Molecular Engineering

Department Website: http://ime.uchicago.edu/students/undergraduates

Engineering is the science of solving complex technological problems and, in the case of molecular engineering, using tools and concepts that arise from the fundamentals of science at the nanoscale. The tools of engineering are important in making and translating basic discoveries in other fields into new intellectual opportunities and, sometimes, useful technologies.

Institute for Molecular Engineering

The Institute for Molecular Engineering (IME) was founded on the principle of collaborative problem-solving, not rigid academic disciplines. It is at the forefront of an emerging field that has the potential to address fundamental problems of societal import. This exciting new field involves the incorporation of synthetic molecular building blocks into functional systems that will impact technologies from advanced medical therapies to quantum computing.

Created in partnership with Argonne National Laboratory, the IME builds on the tradition of collaboration and cutting-edge research well-established at Argonne and the University of Chicago. It conducts research at the intersection of chemical, electrical, mechanical, and biological engineering, as well as materials, biological, and physical sciences. The institute's exploration of innovative technologies in nanoscale manipulation and design at a molecular scale has the potential for impact in such areas as energy, health care, and the environment.

Major Program in Molecular Engineering

The BS degree program in Molecular Engineering offers undergraduates a cutting-edge engineering curriculum built on a strong foundation in mathematics, physics, chemistry, and biology. Majors choose from three quantitative engineering tracks: one track aimed at engineering with a biology emphasis, a track with a focus on chemical and soft materials, and a track geared toward applied physics. The applied physics track, offered in close collaboration with the Department of Physics, is one of the first initiatives worldwide to formally educate quantum engineers at the undergraduate level.

Courses in the major are designed to develop quantitative reasoning and problem-solving skills; to introduce engineering analysis of physical, chemical, and biological systems; and to address open-ended technological questions across a spectrum of disciplines. The aim is to introduce invention and design, along with inquiry and discovery, as fruitful and complementary intellectual activities. The program will both prepare undergraduates for a wide variety of careers in technology-focused industries and position graduates for further postgraduate study in such fields as science, engineering, medicine, business, or law.

Major Program Requirements

1. A strong and broad background in mathematics, physics, chemistry, and biology. It is imperative for a modern engineer to have a strong and broad background in the sciences. Traditional engineering disciplines have had requirements in math, chemistry, and physics for decades and many programs have evolved to require biology as well. The highly interdisciplinary nature of Molecular Engineering requires a foundation built across the mathematical, physical, and biological sciences. Students are encouraged to complete their general education requirements as early in their academic sequence as possible and at the highest level for which they are prepared. This will better position students to take advantage of advanced electives and research opportunities.

As discussed in more detail below, there are three tracks for Molecular Engineering majors: the Biology Track, the Chemical and Soft Materials Track, and the Quantum Track. Students in the first two tracks will follow precedents set by Chemistry and Biological Sciences majors in that they will likely take chemistry in year 1, physics in year 2, and follow the recommended mathematics courses in the Chemistry curriculum. Students in the Quantum Track will follow precedent set by Physics majors in that they will likely take physics in year 1, follow the mathematics guidelines of Physics majors, and take chemistry in year 2.

2. MENG 26030 Introduction to Engineering Analysis. One of the first courses for all Molecular Engineering majors, this course teaches students to apply mathematical methods towards solving problems that cut across multiple engineering sub-disciplines. A major objective of the course is to teach simple programming skills and computational methods in applied mathematics, including the use of engineering software such as Matlab, Mathematica, and elements of Python. The skills that are introduced here will be further developed and strengthened throughout the rest of the curriculum.

3. Three Molecular Engineering tracks. Reflecting the research and education themes of the IME, three distinct tracks for the major are available to students. One is aimed at preparing students oriented towards biological engineering, another is aimed toward chemical and soft materials, and the other is aimed at preparing students for the engineering of quantum-based materials, devices, and processes.

