Chemical and Materials 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 three 3- credit courses PHEN 500, PHEN 501 and PHEN 502) specifically designed to provide non- chemical engineers with the necessary prerequisites to enter the program. The bridge courses cover a variety of topics, such as differential equations (especially applied to transport phenomena), optimization and business math (PHEN 500), mass balances, thermodynamics, and chemical kinetics (PHEN 501), and fluid flow, heat transfer and mass transfer (PHEN 502) Bridge courses are not counted toward degree credit.

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 and Materials 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.

Pharmaceutical Engineering Program Objective

The Master of Science Program in Pharmaceutical Engineering is a program developed and administered by the Otto H. York Department of Chemical and Materials 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 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, international students must achieve a minimum TOEFL score of 550 (pencil and paper); 213 (computer-based); 79 (internet-based).

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.

Master of Science in Materials Science and Engineering

This program is offered by the Department of Chemical and Materials Engineering (Materials Engineering Option), and is intended for those interested in advancing their understanding of Materials Science and Engineering. It may be taken on a part-time or full-time basis. There are two options: one without and one with a master's thesis.

Admission Requirements:

An undergraduate degree in engineering (e.g. biomedical, chemical, civil, mechanical), or in physics or chemistry is usually required. Students who do not have one of these degrees may be considered for a admission by taking a number of bridge courses that are not counted toward degree credit.

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 and Materials Engineering also require a GRE. International students must achieve a minimum TOEFL score of 550 (pencil and paper) and 213 (computer-based).

NJIT Faculty

A

Armenante, Piero M., Distinguished Professor

Axe, Lisa, Professor

B

Baltzis, Basil C., Professor

Barat, Robert B., Professor Emeritus

Basuray, Sagnik, Associate Professor

Bilgili, Ecevit A., Professor

C

Cimino, Richard, Senior University Lecturer

Chintersingh, Kerri-lee, Assistant Professor

D

Dave, Rajesh N., Distinguished Professor

Dreyzin, Edward L., Distinguished Professor

G

Gor, Gennady, Assistant Professor

Gogos, Costas G., Distinguished Research Professor

Guvendiren, Murat, Assistant Professor

K

Khusid, Boris, Professor

L

Loney, Norman, Professor Emeritus

M

McEnnis, Kathleen, Assistant Professor

Molodetsky, Irina, Senior University Lecturer

P

Pfeffer, Robert, Distinguished Professor Emeritus

R

Reid, Nellone, Senior University Lecturer

S

Schoenitz, Mirko, Associate Research Professor

Sebastian, Donald H., Professor

Simon, Laurent, Professor

Sirkar, Kamalesh K., Distinguished Professor

T

Tomkins, Reginald P.T., Professor Emeritus

V

Venerus, David, Professor

Voronov, Roman S., Associate Professor

W

Wang, Xianqin, Professor

X

Xu, Xiaoyang, Associate Professor

Y

Young, Joshua, Assistant Professor

Z

Zhao, Mark, Assistant Professor

Programs

- Chemical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/chemical-ms/)
- Materials Science and Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/materials-science-engineering-ms/)
- Pharmaceutical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-ms/)

Programs

- Chemical Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/chemical-phd/)
- Materials Science & Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/materials-science-engineering-phd/)

Programs

- Data Science for Chemical and Materials Engineers (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/data-science-for-chemical-and-materials-engineers-cert/)
- Pharmaceutical Management (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-management-cert/)
- Pharmaceutical Manufacturing (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-manufacturing-cert/)
- Pharmaceutical Technology (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-technology-cert/)
- Polymers and Plastics (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/polymers-and-plastics-cert/)

Chemical and Materials 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. 1 credit, 1 contact hour.
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. 1 credit, 1 contact hour.
Restriction: permission from department and Division of Career Development Services.

CHE 592. Graduate Co-op Work Experience III. 1 credit, 1 contact hour.
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.
Prerequisites: Undergraduate course in chemical engineering kinetics or equivalent. Elements of optimum design for various reactor types, multiple reactions, and temperature effects. Yield and selectivity optimization with emphasis on small-scale pharmaceutical production. 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.
Prerequisites: 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 626. Mathematical Methods in Chemical Engineering. 3 credits, 3 contact hours.
Prerequisites: MATH 222 or equivalent undergraduate degree in Chemical Engineering. This course aims to provide students with advanced knowledge–skills to formulate mathematical models, derive analytical solutions, and find numerical solutions of steady- and unsteady-state problems encountered in chemical engineering systems. First and higher order ordinary differential equations as well as their systems are presented along with applications to dynamic systems. Sturm-Liouville eigenvalue problems, eigenfunction expansion, orthogonality of functions, and Fourier and generalized Fourier series are presented with the dual purpose of solving boundary-value problems and building the foundation needed for solving partial differential equations. Separation of variables is used to solve partial differential equations in 2D-3D steady-state and 1D-3D transient problems that arise in Cartesian, cylindrical, and spherical coordinates. Laplace transform and similarity transformation are used to solve semi-infinite domain problems. Numerical methods based on finite differences, full or semi-discretization of partial differential equations, accuracy, and error estimates are covered.

