Chemical, Biological, and Pharmaceutical Engineering

The graduate programs in Chemical Engineering offer opportunities for students to enhance their knowledge in the core areas of the discipline, learn about advanced topics in various established as well as emerging technologies through specialized courses, and engage in original research. Courses are taught by full-time faculty members that are also involved in cutting-edge research, and adjunct faculty with extensive industrial experience.
The department enjoys close ties to the pharmaceutical and petrochemical industries, and plastics manufacturers through the Polymer Processing Institute (PPI). In addition to independent research, faculty members are associated with various research centers including the Center for Membrane Technology, the Particle Technology Center, and PPI. There are opportunities for interdisciplinary collaborative research with the Federated Department of Biological Sciences, the Department of Biomedical Engineering, the Department of Chemistry and Environmental Science, and the University of Medicine and Dentistry of New Jersey.

Master of Science in Chemical Engineering

This program is intended for those interested in advancing their understanding of chemical engineering. It may be taken on a part-time or full-time basis. There are two options, one of which includes a master's thesis.

Admission Requirements

An undergraduate degree in chemical engineering is usually required. Students who do not have a degree in chemical engineering may be considered for admission through the bridge program. The bridge program is comprised of a sequence of two courses,PHEN 501, Pharmaceutical Engineering Fundamentals11 and PHEN 502,Pharmaceutical Engineering Fundamentals 111   and , that needs to be completed before beginning the graduate program. Bridge courses are not counted toward degree credit. The bridge program is primarily for individuals who have a degree in either chemistry or an engineering discipline other than chemical engineering.

A minimum undergraduate GPA of 3.0 on a 4.0 scale, or equivalent, is typically required for admission. All full-time applicants pursuing a degree in the Otto H. York Department of Chemical, Biological and Pharmaceutical Engineering also require a GRE. International students must achieve a minimum TOEFL score of 550 (pencil and paper) and 213 (computer-based).

Doctor of Philosophy in Chemical Engineering

This is a research-oriented degree intended primarily for full-time students. Although courses may be taken on a part-time basis, a minimum of one year of full-time residency is typically required for completion of the doctoral dissertation.

Admission Requirements

A master's degree in chemical engineering and a GPA of at least 3.5 on a 4.0 scale, or equivalent, are usually required. All applicants must submit GRE scores. International students must also achieve a minimum TOEFL score of 213 (computer-based) or 550 (non-computer-based). Exceptional students with undergraduate degrees in chemical engineering may also apply directly for admission to the doctoral program. In addition to the GRE and TOEFL requirements mentioned above, a minimum undergraduate GPA of 3.5 on a 4.0 scale, or equivalent, is normally required. Students admitted to the program without a master's degree in chemical engineering must complete an additional 18 credits of course work as specified below. Admission of full-time doctoral students is on a competitive basis as the department admits only as many students as it can support through departmental and research-based funds.

Biopharmaceutical Engineering Program Objective

The Master of Science Program in Biopharmaceutical Engineering is a program developed and administered by the Otto H. York Department of Chemical, Biological and Pharmaceutical Engineering at NJIT. The primary objective of the program is to educate professionals by providing them with the skills required to work in the bioprocessing and biomanufacturing, biopharmaceutical production, and biological/biochemical development.

New Jersey is considered a "hot bed" for pharmaceutical, health care, and bioscience companies, and examples of large and small companies having major facilities in New Jersey abound. The use of microbial/biological systems and the manipulation of biological systems for the production of pharmaceutical products and therapeutic agents are becoming increasingly important for these companies and for the health care industry as a whole. The Biopharmaceutical Engineering program is designed to address the engineering component of the educational needs in this area: students are trained in areas such as microbial and cell growth operations, bioreactor and bioprocess design, fermentation and cell culture processing, recovery and bioseparation processes, and validation and regulatory issues for biological production. Since this program is strongly tied to the pharmaceutical engineering and chemical engineering programs, Biopharmaceutical Engineering students are able to benefit from the use of basic chemical/pharmaceutical engineering approaches, such as transport phenomena, (bio)reaction engineering and unit-operations principles, to understand and design bioprocesses for new biotherapeutics.

