course materials will be included. Prerequisite: graduate standing.

**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 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.

**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 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 5220 Introduction to Nanomaterials (LEC 3.0)**

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 5230 Bioprocess Safety (LEC 1.0)**

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 5240 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 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 3131 and Chem 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.

**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 doctoral 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 (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.

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 (LAB 1.0 and LEC 2.0)
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)

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).