CHE 627. Introduction to Biomedical Engineering. 3 credits, 3 contact hours.
Prerequisites: 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 632. Visual Communication with Chemical & Materials Engineering Data. 3 credits, 3 contact hours.
Prerequisites: BS degree in Chemical, Mechanical, Electrical or Biomedical Engineering, or in Physics or Chemistry. This course will focus on training students to communicate data relevant to chemical and materials engineering and related professions. Students will learn both the theoretical and practical aspects of data communication, including visualization aesthetics and design principles, as well as how to critically analyze and interpret engineering data. Throughout the course, students will also gain a broader understanding of data visualization best practices and how data can be used to enhance engineering analysis, using digital tools. A special emphasis will be placed on making engineering data accessible to all individuals, using the principles of Universal Design. Students will incorporate each of these design principles into a capstone multimedia course project.

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 675. Statistical Thermodynamics. 3 credits, 3 contact hours.
Prerequisites: 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 683. Polymer Processing. 3 credits, 3 contact hours.
Prerequisites: 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 700B. Masters Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemical engineering. A written report must be submitted to the project advisor. The student cannot register in CHE 700B more than once and the incomplete (I) grade is not allowed. Master's students registering for the first time in Master's Project must take simultaneously the INTD 799 (Responsible Contact of Research) course.

CHE 701B. Masters Thesis. 3 credits, 3 contact hours.
Corequisite for full-time students: CHE 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in CHE 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply). Master's students registering for the first time in Master's Thesis must take simultaneously the INTD 799 (Responsible Contact of Research) course.

CHE 701C. Masters Thesis. 6 credits, 6 contact hours.
Co-requisite for full-time students: CHE 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in chemical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (CHE 701B course) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

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.
Pre-requisite: CHE 705. 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 709. Adv Separation Processes. 3 credits, 3 contact hours.
Prerequisites: CHE 360, CHE 460, CHE 612, CHE 624 and CHE 626 or permission of instructor. Students having a background in undergraduate separations courses will be introduced to advanced concepts in separations. These include: descriptions of separation; forces causing separation in equilibrium, field and membrane separation processes; flux-force relations; chemical potential profiles; role of chemical reactions in separations; four different combinations of directions of force and bulk motions in separators; time-dependent processes. Advanced analysis of important individual separation processes of three types, namely, equilibrium-based, membrane-based and external field-based processes will be carried out.

CHE 710. Adv Membrane Separation Proc. 3 credits, 3 contact hours.
Prerequisites: CHE 460, CHE 603, CHE 624, CHE 626 or permission of instructor. This course will provide advanced treatments of science, technology, engineering analysis and design of the following membrane separation processes: reverse osmosis, nanofiltration, ultrafiltration, dialysis, electrodialysis, Donnan dialysis, liquid membrane permeation, microfiltration, gas permeation through polymeric membranes, pervaporation, membrane-based equilibrium separation processes, membrane reactors and hybrid membrane processes. Membrane structure/function and device design for each technology are of interest.

CHE 714. Micromechanics of Part Tech Pr. 3 credits, 3 contact hours.
Prerequisite: CHE 624 or equivalent. Corequisite: PHEN 601 or equivalent (not required but suggested). Presents methodologies for analyzing the macroscopic properties of particulate systems. Includes characterization and processing of particulate systems at the microlevel, predicting macroscopic properties from microlevel models, and analysis of particulate manufacturing processes involving solids processing, such as solids characterization, blending, milling, granulation, tableting, etc. Course includes laboratory demonstrations and a class project involving use of surface modification.

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 722. Additive Manufacturing & Appl. 3 credits, 3 contact hours.
Prerequisites: CHE 624 and CHE 626 are both prerequisites or can be taken concurrently. Other equivalent courses can be acceptable for non-chemical engineering students with permission of the instructor. This course describes additive manufacturing technologies and current (and emerging) applications of 3D printing. The course will be composed of a lecture and a hands-on laboratory session, during which students will create 3D designs and print functional prototypes.