NJIT'd M.S. program in Biopharmaceutical Engineering provides the intellectual climate and the necessary tools needed to prepare students for positions and career advancement within the industry, based on the rigorous technological requirements of this highly regulated work environment.

Master of Science in Biopharmaceutical Engineering

Admission Requirements

An undergraduate degree in chemical engineering or, in most cases, mechanical engineering, with a cumulative grade point average (GPA) of at least 3.0 on a 4.0 scale is usually required. Applicants with:

1. a science degree,
2. engineering degree in a discipline other than chemical engineering, or
3. a GPA below 3.0 but at least 2.8,

may be conditionally admitted to the program. Conditions may involve completion of a bridge program designed on a case-by-case basis, and typically requiring taking extra bridge courses, as further explained bellow. Depending on the background of the student, admission conditions may additionally require taking undergraduate course (e.g., chemistry) or graduate courses. Bridge courses and undergraduate courses do not count toward degree credit; graduate-level courses do.

Submission of Graduate Record Examination (GRE) score is encouraged in all cases, but it is required of those seeking financial support and those whose last prior degree is from an institution outside United States. International students must also submit scores from the Test of English as a Foreign Language (TOEFL). According to University policy, a minimum score of 79 (internet-based TOEFL) or 213 (computer_based TOEFL) is required for all international applicants.

Bridge Program

The Biopharmaceutical Engineeringprogram has been designed so that applicants with different backgrounds can be admitted. Nevertheless, the program is strongly oriented toward the engineering and processing components of "Biopharmaceutical Engineering". In addition, since the biopharmaceutical industry is a chemistry/biology-based industry a chemical or biochemical engineering background is the most appropriate to enter the program. This implies that students who have science background (e.g., a chemistry or pharmacy B.S. degree) or an engineering degree in a discipline other than chemical, biochemical or, possibly, mechanical engineering, may be required to take a bridge program.

Pharmaceutical Engineering Program Program Objective

The Master of Science Program in Pharmaceutical Engineering is a program developed and administered by the Otto H. York Department of Chemical, Biological and Pharmaceutical Engineering at NJIT. The primary objective of the program is to educate professionals and provide them with the skills required to work in the pharmaceutical field, with particular emphasis on the engineering aspects of drug manufacturing, pharmaceutical production, pharmaceutical development, and pharmaceutical operations.

The pharmaceutical/medical technology industry is the largest manufacturing industry in New Jersey. New Jersey is home to the headquarters of more global pharmaceutical and medical technology companies than any other state in the country, or any single country throughout the world. NJIT's M.S. program in Pharmaceutical Engineering provides the intellectual climate and the necessary tools needed to prepare students for positions and career advancement within the industry, based on the rigorous technological requirements of this highly regulated work environment.

The program is designed to provide opportunities for specialization in such areas as pharmaceutical processing and manufacturing, validation and regulatory issues in the pharmaceutical industry, pharmaceutical facility design, pharmaceutical packaging technology, reaction engineering for pharmaceutical production, pharmaceutical separation processes, pharmacokinetics and drug delivery, molecular modeling for drug discovery, pharmaceutical synthesis, fluid mixing in the pharmaceutical industry, instrumental analysis, and industrial quality control.

Master of Science in Pharmaceutical Engineering

Admission Requirements

An undergraduate degree in chemical engineering or, in most cases, mechanical engineering, with a cumulative grade point average (GPA) of at least 3.0 on a 4.0 scale is usually required. Applicants with:

1. a science degree,
2. an engineering degree in a discipline other than chemical or mechanical engineering, or
3. a GPA below 3.0 but at least 2.8, may be conditionally admitted to the program.

Conditions may involve completion of a bridge program designed on a case-by-case basis, and typically requiring taking extra bridge courses, as further explained below. Depending on the background of the student, admission conditions may additionally require taking undergraduate courses (e.g., chemistry) or graduate courses. Bridge and undergraduate courses do not count toward degree credit; graduate-level courses do.

Submission of Graduate Record Examination (GRE) scores is encouraged in all cases, and required of those seeking financial support and those whose last prior degree is from an institution outside the United States. International students must also submit scores from the Test of English as a Foreign Language (TOEFL). According to university policy, a minimum TOEFL score of 550 (pencil and paper) and 213 (computer-based) is required.

