The Institute for Molecular Engineering (IME) is at the forefront of an emerging field. This exciting venture prepares students to combine problem-solving skills with broad expertise in the fundamental sciences to build useful systems from the molecular level up. The IME’s approach to engineering research and education emphasizes analytical and disciplinary integration, rather than the traditional separation of engineering disciplines. As a result, students from diverse scientific backgrounds may collaborate on research projects that involve the incorporation of synthetic molecular building blocks, including electronic, optical, mechanical, chemical, and biological components, into functional systems that will impact technologies from advanced medical therapies to quantum computing.

Established in 2011 by the University of Chicago, in partnership with Argonne National Laboratory (http://www.anl.gov), the IME brings together a growing team of world-class researchers from diverse science and engineering disciplines who take a hands-on approach to mentoring students and cultivating relationships with industrial and academic partners - resulting in exciting discoveries, new technologies, and innovative solutions.
IME researchers conduct their work at the new William Eckhardt Research Center, one of the largest and most modern accessible nanofabrication facilities in the Midwest, which includes cutting-edge clean rooms, molecular imaging facilities, biomolecular research labs, and a wet-lab for nanofabrication and other materials work. Additionally, Argonne National Laboratory brings important resources to the endeavor, including the Advanced Photon Source (http://www.aps.anl.gov), the Argonne Leadership Computing Facility (http://www.alcf.anl.gov) and the Center for Nanoscale Materials (http://nano.anl.gov).

In May 2013, the University of Chicago’s Council of the University Senate approved the Institute for Molecular Engineering’s PhD program, thus launching the first engineering graduate program in the history of the University of Chicago.

How to Apply

The Institute for Molecular Engineering welcomes students with diverse academic backgrounds, including all fields of physical, biological and computational sciences, who possess the motivation and background to transcend disciplinary boundaries and pursue research in a bold, problem-focused way. Applicants to the Ph.D. program should have a bachelor’s degree in a STEM field and should provide scores for the GRE general test and the TOEFL (if not a native English speaker). The relevant GRE subject test scores will be considered if submitted, and could strengthen an application, but are not strictly required. Please submit a personal statement of research interests, three recommendation letters, and transcript(s) from all undergraduate and graduate institutions. Applications are due January 5, 2016. https://apply-ime.uchicago.edu/apply

Degree Requirements

Graduate students entering the IME Ph.D. program are expected to fulfill a set of course requirements including 3 core courses, 4 in-depth courses in the area relevant to their research field of choice, and 2 broad elective courses. The core and in-depth courses are selected from a portfolio of graduate-level courses, in conjunction with the faculty advisor. These courses are offered by the IME, sister departments (Physics, Chemistry, Biophysics, Computer Science and Biological Sciences) or developed specifically for IME students. The broad electives are to provide students with the opportunity to acquire skills in leadership, communication, technology development and product design. The hallmark of IME’s Ph.D. program is a highly customized curriculum tailored to each individual student’s needs and inspirations.

The vibrant and diverse research activities pursued by IME faculty members offer students a broad range of research opportunities. First-year students are encouraged to explore these opportunities by participating in the IME Forum, a series of faculty research talks during autumn quarter, and by establishing relationships with individual faculty members. As the institute works in a highly interdisciplinary environment, there are many opportunities to work with multiple faculty members within the institute and/or with faculty in other partner institutes at the University of Chicago and Argonne National Laboratory (see our website (http://ime.uchicago.edu/partners) for a full list). Every effort will be made to facilitate the matching of each student with one of their preferred advisors by the end of the first term.
Some students may be recommended for a terminal M.S. degree. Such students must have registered full time in the division for a minimum of three quarters, have completed nine 30000-level courses in STEM departments with grades of C or better, and have completed at least 200 units of research with an approved faculty member. In addition, these students may, at the discretion of the Director of Graduate Studies, be required to submit a paper on their research.

To establish candidacy, students are required to develop a research proposal describing the objectives, approaches and expected outcomes of their Ph.D. thesis work. Students will give an oral presentation of their written proposal in front of a faculty review committee for approval. This process should be completed no later than the end of the Winter quarter of the second year.

All graduate students are expected to have two quarters of teaching experience, or equivalent activity, in order to graduate.