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 734. Chem Process Dynamic & Control. 3 credits, 3 contact hours.
Prerequisite: CHE 626 or equivalent. Corequisites: CHE 611, CHE 612 or equivalent 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 750. Environmental Catalysis. 3 credits, 3 contact hours.
Prerequisites: CHE 612 or equivalent. An introduction to catalytic processes used for environmental abatement. The course provides background information necessary to understand environmental catalytic processes. Mobile and stationary pollution abatement technologies are reviewed.

CHE 756. Industrial Catalysis. 3 credits, 3 contact hours.
Prerequisites: CHE 612 or equivalent. The class provides an introduction to catalytic phenomena as well as catalysts with the background information necessary to understand industrial catalytic processes. Examples discussed are hydrogen, ammonia and methanol synthesis, inorganic and organic oxidation reactions, petrochemical processes, pollution abatement and other important processes. The course provides insight into the theory of catalytic phenomena and information about related technologies from an industrial perspective.

CHE 775. Molecular Simulations in CHE. 3 credits, 3 contact hours.
Prerequisites: CHE 611 and CHE 626. Minimal programming experience in any programming language (e.g. Matlab, Python or Fortran). The course is aimed to introduce graduate students to the basics of molecular simulation. Two simulation techniques will be discussed in detail: Monte Carlo and molecular dynamics methods. The students will study the algorithms, and the statistical mechanics basis of these algorithms. Then they will use popular open source codes to simulate systems relevant for chemical engineers.

CHE 781. Polymerization-Principles and Practice. 3 credits, 3 contact hours.
Pre or Corequisite: CHE 611. 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 782. Polymer Structures and Properties. 3 credits, 3 contact hours.
Pre or Corequisite: CHE 611. 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 790. Doct Dissertation & Res. 0 credits, 0 contact hours.
Co-Requisite: CHE 791. For students admitted before Fall 2015. 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.
Co-requisite: CHE 791. For students admitted to the Doctor of Philosophy Program in Chemical Engineering who have passed the Qualifying Examination and Research Proposal. Required of all students for the degree of Doctor of Philosophy. Approval of dissertation advisor is necessary for registration. Experimental or theoretical investigation of a topic in chemical engineering. Students must register for 1 credit of dissertation per semester until a written dissertation is approved.

CHE 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite: CHE 791. For students admitted to the Doctor of Philosophy Program in Chemical Engineering who have passed the Qualifying Examination but have not defended Research Proposal. Required of all students for the degree of Doctor of Philosophy. Approval of dissertation advisor is necessary for registration. Experimental or theoretical investigation of a topic in chemical engineering. Students must register for 3 credits of dissertation per semester after passing Qualifying Examination until they successfully defend their Research Proposal.

CHE 790C. Doct Dissertation & Res. 6 credits, 6 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. Doct 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.
Co-requisite for full time students: CHE 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in chemical engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well, for students who have completed the required coursework but have not passed the qualifying examination.

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.

CHE 795. Research Methods for Doctoral. 3 credits, 3 contact hours.
Prerequisites: Doctoral standing in CBPE or permission of the instructor. This course is designed to enhance professional development of our doctoral students in order to significantly increase their research productivity, communications, and leadership skills while preparing them for a successful career. Concepts include setting priorities, time management, and learning best practices in research planning, execution, communication, writing and presentation. Advanced topics include understanding innovation, intellectual property and writing better proposals.

MTEN 610. Found of Materials Sci & Engr. 3 credits, 3 contact hours.
Prerequisite: Graduate standing. Core course for students in Material Science and Engineering. The effect of structure on the properties and behavior of engineering materials. Topics include atomic structure, bonding, crystallography, and defects in solids; properties of metals, semiconductors, ceramics, and polymers and their behavioral response to mechanical, chemical, optical, electrical, and magnetic stimuli.

MTEN 611. Diffusion & Solid State Kineti. 3 credits, 3 contact hours.
Prerequisite: MTSE 602. The atomic theory of diffusion and mathematical derivation of the diffusion equations. Diffusion phenomena in dilute alloys as well as in ionic and covalent solids are considered. High atom mobility effects at defect sites and surfaces are examined. Chemical kinetics and kinetics of phase transformations including nucleation, growth, and spinodal decomposition are discussed.

MTEN 612. Thermodynamics of Materials. 3 credits, 3 contact hours.
Prerequisite: Undergraduate thermodynamics. Core course for students in Material Science and Engineering. Review of first, second, and third laws of thermodynamics and their applications to materials. Stability criteria, simultaneous chemical reactions, binary and multicomponent solutions, phase diagrams, surfaces, adsorption phenomena, thermochemistry of homogeneous and heterogeneous reactions are covered.