The admission requirements described above can be partially relaxed for applicants with significant industrial experience in the pharmaceutical industry (5+ years). The admission requirements for such candidates will be established on a case-by-case basis, and will be determined through an interview with the prospective student and the submission of letters of support attesting the level of experience attained.

Bridge Program

The Pharmaceutical Engineering program has been designed so that applicants with different backgrounds can be admitted. Nevertheless, the program is strongly oriented toward the engineering component of "Pharmaceutical Engineering". In addition, since the pharmaceutical industry is a chemistry-based industry a chemical engineering background is the most appropriate to enter the program (mechanical engineers are also generally well prepared to enter the program). This implies that students who have a science background (e.g., a chemistry or pharmacy B.S. degree) or an engineering degree in a discipline other than chemical or, possibly, mechanical engineering, may be required to take a bridge program.

NJIT Faculty

A

Armenante, Piero M., Distinguished Professor

B

Baltzis, Basil C., Professor

Barat, Robert B., Professor

Bilgili, Ecevit A., Assistant Professor

D

Dave, Rajesh N., Distinguished Professor

Dreyzin, Edward L., Professor

E

Engler, Peter, Associate Professor Emeritus

G

Gogos, Costas G., Distinguished Research Professor

H

Hanesian, Deran, Professor

Huang, Ching-Rong, Professor Emeritus

K

Khusid, Boris, Professor

Kristol, David, Professor Emeritus

L

Loney, Norman, Professor

P

Perlmutter, Howard D., Professor Emeritus

Perna, Angelo, Professor

Pfeffer, Robert, Distinguished Professor Emeritus

R

Roche, Edward C., Professor Emeritus

Rosty, Roberta, Senior University Lecturer

S

Schoenitz, Mirko, Associate Research Profess

Sebastian, Donald H., Professor

Shilman, Avner, Professor Emeritus

Simon, Laurent, Associate Professor

Sirkar, Kamalesh K., Distinguished Professor

Sofer, Samir, Professor Emeritus

T

Tomkins, Reginald P.T., Professor

V

Voronov, Roman S., Assistant Professor

W

Wang, Xianqin, Associate Professor

X

Xu, Xiaoyang, Assistant Professor

Programs

- Biopharmaceutical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-biological-pharmaceutical/biopharmaceutical-ms)
- Chemical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-biological-pharmaceutical/chemical-ms)
- Pharmaceutical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-biological-pharmaceutical/pharmaceutical-ms)

Programs

- Chemical Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-biological-pharmaceutical/chemical-phd)

Pharmaceutical Technology

Pharmaceutical Management

Chemical, Biological, and Pharmaceutical Engineering Courses

CHE 501. Fundamentals of Chemical Engineering I. 6 credits, 6 contact hours.
Prerequisites: MATH 222 or equivalent, CHEM 231 or equivalent(see undergraduate catalog descriptions). An intensive course in basic chemical engineering science intended for students in the bridge program. Topics include material and energy balances, thermodynamics, kinetics and reactor design, and staged separation processes. May not be taken for degree credit in any chemical engineering program.

CHE 502. Fundamentals of Chemical Engineering II. 4 credits, 4 contact hours.
Prerequisites: MATH 222 or equivalent (see undergraduate catalog for description), CHE 501 or equivalent. A continuation of CHE 501. An intensive course in basic chemical engineering science intended for students in the bridge program. Topics include fluid mechanics, heat transfer and diffusion-controlled processes. May not be taken for degree credit in any chemical engineering program.

CHE 590. Graduate Co-op Work Experience I. 3 credits, 0 contact hours.
Restriction: permission from department and Division of Career Development Services. Cooperative education internship provides on-the-job reinforcement of the academic program by placement in major-related work situations. Work assignment developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

CHE 591. Graduate Co-op Work Experience II. 3 credits, 3 contact hours.
Restriction: permission from department and Division of Career Development Services.

CHE 592. Graduate Co-op Work Experience III. 3 credits, 3 contact hours.
Restriction: permission from department and Division of Career Development Services.

CHE 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer and approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

CHE 599. Methods for Teaching Assistants and Graduate Assistants. 3 credits, 3 contact hours.
Restriction: graduate standing. Required for all chemical engineering teaching assistants and graduate assistants. Covers techniques of teaching, interaction with students, and safety. Does not count as degree credit.