4. MENG 29511-29512 Engineering Design I-II (200-unit capstone sequence) . This design course is a two-quarter sequence that teaches students how to combine fundamental science and engineering to solve open-ended problems, for example, analyzing the chemical and biological properties of cancer cells to develop new treatment and delivery vehicles or harnessing the properties of electrons in materials to develop quantum information technologies. Engineers from industry, the national laboratories, and academia, including IME faculty and fellows, will propose real-world projects for which they will serve as mentors. Students will work together in small teams throughout the two quarters to address the diverse engineering challenges that arise.

The design course also serves as a vehicle to teach other equally important non-technical skills, including:

- Problem identification: technology analysis, competitive analysis, market analysis, stakeholder analysis, product definition
- Impact of the project, including sociological and engineering ethics
- Project planning
- Project economics: costs, value/investment analysis, risk analysis and adjustment
- Prototyping, experimental design, data analysis, error analysis
- IP: patenting, prior art, patentability
- Legal and regulatory analysis
- Proposing, presenting, and reporting
- Teamwork

For the 2018–19 academic year only, MENG 29500 Engineering Design will be offered in the Winter Quarter as an alternative capstone option. This intensive, 300-unit course covers many of the same principles as MENG 29511-29512 Engineering Design I-II, with an eye toward similar outcomes. MENG 29501 Undergraduate Research Colloquium will no longer be offered or required. The Molecular Engineering department recommends that majors take MENG 29511-29512 Engineering Design I-II rather than MENG 29500, unless their Autumn Quarter schedule makes doing so unfeasible. Students with questions should contact the adviser for Molecular Engineering as early as possible.

5. Advanced electives (four required courses in the major). The major is structured to allow for considerable flexibility for students to tailor their programs along individualized trajectories, with help from faculty advisers. Not only can students choose between multiple tracks, but they can further build breadth or depth through their choice of advanced electives. Moreover, we anticipate that our students will use their general electives outside of the major requirements to strengthen their backgrounds in specific areas of interest, also in consultation with Molecular Engineering advisers, to achieve desired outcomes such as preparation for graduate school in more traditional engineering disciplines.

6. Laboratory skills and hands-on experience. Critical skills that molecular engineers must acquire as part of their educational program include the ability to apply knowledge of mathematics, science, and engineering and the ability to design and conduct experiments, as well as the ability to analyze and interpret data. Molecular Engineering majors develop these skills through lab components associated with required courses in the physical and biological sciences and Molecular Engineering courses including MENG 26101 Transport Phenomena I: Forces and Flows and MENG 26201-26202 Thermodynamics and Statistical Mechanics I-II. We also anticipate that many Molecular Engineering students will receive advanced laboratory experience pursuing undergraduate research projects.

7. Non-technical skills. Many decades of workshops and panels engaging stakeholders in academia and industry, often associated with the Accreditation Board for Engineering and Technology (ABET), have identified criteria for outcomes of students in engineering education programs. Although there is no plan to seek ABET accreditation for the Molecular Engineering major, many ABET criteria, particularly those related to non-technological skills, are viewed as essential to incorporate into the Molecular Engineering major. Examples of student outcomes that fall into this category include: (a) an ability to formulate or design a system, process, or program to meet desired needs, (b) an ability to function on multidisciplinary teams, (c) an understanding of professional and ethical responsibility, (d) an ability to communicate effectively, (e) the broad education necessary to understand the impact of solutions in a global and societal context, (f) a recognition of the need for and an ability to engage in life-long learning, and (g) a knowledge of contemporary issues. Many of these outcomes will be addressed through both the Molecular Engineering degree curriculum (particularly emphasized in the Design sequence) and the College general education requirements. Students who are able to both develop and articulate these skills will be positioned favorably for employment in industry and for postgraduate study in engineering, medicine, law, and business administration.

Entering the Program

Students must indicate their intent to pursue the BS program at the end of the Autumn Quarter in their second year of study by completing the *Intent to Pursue Molecular Engineering* questionnaire (https://ime.uchicago.edu/students/undergraduates/undergraduate_faq) available on the IME website. They begin the engineering curriculum in the following Spring Quarter with enrollment in either MENG 26010 Engineering Principles of Conservation or MENG 26020 Engineering Electrodynamics. Both courses require the completion of their stated prerequisites. Students should plan with their College advisers early in their first year of study for those prerequisites to be completed in a timely manner.