All students will receive scholarship support from the Institute for the first quarter. Subsequently, IME provides full financial support to all graduate students throughout their graduate study at IME as long as they remain in good standing.

The IME adopts the residency requirement of the University of Chicago as a part of the degree requirements.

**Molecular Engineering Courses**

**MENG 30000. Introduction to Emerging Technologies. 100 Units.**
This course will examine five emerging technologies (stem cells in regenerative medicine, quantum computing, water purification, new batteries, etc.) over two weeks each. The first of the two weeks will present the basic science underlying the emerging technology; the second of the two weeks will discuss the hurdles that must be addressed successfully to convert a good scientific concept into a commercial product that addresses needs in the market place.
Instructor(s): Matthew Tirrell Terms Offered: Autumn

**MENG 31000. Material Sciences and Engineering. 100 Units.**
This course will discuss the structure and properties of organic and inorganic materials, ranging from polymeric systems, to metallic alloys; the focus will be on the interrelations between chemical bonding, molecular structure, and the resulting behaviour of materials. The course will address physical, chemical, and processing considerations in materials selections for specific applications.
Instructor(s): Paul Nealey Terms Offered: Autumn
MENG 32000. Mathematical Foundations of Molecular Engineering. 100 Units.
This course will provide an overview of the general mathematical framework required to describe mass, momentum, energy and electronic transport in gases, liquids and solids. That framework will be illustrated in the context of common problems in diffusion, heat conduction, viscous flow and charge transfer. The course will also provide an introduction to elementary numerical and statistical methods for solution of such problems in representative engineering applications.
Instructor(s): Andrew Spakowitz Terms Offered: Autumn
Prerequisite(s): Required Math Courses in the Core, Algebra, Calculus, Physics

MENG 32500. Polymer Science and Engineering. 100 Units.
This course is an advanced introduction to polymer physics and engineering taught at a level suitable for senior undergraduates and graduate students in STEM fields. Topics that will be covered include the statistics and conformations of linear chain molecules, thermodynamics and dynamics of polymers, polymer blends and polymer solutions, phase equilibria, networks, gels, and rubber elasticity, linear viscoelasticity, thermal and mechanical properties. A laboratory component will supplement the lectures.
Instructor(s): Paul Nealey Terms Offered: Autumn
Prerequisite(s): Background in thermodynamics and transport.

MENG 33000. Thermodynamics and Statistical Mechanics. 100 Units.
This course will present an overview of thermodynamics and statistical mechanics in the context of molecular engineering applications. Such applications will include prediction of the thermophysical properties of multicomponent gases, solids and liquids, prediction of adsorption processes on surfaces or interfaces, and molecular-level descriptions of synthetic and biological macromolecules in solution. Throughout the course, emphasis will be placed on connecting molecular structure and interactions to measurable macroscopic properties.
Instructor(s): Juan de Pablo Terms Offered: Autumn
Prerequisite(s): Chemistry 26100-26200 or equivalent or the consent of the instructor

MENG 33100. Applied Numerical Methods in Molecular Engineering. 100 Units.
The course is intended to provide the fundamental tools of numerical methods for problems in molecular engineering. It includes interpolation, integration, minimization techniques and weighted residuals. Application of the methods towards multi-scale solutions from atomistic to continuum approximations are covered. Finite differences, finite elements, boundary elements and collocation methods are explained and used in molecular engineering problems. Fundamental concepts of statistical thermodynamics, transport phenomena, electromagnetism and Rheology are revisited.
Instructor(s): Staff Terms Offered: Spring
Prerequisite(s): MATH 20000-20100 or MATH 22000 or PHYS 22100; and CHEM 11300/12300 or PHYS 13300/14300. Grads should have work in Thermodynamics and Transport.
Equivalent Course(s): MENG 23100
MENG 33400. Applied Probability for Engineers. 100 Units.
This course will begin with a review of basic probability axioms, events, Independence, Bayes theorem, combinatorics and discrete and continuous random variables. It will also cover functions of random variables, expectation and moments and conditional expectation. Markov, Chebychev and Chernoff concentration bounds will be covered. Stochastic convergence and laws of large numbers, random walks and Markov chains and estimation methods will also be covered. Engineering examples will be used throughout the course to clarify concepts. Instructor(s): Monisha Ghosh Terms Offered: Spring Prerequisite(s): MATH 13300, MATH 15300, MATH 16300, MATH 19620, or PHYS 22000. Equivalent Course(s): MENG 23400