CHE 602. Selected Topics in Chemical Engineering I. 3 credits, 3 contact hours.
Restriction: graduate standing. Topics of current interest in chemical engineering.

CHE 603. Separation Process Principles. 3 credits, 3 contact hours.
Prerequisites: CHE 342, CHE 349, CHE 363, CHE 364, CHE 367, CHE 471. The course covers the basic principles of separation with or without chemical reaction in phase equilibrium-based, external field-driven and membrane-based separation processes.

CHE 604. Membrane Separation Processes. 3 credits, 3 contact hours.
Prerequisites: CHE 342, CHE 349, CHE 363, CHE 364, CHE 367, CHE 471. This course covers the science, technology, engineering analysis and design of membrane separation processes, membrane reactors, membrane-based equilibrium separation processes and hybrid membrane processes.

CHE 611. Thermodynamics. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in physical chemistry and thermodynamics, or equivalent. Principles of thermodynamics developed quantitatively to include thermodynamic functions and their application to chemical engineering processes.

CHE 612. Kinetics of Reactions and Reactor Design. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in chemical engineering kinetics, or equivalent. Elements of optimum design introduced for reactor types, series and parallel reactor systems, multiple reactions, and temperature effects. Introduction to non-ideal reactor design. Study of various models for catalytic and non-catalytic solid-fluid reactions.

CHE 619. Nano-scale Characterization of Materials. 3 credits, 3 contact hours.
The course presents the basics of nanotechnology and the principles and application of advanced instrumentation for the characterization of nanostructures. Topics include atomic force microscopy; near-field optics, dielectric spectroscopy, and light scattering. The significant component of the course is laboratory work at the W. M. Keck Foundation Laboratory and research project.

CHE 623. Heat Transfer. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in heat transfer. Heat transmission applied to practical problems in design. An introduction will include review of conduction, convection and radiation heat transfer modes. Related topics covered will be heat exchangers, types and design principles (including Kern & Bell?s methods), effectiveness, (NTU Design and Rating methods), Fired Heaters, Design & Rating and Cooling Towers, Design & Rating.

CHE 624. Transport Phenomena I. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in fluid mechanics, heat transfer, and mass transfer. A unified treatment of molecular and turbulent momentum, energy, and mass transport. Emphasis is on the mathematical description of physical mechanisms in momentum and energy transport.

CHE 625. Microlevel Modeling in Particle Technology. 3 credits, 3 contact hours.
Presents methodologies for analyzing the macroscopic properties of particulate systems in terms of the underlying microlevel processes. Significant components are the mathematical modeling of particulate systems at the microlevel, analytical and numerical methods for predicting macroscopic properties from microlevel models, and comparison of theoretical predictions with experimental results. Demonstrates the importance of the interaction of these three components in the scientific process. The first part concerns the flow of dry particles where any interstitial fluid can be ignored. The second part considers the flow of particles suspended in an interstitial fluid. Also includes a class project involving development of simulations. Same as ME 624.

CHE 626. Mathematical Methods in Chemical Engineering. 3 credits, 3 contact hours.
Prerequisite: MATH 222 or equivalent undergraduate degree in Chemical Engineering. The purpose of the course is to emphasize the importance of mathematics to chemical engineering practice. Applications of ordinary differential equations, Sturm-Liouville problems arising from partial differential equations, regular Perturbation approaches to some nonlinear systems of chemical engineering interests, use of Laplace transfroms expecially the Residue Theorem for inversions and some numerical methods. It is suggested that students take this course before taking CHE 624.

CHE 627. Introduction to Biomedical Engineering. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in thermodynamics and differential equations. Introduction to the structure and composition of the body followed by an exploration of the properties of blood and its flow in the cardiovascular system; the body as a heat source and as a series of compartments involved in mass transfer of materials (such as those in the kidneys and lungs). Design of artificial kidneys and heart-lung machines is also explored. Same as BME 627.

CHE 628. Biochemical Engineering. 3 credits, 3 contact hours.
Prerequisite: undergraduate degree in chemical engineering. The application of chemical engineering to biological processes, biochemical reaction systems, and their technological use. Special attention given to problems in momentum, energy, and mass transport, as well as chemical reaction kinetics in biological systems.