Summary of Requirements for the Major in Molecular Engineering: Biology Track

GENERAL EDUCATION		
CHEM 10100 & CHEM 10200	Introductory General Chemistry I and Introductory General Chemistry II (or higher) [1]	200
One of the following sequences:		200
MATH 13100-13200	Elementary Functions and Calculus I-II (requires a grade of A- or higher)	

MATH 15100-15200	Calculus I-II [1]	
MATH 16100-16200	Honors Calculus I-II	
One of the following sequences:		200
BIOS 20186-20187	Fundamentals of Cell and Molecular Biology; Fundamentals of Genetics [2]	
BIOS 20234 & BIOS 20235	Molecular Biology of the Cell and Biological Systems [3]	
Total Units		600

MAJOR

CHEM 11300	Comprehensive General Chemistry III (or higher) [1]	100
PHYS 13100-13200-13300	Mechanics; Electricity and Magnetism; Waves, Optics, and Heat (or higher)	300
One of the following sets of three courses:		300
MATH 13300 Elementary Functions and Calculus III OR MATH 15300 Calculus III OR MATH 16300 Honors Calculus III OR MATH 19620 Linear Algebra, AND MATH 20000-20100 Mathematical Methods for Physical Sciences I-II [4]		
OR		
MATH 16300 Honors Calculus III, AND MATH 20500 Analysis in Rn III OR MATH 20900 Honors Analysis in Rn III, AND MATH 27300 Basic Theory of Ordinary Differential Equations		
MENG 26010	Engineering Principles of Conservation	100
MENG 26030	Introduction to Engineering Analysis	100
MENG 26101-26102	Transport Phenomena I: Forces + Flows; Transport Phenomena II	200
MENG 26201-26202	Thermodynamics and Statistical Mechanics I-II	200
MENG 29511-29512	Engineering Design I-II	200
Four advanced electives selected in consultation with the adviser for Molecular Engineering (at least two should be in the Biological Sciences above BIOS 20242). [6, 7]		400
Total Units		1900

1 Credit may be granted by examination.

2 Molecular Engineering majors can take these courses without the Biological Sciences prerequisites (BIOS 20150-20151) unless they pursue a double major in the Biological Sciences. They are expected to show competency in mathematical modeling of biological phenomena covered in BIOS 20151 Introduction to Quantitative Modeling in Biology (Basic).

3 Open only to students with a 4 or 5 on the AP Biology exam. Upon completion of BIOS 20234-20235-20236, students will be awarded a total of 200 units to be counted toward the general education requirement in the biological sciences.

4 MATH 13300 requires a grade of A- or higher.

5 For 2018–19 only, students may substitute MENG 29500.

6 Students should seek approval from the adviser for Molecular Engineering for their major electives before registering for and completing the courses.

7 Students who enroll in MENG 29500 will need only 300 units of major electives.

Summary of Requirements for the Major in Molecular Engineering: Chemical and Soft Materials Track

GENERAL EDUCATION

CHEM 10100 & CHEM 10200	Introductory General Chemistry I and Introductory General Chemistry II (or higher) [1]	200
One of the following sequences:		200
MATH 13100-13200	Elementary Functions and Calculus I-II (requires a grade of A- or higher)	
MATH 15100-15200	Calculus I-II [1]	
MATH 16100-16200	Honors Calculus I-II	
One of the following sequences:		200
BIOS 10602 & BIOS 10603	Multiscale Modeling of Biological Systems I and Multiscale Modeling of Biological Systems II	
BIOS 20186-20187	Fundamentals of Cell and Molecular Biology; Fundamentals of Genetics [2]	
BIOS 20234 & BIOS 20235	Molecular Biology of the Cell and Biological Systems [3]	
Total Units		600

