CHEMICAL & BIOCHEMICAL ENGINEERING

The Linda and Bipin Doshi Department of Chemical and Biochemical Engineering has excellent research and teaching facilities in the 68,000 square foot Bertelsmeyer Hall and pursues cutting-edge experimental, computational, and theoretical projects. The principal areas of research include biomanufacturing and pharmaceutical engineering, bioseparations and bioassembly, multiphase reactors engineering, nanostructured materials and nanotechnology, adsorption and separation, transport and interfacial phenomena, modeling-aided design and characterization, thermodynamics and statistical mechanics, sustainable infrastructure, environmental remediation, energy technology, process design, and education pedagogies.

Examples of recent and ongoing graduate research topics include drug and gene delivery, protein purification, protein aggregation, static light scattering, polymeric nanoparticles, nanofluids, nano-film coating, atomic layer deposition, flue gas and wastewater treatments, petroleum hydrotreating, advanced process measurement, reaction mechanisms and kinetics, battery, energy materials, porous media, structured adsorbents, metal organic framework, hydrogel, gas separation, hydrogen storage, catalysis, membrane, dynamic contact angles, solubilization kinetics, electrodeposition, enhancement oil recovery, cement-based materials, CO_2 capture and utilization, gas flare design, hybrid energy systems, process intensification, control and optimization, hydrocarbon lubricants, food dehydration, molecular and multiscale modeling.

The graduate program of the Linda and Bipin Doshi Department of Chemical and Biochemical Engineering offers M.S. and Ph.D. degrees in chemical engineering. A baccalaureate degree in chemical engineering or a closely allied discipline with a minimum undergraduate grade point average of 3.0/4.0 or equivalent is required for admission into one of the graduate degree programs.

The departmental core courses for the graduate program are CHEM ENG 5100, CHEM ENG 5110, CHEM ENG 5150 and CHEM ENG 5220. All students, except for those in their first semester and in their last semester as PhD students, need to register for 1 credit hour of CHEM ENG 6015 Lecture Series every semester. Lecture Series can be used for a total of 3 credit hours towards graduate students' 6000 level course requirement.

The master of science thesis program consists of a minimum of 30 semester hours, including 9-12 hours from the departmental graduate core course requirement, with CHEM ENG 5150 being an optional course, plus 6-12 hours of additional coursework. A M.S. thesis from research must also be prepared and defended, which shall include 6-12 credit hours of CHEM ENG 6099.

A master of science non-thesis program consists of 30 semester hours of coursework, including 12 hours from the departmental graduate core course requirement plus 12 hours of additional coursework within the department. The program of study must include a minimum of 9 credit hours of 6000-level courses in or out of the department, of which up to three can come from CHEM ENG 6015.

A candidate for the Ph.D. degree normally follows a program of 72 semester hours beyond the B.S. degree or 42 semester hours beyond the M.S. 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 graduate core course requirement and must include CHEM ENG 6100, CHEM ENG 6110, and at least 6 additional hours of 6000-level courses in or out of the department for a minimum of twelve 6000-level credit hours. To maintain PhD candidacy, a minimum GPA of 3.0 from 5000- and 6000-level courses on campus is required.

In addition to the course requirements, all Ph.D. students must pass the qualifying exam, which consists of written and oral assignments specified by the department. The comprehensive examination, consisting of written and oral presentation of a research proposal, should be taken following the completion of all required coursework and at least 12 weeks prior to the final examination. The final examination, consisting of the dissertation defense based on PhD research, should be conducted according to the rules of the graduate faculty, College of Engineering and Computing, and the department. A PhD candidate, in consultation with the candidates research advisor, should form an advisory committee for comprehensive exam and dissertation defense. The advisory committee is chaired by the research advisor and must include at least three CHEM ENG faculty members.

Carbon Management Engineering Certificate

The Carbon Management Engineering Certificate Program introduces the students to carbon management strategies related to the engineering principles of carbon capture, transformation, and storage. It is open to all persons holding a B.S., M.S., or Ph.D. degree in chemical engineering, petroleum engineering, mechanical engineering, or a closely allied discipline, including those who are currently accepted into a graduate degree program at Missouri S&T. It requires the students to complete three carbon management courses offered by Chemical and Biochemical Engineering (ChBE), Mechanical and Aerospace Engineering (MAE), and Geosciences and Geological and Petroleum Engineering (GGPE), respectively, plus an additional course to be selected from a variety of existing courses from these same departments.

In order to be admitted, a student must have an overall GPA of 3.0, or 2.75 with a minimum of one year of work experience. Once admitted to the program, the student must take the four designated courses. To receive the certificate, the student must have an average cumulative grade point of 3.0 or better in the certificate courses. Once admitted to the certificate program, a student will be given three years to complete the program.