CHE 634. Chemical Process Dynamics and Control. 3 credits, 3 contact hours.
Prerequisite: undergraduate chemical engineering course in process dynamics and control. Mathematical principles of process dynamics and control; derivation and solution of differential equations describing the behavior of typical chemical engineering processing units; and mathematical analysis and design of control systems. Digital and sampled data control systems also discussed.

CHE 650. Environ Catalysis Fund & Appl. 3 credits, 3 contact hours.
Prerequisites:Senior Standing or Graduate Industrial Catalysis course. An introduction to catalytic processes used for environmental abatement. The course provides background information necessary to understand environmental catalytic processes. A review of mobile and stationary pollution abatement technologies are reviewed.

CHE 654. Corrosion. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in Chemistry. Fundamental principles including thermodynamics and kinetics of corrosion; forms of corrosion (e.g. galvanic, crevice and stress); methods of corrosion measurement; high temperature corrosion; and special case histories.

CHE 656. Industrial Catalysis: Fundamentals and Applications. 3 credits, 3 contact hours.
The class provides an introduction to catalytic phenomena as well as catalysts. It provides the background information necessary to understand industrial catalytic processes. Examples which will be discussed are hydrogen, ammonia and methanol synthesis, inorganic and organic oxidation reactions, petrochemical processes as well as pollution abatement and other important processes. The course provides insight into the theory of catalytic phenomena and also provides practical information about these processes from an industrial perspective.

CHE 675. Statistical Thermodynamics. 3 credits, 3 contact hours.
Prerequisite: CHE 611 or permission of instructor. Application of equilibrium statistical mechanics to chemical engineering problems. Basic postulates and relationships of statistical thermodynamics, including the ideal gas, ideal crystal, and virial equation; statistical theories of fluid mixtures and other advanced topics.

CHE 681. Polymerization-Principles and Practice. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in physical or organic chemistry or CHE 503 or equivalent. The course focuses on the structural and synthetic aspects of polymers and examines in detail a number of bench and industrial scale polymerization methods. In addition to kinetics and mechanisms of commercially important polymerization systems, the course examines reactive modification of synthetic and natural polymers and provides an introduction to applicable characterization methods.

CHE 682. Polymer Structures and Properties. 3 credits, 3 contact hours.
Prerequisite: Undergraduate physical chemistry, a materials related course or CHE 503 or equivalent. The course provides an overview of polymer structures and properties and their relationships from the molecular viewpoint to phenomenological descriptions. Topics include thermodynamics of a single molecule, dynamic theory and viscoelasticity of polymers, polymer solids and mechanical properties, rubbers, polymer blends and composites, biological polymers, and special applications. New areas and innovative applications of polymers will be introduced.

CHE 683. Polymer Processing. 3 credits, 3 contact hours.
Prerequisite: undergraduate courses in transport phenomena, fluid flow, or heat transfer or approval of graduate advisor. The course provides a systematic approach to the physical phenomena occurring in polymer processing machinery. The synthesis of the elementary steps of polymer processing are shown in relation to the development of extrusion die flow and extrusion products and injection mold flows and molded products. Structural and residual stresses are examined.

CHE 684. Materials and Process Selection for Polymer Product Design. 3 credits, 3 contact hours.
Prerequisites or corequisites: CHE 681, CHE 682, CHE 683 or approval of graduate advisor. The course provides methodologies for designing polymer-based products by considering materials and processing methods. Methods for selecting homopolymers, polymer blends and composites for specific appilcations will be presented in terms of properties, processability, manufacturing methods and economics. Process/structure/property correlations are presented as well as approaches to product design including CAD, prototyping, and strength and failure criteria. Case studies from biomedical, packaging and other applications are discussed.

CHE 700. Master's Project. 0 credits, 0 contact hours.

CHE 700B. Masters Project. 3 credits, 3 contact hours.

CHE 701B. Masters Thesis. 3 credits, 3 contact hours.

CHE 701C. Masters Thesis. 6 credits, 3 contact hours.

CHE 702. Selected Topics in Chemical Engineering II. 3 credits, 3 contact hours.
Restriction: graduate standing. Topics of current interest in chemical engineering.