MAJOR

CHEM 11300	Comprehensive General Chemistry III (or higher) [1]	100
PHYS 13100-13200-13300	Mechanics; Electricity and Magnetism; Waves, Optics, and Heat (or higher)	300
One of the following sets of three courses:		300
MATH 13300 Elementary Functions and Calculus III OR MATH 15300 Calculus III OR MATH 16300 Honors Calculus III OR MATH 19620 Linear Algebra, AND MATH 20000-20100 Mathematical Methods for Physical Sciences I-II [4]		
OR		
MATH 16300 Honors Calculus III, AND MATH 20500 Analysis in Rn III OR MATH 20900 Honors Analysis in Rn III, AND MATH 27300 Basic Theory of Ordinary Differential Equations		
MENG 26010	Engineering Principles of Conservation	100
MENG 26030	Introduction to Engineering Analysis	100
MENG 26101-26102	Transport Phenomena I: Forces + Flows; Transport Phenomena II	200
MENG 26201-26202	Thermodynamics and Statistical Mechanics I-II	200
MENG 29511-29512	Engineering Design I-II	200
Four advanced electives selected in consultation with the adviser for Molecular Engineering. [6, 7]		400
Total Units		1900

1 Credit may be granted by examination.

2 Molecular Engineering majors can take these courses without the Biological Sciences prerequisites (BIOS 20150-20151) unless they pursue a double major in the Biological Sciences. They are expected to show competency in mathematical modeling of biological phenomena covered in BIOS 20151 Introduction to Quantitative Modeling in Biology (Basic).

3 Open only to students with a 4 or 5 on the AP Biology exam. Upon completion of BIOS 20234-20235-20236 Molecular Biology of the Cell; Biological Systems; Biological Dynamics, students will be awarded a total of 200 units to be counted toward the general education requirement in the biological sciences.

4 MATH 13300 requires a grade of A- or higher.

5 For 2018–19 only, students may substitute MENG 29500.

6 Students should seek approval from the adviser for Molecular Engineering for their major electives before registering for and completing the courses.

7 Students who enroll in MENG 29500 will only need 300 units of major electives.

Summary of Requirements for the Major in Molecular Engineering: Quantum Track

GENERAL EDUCATION

PHYS 13100-13200	Mechanics; Electricity and Magnetism (or higher)	200
One of the following sequences:		200
MATH 13100-13200	Elementary Functions and Calculus I-II (requires a grade of A- or higher)	
MATH 15100-15200	Calculus I-II [1]	
MATH 16100-16200	Honors Calculus I-II	
Total Units		400

MAJOR

PHYS 13300	Waves, Optics, and Heat (or higher)	100
One of the following:		100
MATH 13300	Elementary Functions and Calculus III (requires a grade of A- or higher)	
MATH 15300	Calculus III	
MATH 16300	Honors Calculus III	
PHYS 22000	Introduction to Mathematical Methods in Physics	
CHEM 10100 & CHEM 10200 & CHEM 11300	Introductory General Chemistry I and Introductory General Chemistry II and Comprehensive General Chemistry III (or higher) [1]	300
One of the following:		100
PHYS 22100	Mathematical Methods in Physics	
MATH 20500	Analysis in Rn III	
MATH 20900	Honors Analysis in Rn III	
PHYS 15400	Modern Physics	100
PHYS 23400-23500	Quantum Mechanics I-II	200
MENG 26020	Engineering Electrodynamics	100

MENG 26030	Introduction to Engineering Analysis	100
One of the following sets of two courses: [2]		200
MENG 26201-26202	Thermodynamics and Statistical Mechanics I-II	
OR		
PHYS 19700 Statistical and Thermal Physics, AND PHYS 23600 Solid State Physics OR PHYS 25000 Computational Physics OR CHEM 26300 Chemical Kinetics and Dynamics		
OR		
CHEM 26200 Thermodynamics, AND PHYS 23600 Solid State Physics OR PHYS 25000 Computational Physics OR CHEM 26300 Chemical Kinetics and Dynamics		
MENG 29511-29512	Engineering Design I-II	200
Four advanced electives selected in consultation with the adviser for Molecular Engineering. [4, 5]		400
Total Units		1900

1 Credit may be granted by examination; consult the adviser for Molecular Engineering.

2 Note: PHYS 19700 requires, and CHEM 26200 expects, prior experience with intermediate quantum mechanics; these options are well-suited to, but not exclusively for, students double-majoring in Physics or Chemistry.