Students admitted to the Carbon Management Engineering Certificate Program will have non-degree graduate status but will earn graduate credit for the courses they complete. If the students complete the four-course sequence with a grade of B or better in each of the courses taken, they, upon application, will be automatically admitted to the non-thesis MS degree program that is appropriate based on the undergraduate program from which they graduated in either Chemical Engineering, Petroleum Engineering, or Mechanic Engineering. Students may also apply and be considered for admission to thesis-based MS or PhD programs in the same areas. The certificate credits taken by the students admitted to any of these degree programs will count towards their degree requirements.

The following three courses are required:

CHEM ENG 5325	Carbon Capture Process Engineering	3
PET ENG 5050	Carbon Storage	3
MECH ENG 5535	Carbon Conversion and Energy Utilization	3

One 3-credit course selected from the following list:		
CHEM ENG 5100	Intermediate Transport Phenomena	3
CHEM ENG 5110	Intermediate Chemical Reactor Design	3
CHEM ENG 5120	Interfacial Phenomena In Chemical Engineering	3
CHEM ENG 5150	Intermediate Process Computing	3
CHEM ENG 5161	Intermediate Molecular Engineering	3
CHEM ENG 5170	Physical Property Estimation	3
CHEM ENG 5190	Plantwide Process Control	3
CHEM ENG 5220	Intermediate Engineering Thermodynamics	3
CHEM ENG 5330	Alternative Fuels	3
CHEM ENG 5340	Principles of Environmental Monitoring	3
CHEM ENG 5350	Environmental Chemodynamics	3
CHEM ENG 6150	Molecular Modeling and Simulation	3
CHEM ENG 6180	Advanced Applications of Computational Fluid Dynamics	3
CHEM ENG 6241		3
GEOPHYS 4231	Seismic Interpretation	3
GEOPHYS 5202	Exploration and Development Seismology	3
GEOLOGY 5311	Depositional Systems	3
GEOLOGY 5511	Applied Petroleum Geology	3
GEOLOGY 5513	Petroleum Geology	3
GEOLOGY 5661	Advanced Stratigraphy and Basin Evolution	3
GEOLOGY 6511	Advanced Petroleum Geology	3
GEOLOGY 6621	Clastic Sedimentary Petrology	3
GEOLOGY 6811	Sedimentary Basin Analysis	3
PET ENG 4111	Fundamental Digital Applications In Petroleum Engineering	3
PET ENG 4210	Drilling and Well Integrity	3
PET ENG 4311	Reservoir Characterization	3
PET ENG 4590	Subsurface Energy Economics	3
PET ENG 4720	Reservoir Geomechanics	3
PET ENG 6621	Advanced Applied Reservoir Simulation	3
PET ENG 6711	Geodynamics	3
MECH ENG 5229	Smart Materials and Sensors	3
MECH ENG 5420	Signal Processing for Instrumentation and Control	3
MECH ENG 5523	Transport Phenomena In Manufacturing Processes	3
MECH ENG 5527	Combustion Processes	3
MECH ENG 5533	Internal Combustion Engines	3
MECH ENG 5537	Fuel Cell Principles	3
MECH ENG 5541	Applied Energy Conversion	3
MECH ENG 5543	Energy Efficiency of Vehicles	3
MECH ENG 5544	Non-Intrusive Measurement Methods	3
MECH ENG 5566	Solar Energy Technology	3
MECH ENG 5571	Environmental Controls	3
MECH ENG 5757	Integrated Product And Process Design	3
MECH ENG 5764	Introduction to Decision Analysis	3

Chemical Process Engineering Certificate

The graduate certificate in Chemical Process Engineering allows working professionals to add to skills relevant to their career while developing a deeper understanding of chemical engineering fundamentals.

The graduate certificate program is open to all individuals holding a bachelor's degree in chemical engineering or a closely allied discipline with an overall GPA of 3.0 or those holding a bachelor's degree in chemical engineering or a closely allied discipline with an overall GPA of 2.75 and having a minimum of one year of work experience.

Students admitted to the certificate program will have non-degree graduate status, but will earn graduate credit for the courses they complete. In order to receive a Graduate Certificate, the student must have an average graduate cumulative grade point of 3.0 or better on a 4.0 scale in the certificate courses taken.

If the four-course sequence approved by the graduate advisor is completed with a grade of B or better in each of the courses taken, the student will, upon application, be admitted to the Master of Science in Chemical Engineering program. The certificate courses taken by students admitted to the program will count towards the M.S. in Chemical Engineering program.