CHE 705. Independent Study. 3 credits, 3 contact hours.
Restriction: permission from the graduate advisor (not dissertation advisor) in chemical engineering. Students working on their PhD or MS theses cannot register for this course with their respective thesis advisors. This special course covers areas of study in which one or more students may be interested, but which isn't of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

CHE 706. Independent Study II. 3 credits, 3 contact hours.

CHE 721. Combustion Reaction Engineering. 3 credits, 3 contact hours.
Restriction: undergraduate degree in Chemical or Mechanical Engineering. Topics related to the engineering of combustion systems will be discussed. These include laminar flames, turbulent combustion, ideal reactor modeling of complex combustion systems, combustion chemistry, heterogeneous combustion and incineration.

CHE 724. Sustainable Energy. 3 credits, 3 contact hours.
The course is a project-based advanced graduate course which requires strong background in engineering thermodynamics and transport phenomena. The main goals of this course are to gain an understanding of the cost-benefit ratio of various alternative energy sources and to understand some of the various obstacles associated with current and conventional technologies and industrial applications. Different renewable and conventional energy technologies will be discussed in class. Course materials include biomass energy, fossil fuels, geothermal energy, nuclear power, wind power, solar energy, hydrogen fuel, hydropower, and fuel cells. Students will learn a quantitative framework to aid in evaluation and analysis of energy technology systems in the context of engineering, political, social, economic, and environmental goals.

CHE 725. Transport Phenomena II. 3 credits, 3 contact hours.
Prerequisite: CHE 624 or equivalent. Transport in laminar and turbulent flow: in solids, between phases, and macroscopic transport in flow systems.

CHE 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Required of all students for the degree of Doctor of Philosophy. A minimum of 36 credits is required. Approval of dissertation advisor is necessary for registration. Students must register for at least 6 credits of dissertation per semester until 36 credits are reached and then for 3 credits each semester thereafter until a written dissertation is approved.

CHE 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.

CHE 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.

CHE 790C. Doct Dissertation & Res. 6 credits, 3 contact hours.

CHE 790D. Doct Dissertation & Res. 9 credits, 3 contact hours.

CHE 790E. Doct Dissertation & Res. 12 credits, 3 contact hours.

CHE 790F. Dissertation & Res. 15 credits, 3 contact hours.

CHE 790G. Doctrl Dissertatopm & Resrch. 18 credits, 0 contact hours.

CHE 791. Graduate Seminar. 0 credits, 1 contact hour.
Required of all chemical engineering students receiving departmental or research-based awards and all doctoral students. The student must register each semester until completion of the degree. Outside speakers and department members present their research for general discussion.

CHE 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Restriction: permission of Associate Chairperson for Graduate Studies. For students admitted to the Doctor of Philosophy Program in Chemical Engineering who have not yet passed the qualifying examination. Research is carried out under the supervision of designated chemical engineering faculty. If the student's research activity culminates in doctoral research in the same area, up to a maximum of 6 credits may be applied to the 36 credits required under ChE 790.

CHE 792C. Pre-Doctoral Research. 6 credits, 0 contact hours.

CHE 794. Professional Presentations for Ph.D. Students. 0 credits, 0 contact hours.
Intended to help students make better technical presentations. Each student is required to make a presentation on a research topic; guest lectures will occur during the semester.

PHEN 500. Pharmaceutical Engineering Fundamentals I. 3 credits, 3 contact hours.
Prerequisite: undergraduate calculus. This is a required bridge course for those students who are admitted to the Pharmaceutical Engineering MS program without an undergraduate engineering degree. This course is not counted toward degree credit related to the Pharmaceutical Engineering MS program. The course covers the fundamentals of calculus, differential equations, probability and statistics, and finance business mathematics applied to pharmaceutical engineering problems and illustrated through pharmaceutical engineering examples.

PHEN 501. Pharmaceutical Engineering Fundamentals II. 3 credits, 3 contact hours.
Prerequisite: If needed, PHEN 500 (which can also be taken concurrently with this course), as well as an undergraduate course in physical chemistry. This course is a required bridge course for those students who are admitted to the Pharmaceutical Engineering MS program without an undergraduate engineering degree or with an engineering background that did not include the topics covered in this course. The course is not counted toward degree credit related to the Pharmaceutical Engineering MS program. The course covers the fundamentals of pharmaceutical engineering calculations related to material and energy balances applied to pharmaceutical facilities and systems; estimation of thermophysical properties, phase and reaction equilibrium; and chemical kinetics and basic reactor design.