3 For 2018–19 only, students may enroll in MENG 29500.

4 Students should seek approval from the adviser for Molecular Engineering for their major electives before registering for and completing the courses.

5 Students who enroll in MENG 29500 will only need 300 units of major electives.

Approved Quantum Track Advanced Electives

All 20000-level Molecular Engineering courses not otherwise required for the major (except those numbered MENG 20XXX and 29XXX)	
All 20000-level Physics courses (except PHYS 29100-29200-29300 and PHYS 29700)	
Courses in Mathematics and Statistics (no more than two to be used as program electives):	
MATH 20400	Analysis in Rn II
or MATH 20800	Honors Analysis in Rn II
MATH 20500	Analysis in Rn III (Neither MATH 20500 nor MATH 20900 can be counted toward electives if substituted for PHYS 22100.)
or MATH 20900	Honors Analysis in Rn III
MATH 27000	Basic Complex Variables
MATH 27200	Basic Functional Analysis
MATH 27300	Basic Theory of Ordinary Differential Equations
MATH 27400	Introduction to Differentiable Manifolds and Integration on Manifolds
MATH 27500	Basic Theory of Partial Differential Equations
STAT 23400	Statistical Models and Methods
or STAT 24400	Statistical Theory and Methods I
STAT 24500	Statistical Theory and Methods II
Other courses in the physical sciences:	
CHEM 26300	Chemical Kinetics and Dynamics
CHEM 26800	Computational Chemistry and Biology
CMSC 23710	Scientific Visualization
CMSC 28510	Introduction to Scientific Computing
GEOS 21200	Physics of the Earth
GEOS 23200	Climate Dynamics of the Earth and Other Planets
Courses in the biological sciences:	
BIOS 29326	Introduction to Medical Physics and Medical Imaging
Courses not listed here can satisfy the advanced elective requirement if explicitly approved, on a case-by-case basis, by the adviser for Molecular Engineering.	

Sample Major Programs

Below is a sample four-year program for the Chemical and Soft Materials Track. *Students should rely on relevant placement tests and on the direction of the College advisers in creating a personal four-year program that accommodates their individual backgrounds and interests. Again, we recommend that students complete their science and mathematics general education requirements at the highest level for which they are prepared.*

First Year		
Autumn Quarter	**Winter Quarter**	**Spring Quarter**
MATH 15100	MATH 15200	MATH 15300
CHEM 11100	CHEM 11200	CHEM 11300
		BIOS 20186
Second Year		
Autumn Quarter	**Winter Quarter**	**Spring Quarter**
PHYS 13100	PHYS 13200	PHYS 13300
MATH 20000	MATH 20100	MENG 26010
BIOS 20187		
Third Year		
Autumn Quarter	**Winter Quarter**	**Spring Quarter**
MENG 26101	MENG 26102	MENG 26202
MENG 26030	MENG 26201	Advanced Elective
Fourth Year		
Autumn Quarter	**Winter Quarter**	**Spring Quarter**
MENG 29511	MENG 29512	Advanced Elective
Advanced Elective	Advanced Elective	

Below is a <u>*sample*</u> *four-year program for the* Quantum Track. *Students should rely on relevant placement tests and on the direction of the College advisers in creating a personal four-year program that accommodates their individual backgrounds and interests. Again, we recommend that students complete their science and mathematics general education requirements at the highest level for which they are prepared.*

First Year		
Autumn Quarter	**Winter Quarter**	**Spring Quarter**
MATH 15100	MATH 15200	MATH 15300
PHYS 14100	PHYS 14200	PHYS 14300
Second Year		
Autumn Quarter	**Winter Quarter**	**Spring Quarter**
CHEM 11100	CHEM 11200	CHEM 11300
PHYS 22100		MENG 26020
PHYS 15400		PHYS 23400
Third Year		
Autumn Quarter	**Winter Quarter**	**Spring Quarter**
MENG 26030	MENG 26201	MENG 26202
PHYS 23500	Advanced Elective	Advanced Elective
Fourth Year		
Autumn Quarter	**Winter Quarter**	
MENG 29511	MENG 29512	
Advanced Elective	Advanced Elective	

Minor Program in Molecular Engineering

The minor program in Molecular Engineering is designed for undergraduates majoring in the physical or biological sciences, mathematics, computer science, economics, or related fields. The overall objective of the program is to provide basic engineering tools and ways of thinking to students that augment scientific approaches and problem solving skills.