Core Courses: Select two from the following courses		
CHEM ENG 5100	Intermediate Transport Phenomena	3
CHEM ENG 5110	Intermediate Chemical Reactor Design	3
CHEM ENG 5150	Intermediate Process Computing	3
CHEM ENG 5220	Intermediate Engineering Thermodynamics	3

Elective Courses: Select two additional 3-credit Chem Eng courses at the 5000 or 6000-level		
CHEM ENG 5120	Interfacial Phenomena In Chemical Engineering	3
CHEM ENG 5130	Risk Assessment and Reduction	3
CHEM ENG 5161	Intermediate Molecular Engineering	3
CHEM ENG 5170	Physical Property Estimation	3
CHEM ENG 5190	Plantwide Process Control	3
CHEM ENG 5200	Advanced Thermal Properties of Ceramics	3
CHEM ENG 5210	Intermediate Biochemical Reactors	3
CHEM ENG 5250	Isolation and Purification of Biologicals	3
CHEM ENG 5300	Principles Of Engineering Materials	3
CHEM ENG 5305	Hazardous Materials Management	3
CHEM ENG 5310	Structure and Properties of Polymers	3
CHEM ENG 5315	Corrosion And Its Prevention	3
CHEM ENG 5325	Carbon Capture Process Engineering	3
CHEM ENG 5320	Introduction to Nanomaterials	3
CHEM ENG 5330	Alternative Fuels	3
CHEM ENG 5340	Principles of Environmental Monitoring	3
CHEM ENG 5350	Environmental Chemodynamics	3
CHEM ENG 6100	Advanced Chemical Engineering Thermodynamics	3
CHEM ENG 6110	Advanced Transport Phenomena	3
CHEM ENG 6120	Applied Mathematics In Chemical Engineering	3
CHEM ENG 6140	Applied Optimization In Chemical Engineering	3
CHEM ENG 6150	Molecular Modeling and Simulation	3
CHEM ENG 6180	Advanced Applications of Computational Fluid Dynamics	3
CHEM ENG 6241		3
CHEM ENG 6300	Biomaterials II	3
CHEM ENG 6310	Nanomaterials	3
CHEM ENG 6330	Physicochemical Operations In Environmental Engineering Systems	3

Muthanna Hikmat Al Dahhan, Curators' Distinguished Professor
DSc Washington University
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, Professor and Lester R. Birbeck Chair
PHD New Mexico Institute of Mining and Technology
Enhanced oil recovery target, conformance control, surfactants, biosurfactants, carbon sequestration.

Anthony Convertine, Roberta and G. Robert Couch Assistant Professor
PHD University of Southern Mississippi
Development of versatile new drug delivery technologies with unprecedented therapeutic activity and specificity, developing new polymeric materials, theranostics, and regenerative medicine.

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, Professor
PHD Kyungpook National University, Korea
Functional integration and structural integration of advanced microsystems, biosensors.

Xinhua Liang, Associate Professor
PHD University of Colorado-Boulder
Surface science and catalysis, nano-structured films and devices, energy and environmental applications.

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

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

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

Monday Okoronkwo, Assistant Professor
PHD University of Aberdeen
Chemistry of materials for sustainable infrastructure, energy, and environment.

Fateme Rezaei, Associate 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.

Joseph D Smith, Professor and Laufer Endowed Chair in Energy
PHD Brigham Young University
Wayne and Gayle Laufer Endowed Energy Chair. Hybrid energy generation, renewable energy, gas flare performance, process modeling and control, computational fluid mechanics.

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, Curators Teaching Professor
PHD University of California-Los Angeles
Molecular microbiology, microbial diversity, microbial physiology.

Chenglin Wu, Adjunct Associate Professor
PHD, PHD University of Texas-Austin, Missouri University of Science and Technology
Nanomechanics and nanomaterials, sensing and multifunctional materials, 3D printing of reinforced cementitious materials.

Hu Yang, Department Chair, Professor, Linda and Bipin Doshi Chair
PHD University of Akron
Biomaterials; drug and gene delivery; nanomedicine; pharmaceutical engineering.

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 5211 Intermediate Bioreactor Laboratory (LAB 2.0 and LEC 1.0)
The application of bioengineering principles and bioreactor design to the production of biochemicals. The experiments emphasize cell culture, fermentation, and extraction and isolation of proteins and enzymes from tissue and bacteria cells. Prerequisites: Preceded or accompanied by Chem Eng 5210 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 5242 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. Includes safety regulations and issues related to chemical and biochemical industries. Prerequisites: Graduate Standing and Permission of Instructor.

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: Preceded or accompanied by Chem Eng 3131, and Chem Eng 3141 or BME 3100.

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 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 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 green-house effect and climate change. Prerequisites: Chem Eng 3150 or graduate standing.

CHEM ENG 5335 Introduction to Process Intensification (LEC 3.0)
This course builds on basic knowledge of staged separations and reactor design to develop novel apparatus, techniques, and methods to increase process efficiency, lower energy/material costs, enhance safety, and increase sustainability. These topics are part of process intensification aimed at continuous process improvement. Prerequisites: Senior 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.

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.

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 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 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.

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).