PHEN 502. Pharmaceutical Engineering Fundamentals III. 3 credits, 3 contact hours.
Prerequisite:If needed, PHEN 500 and PHEN 501, as well as undergraduate course in physical chemistry. This is a required bridge course for those students who are admitted to the Pharmaceutical Engineering MS program without an undergraduate engineering degree or with an engineering background that did not include the topics covered in this course. The course is not counted toward degree credit related to the Pharmaceutical Engineering MS program. The course covers the fundamentals of fluid mechanics, heat transfer, mass transfer and the design of unit operations involving these principles.

PHEN 590. Graduate Co-op Work Experience I. 3 credits, 3 contact hours.
Prerequisite: permission from Pharmaceutical Engineering Program Advisor and Division of Career Development Services. Cooperative education internship provides on-the-job reinforcement of the academic program by placement in major-related work situations at pharmaceutical companies or companies serving the pharmaceutical industry. Work assignment developed or approved by the co-op office and evaluated by the department. Cannot be used for degree credit.

PHEN 591. Graduate Co-op Work Experience II. 3 credits, 3 contact hours.
Prerequisite: permission from Pharmaceutical Engineering Program Advisor and Division of Career Development Services. Same range of activities as in PHEN 590.

PHEN 592. Graduate Co-op Work Experience III. 3 credits, 3 contact hours.
Prerequisite: permission from Pharmaceutical Engineering Program Advisor and Division of Career Development Services. Same range of activities as in PHEN 590 and PHEN 591.

PHEN 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Prerequisites: One immediately prior 3-credit registration for graduate co-op work experience with the same employer. Requires approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

PHEN 601. Principles of Pharmaceutical Engineering. 3 credits, 3 contact hours.
This course provides an overview of the pharmaceutical industry, including basic information about drug discovery and development, FDA requirements and approval processes, drug dosage forms, and the role of key operational units in drug manufacturing processes. This course enables the students to: understand the role of the pharmaceutical industry in the global market and its implications; learn the fundamentals of the drug development cycle and the investment required to bring a drug to market; learn the most important drug manufacturing processes and the key elements of dosage formulation.

PHEN 602. Pharmaceutical Facility Design. 3 credits, 3 contact hours.
Prerequisite: PHEN 601, PHEN 603; undergraduate courses in differential equations and fluid flow or completion of bridge program for students who are required to take it. This course provides instruction in design of state-of-the art pharmaceutical facilities for both manufacturing and R&D, by identifying key functional requirements and design concepts necessary to pharmaceutical processes. Interdisciplinary training will be provided in appropriate areas of facility design.

PHEN 603. Pharmaceutical Unit Operations: Processing of Liquid and Dispersed Phase Systems. 3 credits, 3 contact hours.
This course examines methodologies, both applied and fundamental, to analyze and scale up manufacturing pharmaceutical processes involving liquid and dispersed-phase systems, such as liquid and multiphase mixing, sterilization and sanitation, lyophilization, filtration, centrifugation and others. The emphasis is primarily on the engineering aspects of the parmaceutical processes examined in the course.

PHEN 604. Validation and Regulatory Issues in the Pharmaceutical Industry. 3 credits, 3 contact hours.
This course is focused on the development of a working knowledge of the Federal Code of Regulations and its impact on the pharmaceutical and allied industries. The history of the Federal Government's regulation of the pharmaceutical industry is studied. Also covered is the industry's response and the methodologies it uses to comply with these regulations.

PHEN 605. Pharmaceutical Packaging Technology. 3 credits, 3 contact hours.
Prerequisite: PHEN 601, PHEN 603, and completion of the bridge program for students who are required to take it. This course focuses on developing a working knowledge of the machinery and unit operations used in transferring a drug substance in the bulk final form to a finished product ready for sale to the consuming public. Packaging of both liquid and solid forms in various types of delivery containers such as vials/ampoules, blister packs, individual packets, bottles, pouches and syringes is examined. The cleaning, sterilization and scaling/capping required for each dosage form is discussed, as well as freeze-drying, tableting capsule filling, and form/fill/seal, and proper labeling of final drug forms.