MTEN 613. Characterization of Materials. 3 credits, 3 contact hours.
Prerequisites: Undergraduate classes covering physics, chemistry, thermodynamics, and heat and mass transfer, or permission of the instructor. The course is designed to introduce graduate students in chemical and materials engineering, and other engineering and science disciplines, to fundamentals and theory of different types of materials characterization tools. Methods and techniques necessary to understand and quantify diverse materials properties will be discussed. As important for many methods, basic principles of interaction of radiation and particle beams with matter will be studied. Topics include, but are not limited to: Diffraction methods; imaging via optical, scanning, transmission electron, scanning tunnelling, and field ion microscopy; microanalysis and spectroscopy, including energy dispersive, wavelength dispersive, Auger methods; secondary ion mass spectroscopy, X-ray photoelectron spectroscopy; materials preparation for analysis, including electron, ion growth, sputtering; thermal analysis: DTA, DSC; and depending on the availability and functionality of equipment, lab visits and demonstrations will be scheduled to the class to discuss some case studies.

MTEN 631. Data Science for Chemical and Materials Engineers. 3 credits, 3 contact hours.
Prerequisites: BS degree in Chemical, Mechanical, Electrical or Biomedical Engineering, or in Physics or Chemistry. This is a course for graduate level students in chemical engineering, materials engineering, pharmaceutical engineering, or a related discipline. The focus is on the use of data science techniques to solve problems in chemical engineering. We will first discuss the Python programming language and how it can be used to manipulate, clean, explore, and visualize scientific datasets using the pandas package. We will the cover statistics and probability as it applies to engineering problems; this includes conditional probability, probability distributions, hypothesis testing, and Bayesian inference. Basic supervised machine learning models will be introduced, including linear and logistic regression, decision trees and random forest, and support vector machines. Students will then learn different analytical techniques and how to combine all of these skills to solve engineering problems involving large amounts of data and make predictions. Finally, we will cover how to access data and create your own datasets; topics include databases (including relational databases such as SQL) and basic data mining and web scraping. Applications of these methods will be demonstrated in chemical engineering (e.g., optimization and controls, sensor analysis), materials engineering (e.g., structural databases and property selection), and pharmaceutical engineering (e.g., drug selection). Students will gain hands-on experience in implementing and utilizing these various methods through computational laboratory assignments and reports and a semester-long engineering design project.

MTEN 633. Machine Learning for Chemical and Materials Engineers. 3 credits, 3 contact hours.
Prerequisites: Undergraduate degree in either Chemical, Mechanical, Electrical or Biomedical Engineering, or in Physics or Chemistry. This course builds upon foundational knowledge in mathematical and statistical tools or data science and data visualization to learn and apply machine learning approaches for solving problems in Engineering with emphasis on applications in Chemical and Materials. As an engineering course, the emphasis is on case studies involving problem solving to augment mechanistic methods. It will include artificial intelligence (AI) topics such as machine learning and deep learning via methods such as classification, clustering, and neural networks (NNs), along with robust estimation including validation and error quantification. Class projects will concern case studies from a broad range of disciplines and applications to chemical and materials engineering problems.

MTEN 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials engineering. A written report must be submitted to the project advisor. The student cannot register in MTEN 700B more than once and the incomplete (I) grade is not allowed. Master’s students registering for the first time in Master’s Project must take simultaneously the INTD 799 (Responsible Contact of Research) course.

MTEN 701B. Masters Thesis. 3 credits, 3 contact hours.
Corequisite for full-time students: MTEN 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in MTEN 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply). Master’s students registering for the first time in Master’s Thesis must take simultaneously the INTD 799 (Responsible Contact of Research) course.

MTEN 701C. Master's Thesis. 6 credits, 6 contact hours.
Co-requisite for full-time students: MTEN 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in materials engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (MTEN 701B course) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

MTEN 711. Nanocomposite Materials. 3 credits, 3 contact hours.
Prerequisites: Core courses in MTSE, MTEN 611 and MTEN 613 or equivalent courses, or permission of the instructor. This course covers advanced aspects of nanocomposite materials formation, properties, characterization, and applications. Emerging materials and their synthesis techniques are discussed along with key issues in processing, as well as identification and characterization of properties as relevant to application areas. Examples include, Polymer-based and Polymer-filled Nanocomposites, Bio-Nanocomposites, Metal and Ceramic Nanocomposites, Nanocomposites for Energy and Electronics materials, etc.