MENG 34100-34200. Selected Topics in Molecular Engineering: Molecular/Materials Modelling I-II.
Molecular modeling seeks to develop models and computational techniques for prediction of the structure, thermodynamic properties, and non-equilibrium behaviour of gases, liquids, and solids from knowledge of intermolecular interactions. Instructor(s): Juan de Pablo, Giulia Galli Terms Offered: Winter Prerequisite(s): MATH 20000 and MATH 20100 or MATH 22000 or PHYS 22100 Equivalent Course(s): MENG 24100

MENG 34100. Selected Topics in Molecular Engineering: Molecular/Materials Modelling I. 100 Units.
Molecular modeling seeks to develop models and computational techniques for prediction of the structure, thermodynamic properties, and non-equilibrium behaviour of gases, liquids, and solids from knowledge of intermolecular interactions. This course will introduce students to the methods of molecular modeling. The topics covered will include an introduction to the origin of molecular forces, a brief introduction to statistical mechanics and ensemble methods, and an introduction to molecular dynamics, Brownian dynamics, and Monte Carlo simulations. The course will also cover elements of advanced sampling techniques, including parallel tempering, umbrella sampling, and other common biased sampling approaches. Course work or research experience is strongly recommended in: (1) elementary programming (e.g., C or C++), and (2) physical chemistry or thermodynamics. Instructor(s): Juan de Pablo, Giulia Galli Terms Offered: Winter Prerequisite(s): MATH 20000 and MATH 20100 or MATH 22000 or PHYS 22100 Equivalent Course(s): MENG 24100
MENG 34200. Selected Topics in Molecular Engineering: Molecular/Materials Modelling II. 100 Units.
This course provides a continuation of the topics covered in Molecular Modelling I. It seeks to introduce students to electronic structure methods for modelling molecular and condensed systems. The topics covered will include an introduction to quantum mechanical descriptions of ground and excited state properties of molecules and solids. The course will focus on simulations based on the numerical solution of the Schrödinger equation using different approximations, including wavefunctions methods (e.g., Hartree Fock), and density functional theory, and various integration techniques and basis sets. Instructor(s): Giulia Galli, Juan de Pablo Terms Offered: Spring
Prerequisite(s): MENG 24100
Equivalent Course(s): MENG 24200

MENG 34300. The Engineering and Biology of Tissue Repair. 100 Units.
This course will examine the biomolecular and cellular bases for tissue engineering, including biological processes and biomolecular actors underlying morphogenesis and tissue repair in a number of tissue systems. Biomaterials and drug release principles being developed for tissue engineering will be examined, and the means by which molecular engineering is interfaced with the biomolecules and cells involved in tissue morphogenesis for tissue engineering will be elaborated. Selected case studies in different tissue engineering applications will be considered both through didactic presentations and projects undertaken by the students. Instructor(s): Joel Collier Jeffrey Hubbell Terms Offered: Spring
Prerequisite(s): Coursework or research experience in cell biology and biochemistry strongly recommended.

MENG 49900. Research: Molecular Engineering. VAR Units.
No description available.
Instructor(s): Staff Terms Offered: Summer, Autumn, Winter, Spring
MENG 58001. Numerical Methods. 100 Units.
This is a practical programming course focused on the basic theory and efficient implementation of a broad sampling of common numerical methods. Each topic will be introduced conceptually followed by detailed exercises focused on both prototyping (using matlab) and programming the key foundational algorithms efficiently on modern (serial and multicore) architectures. The ideal student in this course would have a strong interest in the use of computer modeling as predictive tool in a range of disciplines -- for example risk management, optimized engineering design, safety analysis, etc. The numerical methods studied in this course underlie the modeling and simulation of a huge range of physical and social phenomena, and are being put to increasing use to an increasing extent in industrial applications. After successfully completing this course, a student should have the necessary foundation to quickly gain expertise in any application-specific area of computer modeling.
Instructor(s): Andrew Siegel Terms Offered: Spring
Prerequisite(s): MPCS 50101 or programming waiver
Note(s): Non-MPCS students must receive approval from program prior to registering.