PHEN 606. Pharmaceutical Unit Operations: Solids Processing. 3 credits, 3 contact hours.
This course examines methodologies, both applied and fundamental, to analyze and scale up manufacturing pharmaceutical processes involving solids processing, such as solids characterization, blending, milling, granulation, tableting, coating, and others. The emphasis is primarily on the engineering aspects of the pharmaceutical processes examined in the course.

PHEN 612. Pharmaceutical Reaction Engineering. 3 credits, 3 contact hours.
Prerequisite: PHEN 601, PHEN 603; undergraduate courses in differential equations and chemical engineering kinetics, or completion of bridge program for students who are required to take it. This course examines a variety of reactions and reactors typically encountered in the pharmaceutical industry, including single/multiphase systems (e.g., crystallization), chemical synthesis, enzymatic, bio-reactions (fermentation), and others. The course then focuses on quantitative pharmaceutical reactor design and scale-up issues.

PHEN 614. Pharmaceutical Separation Processes. 3 credits, 3 contact hours.
This course covers separation processes in general and pharmaceutical separations in particular. Specific processes to be studied include distillation, extraction, crystallization, adsorption, ion exchange, chromatography, moving bed processes, electrophoresis, freeze drying, microfiltration/ultrafiltration, reverse osmosis, and pervaporation.

PHEN 618. Principles of Pharmacokinetics and Drug Delivery. 3 credits, 3 contact hours.
The course covers the basic principles of pharmacokinetics, including drug transport, parenteral and enteral routes of drug administration, and factors affecting drug absorption, distribution, metabolism, and excretion. Mathematical pharmacokinetic models and drug delivery processes are also presented and quantitatively studied.

PHEN 698. Special Topics in Pharmaceutical Engineering I. 3 credits, 3 contact hours.
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in pharmaceutical engineering.

PHEN 699. Special Topics in Pharmaceutical Engineering II. 3 credits, 3 contact hours.
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in pharmaceutical engineering.

PHEN 701. Master's Thesis. 0 credits, 0 contact hours.
Prerequisite: matriculation for the Master's degree in pharmaceutical engineering. Approval of thesis advisor is necessary for registration. Original research under the guidance of a departmental advisor. The final product must be a written thesis approved by at least three faculty members: the primary advisor, another from the pharmaceutical engineering faculty, and one other faculty member. A student must continue to register for at least 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

PHEN 701B. Master'S Thesis. 3 credits, 3 contact hours.
Prerequisite: matriculation for the Master's degree in pharmaceutical engineering. Approval of thesis advisor is necessary for registration. Original research under the guidance of a departmental advisor. The final product must be a written thesis approved by at least three faculty members: the primary advisor, another from the pharmaceutical engineering faculty, and one other faculty member. A student must continue to register for at least 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

PHEN 701C. Master'S Thesis. 6 credits, 3 contact hours.
Prerequisite: matriculation for the Master's degree in pharmaceutical engineering. Approval of thesis advisor is necessary for registration. Original research under the guidance of a departmental advisor. The final product must be a written thesis approved by at least three faculty members: the primary advisor, another from the pharmaceutical engineering faculty, and one other faculty member. A student must continue to register for at least 3 credits per semester until at least 6 credits have been completed and a written thesis is approved. Only a total of 6 credits will count toward the degree.

PHEN 702. Selected Topics in Pharmaceutical Engineering. 3 credits, 3 contact hours.
Prerequisite: graduate standing and permission of the instructor. Topics of current interest in pharmaceutical engineering.

PHEN 725. Independent Study. 3 credits, 3 contact hours.
Prerequisites: permission from the graduate advisor (not the thesis advisor) in pharmaceutical engineering, as well as courses prescribed by a supervising faculty member (who is not the student's thesis advisor). This special course covers areas of study in which one or more students may be interested, but which is not of sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once with the same supervising faculty member.

PHEN 791. Graduate Seminar. 0 credits, 0 contact hours.
Required, when offered, of all pharmaceutical engineering graduate students receiving departmental or research-based awards. The student must register each semester until completion of the degree, if the Graduate Seminar is offered. Outside speakers and department members present their research for general discussion.