MTEN 712. Nanomaterials. 3 credits, 3 contact hours.
New feature of the 700 level course will be hands-on small projects carried out by groups of two students in Professor Iqbal's laboratories during the second half of the semester. The projects will be selected from the topics covered in the course. A second feature will involve a lecture on a specialized nanomaterial topic given by an invited outside lecturer. This 3 credit interdisciplinary course is designed to teach and provide hands-on project experience to M.S. and Ph.D. graduate students in chemistry, physics/materials science, and chemical/biomedical/electrical engineering on the fundamentals, synthesis, characterization and applications of nanomaterials. 75% of the course will comprise of lectures-one or two of which will be given by invited outside lecturers. 25% of the course will involve small projects based on the syllabus and conducted in the research laboratories of the instructor.

MTEN 725. Independent Study I. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

MTEN 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for MTEN 726 if they have taken MTEN 725 in a prior semester. Students cannot register for this course with the same advisor as they had in MTEN 725.

MTEN 790A. Doct Dissertation & Res. 1 credit, 1 contact hour.
Co-requisite for full-time students: MTEN 791. Approval of the dissertation advisor is required for registration. Experimental and theoretical investigation of a relevant topic in materials engineering. For PhD students who have successfully defended their dissertation proposal. The student must register in MTEN 790A every semester until successful dissertation defense. A written dissertation must be defended and approved by a committee of at least five members. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint PhD programs with other universities).

MTEN 790B. Doct Dissertation & Res. 3 credits, 3 contact hours.
Co-requisite for full-time students: MTEN 791. Since the MTEN 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. Experimental and theoretical investigation of a relevant topic in materials engineering. For PhD students who have successfully defended their dissertation proposal. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to joint programs with other universities).

MTEN 790C. Doct Dissertation & Res. 6 credits, 6 contact hours.
Co-requisite for full-time students: MTEN 791. Since the MTEN 790A course should normally be taken instead, approvals of academic and dissertation advisors are required for registration. For PhD students who have successfully defended their dissertation proposal. Experimental and theoretical investigation of a relevant topic in materials engineering. Students enrolled in the PhD program before 2015 Fall must accumulate a minimum number of credits in Doctoral Dissertation Research and Pre-Doctoral Research (see graduate catalog for program-specific details; the same requirement may apply to some joint programs with other universities.

MTEN 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite: CHE 791. For students admitted to the Doctor of Philosophy Program in Materials Science and Engineering with option in Engineering who have not yet passed Qualifying Examination and Research Proposal. Experimental or theoretical investigation of a topic in chemical engineering. Research is carried out under the supervision of designated chemical engineering faculty.

MTEN 792B. Pre-Doctoral Research. 3 credits, 3 contact hours.
Co-requisite for full time students: MTEN 791. Approval of the dissertation advisor is required for registration. Preliminary experimental and/or theoretical investigation of a relevant topic in materials engineering. For students who have passed the qualifying examination but have not defended the dissertation proposal. Permission is needed of the academic advisor as well, for students who have completed the required coursework but have not passed the qualifying examination.

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. 1 credit, 1 contact hour.
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. 1 credit, 1 contact hour.
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. 1 credit, 1 contact hour.
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 700B. Master's Project. 3 credits, 3 contact hours.
Approval of the project advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in the student’s academic program. A written report must be submitted to the project advisor. The student cannot register in 700B more than once and the incomplete (I) grade is not allowed.

PHEN 701B. Master's Thesis. 3 credits, 3 contact hours.
Corequisite for full-time students: PHEN 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in pharmaceutical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student is expected to defend the thesis upon accrual of six thesis credits. Additional registration in PHEN 701B, beyond six credits, is required every semester until successful thesis defense (six credits count toward degree requirements and time limits apply). Master’s students registering for the first time in Master’s Thesis must take simultaneously the INTD 799 (Responsible Contact of Research) course.

PHEN 701C. Master'S Thesis. 6 credits, 3 contact hours.
Corequisite for full-time students: PHEN 791. Approval of the thesis advisor is required for registration. Experimental and/or theoretical investigation of a relevant topic in pharmaceutical engineering that can lead to a quality publication. A written thesis must be defended and approved by a committee of at least three faculty members. The student must continue registering for three thesis credits (PHEN 701B course) each semester until successful thesis defense (six credits count toward degree requirements and time limits apply).

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.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once.

PHEN 726. Independent Study II. 3 credits, 3 contact hours.
Approvals of the academic advisor and course instructor are required for registration. Students working on their PhD dissertation or MS thesis cannot normally register for this course with their respective dissertation/thesis advisor. This special course covers areas of study in which one or more students may be interested but there is not sufficiently broad interest to warrant a regular course offering. Students may not register for this course more than once. Students should only register for PHEN 726 if they have taken PHEN 725 in a prior semester. Students cannot register for this course with the same advisor as they had in PHEN 725.

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.