Minor Program Requirements

Before a student can declare the minor in Molecular Engineering, the student must complete the general education requirements in mathematics and physical sciences along with the course prerequisites for MENG 26010 Engineering Principles of Conservation. Following completion of all requirements, students must meet with the adviser for Molecular Engineering, Dr. Mark Stoykovich (stoykovich@uchicago.edu), to plan a course of study for the minor in the Molecular Engineering program. A student must then receive approval of the minor program on a Consent to Complete a Minor form (https://college.uchicago.edu/sites/college.uchicago.edu/files/Consent_Minor_Program.pdf). The signed form must then be returned to the student's College adviser by the end of the Spring Quarter of the student's third year. Deviations from the course plan agreed upon in the Consent to Complete a Minor form require the approval of Dr. Stoykovich and submission of a revised Consent to Complete a Minor form prior to their implementation.

To earn the minor in Molecular Engineering, a student must complete six courses as outlined below. All courses in Molecular Engineering are pre-approved as advanced electives for the minor. Students should seek approval for all advanced electives that are outside of Molecular Engineering before enrolling in those courses. Before meeting with the adviser for Molecular Engineering, students should invest some thought into which courses they would like to complete for the minor and how those courses relate as a set.

Courses in the minor program may not be (1) double counted with the student's major(s) or with other minors, or (2) counted toward general education requirements. Courses in the minor must be taken for quality grades, and more than half of the requirements for the minor must be met by registering for courses bearing University of Chicago course numbers.

Summary of Requirements for the Minor in Molecular Engineering

MENG 26010	Engineering Principles of Conservation	100
MENG 26030	Introduction to Engineering Analysis	100
One of the following sequences:		200
MENG 26201-26202	Thermodynamics and Statistical Mechanics I-II	
OR		
MENG 26101-26102	Transport Phenomena I: Forces + Flows; Transport Phenomena II	
OR		
MENG 26101	Transport Phenomena I: Forces and Flows	
AND		
MENG 26201	Thermodynamics and Statistical Mechanics I	
Two advanced electives selected in consultation with the IME adviser *		200
Total Units		600

* Students must secure approval before enrolling in courses they wish to use as advanced electives in the minor program.

Minor Program in Molecular Engineering Technology and Innovation

The overall objective of the minor program in Molecular Engineering Technology and Innovation is to introduce basic engineering concepts as they relate to evolving technologies, scientific innovation and entrepreneurship, scientific policy, and the broader impacts of engineering in society. The minor program is open to undergraduates from any major interested in these topics.

Minor Program Requirements

Students must complete the general education requirements in mathematics and physical sciences before declaring the minor in Molecular Engineering Technology and Innovation. Following completion of these requirements, students must meet with the adviser for Molecular Engineering, Dr. Mark Stoykovich (stoykovich@uchicago.edu), to plan a course of study for the minor. This meeting is mandatory and students who fail to have it may not be allowed to complete the minor. Prior to the meeting, students should invest some thought into which courses they would like to complete for the minor and how those courses relate as a set. The student and Dr. Stoykovich will fill out the Consent to Complete a Minor form (https://college.uchicago.edu/sites/college.uchicago.edu/files/Consent_Minor_Program.pdf) jointly, and once the form is signed the student must bring it to the student's College adviser. Deviations from the course plan agreed upon in the Consent to Complete a Minor form require the approval of Dr. Stoykovich and submission of a revised Consent to Complete a Minor form prior to their implementation.

To earn the minor in Molecular Engineering Technology and Innovation, a student must complete six courses as outlined below. Advanced electives must be chosen in consultation with Dr. Stoykovich. All courses in Molecular Engineering are pre-approved as advanced electives for the minor.

Courses in the minor program may not be (1) double counted with the student's major(s) or with other minors, or (2) counted toward general education requirements. Courses in the minor must be taken for quality grades, and more than half of the requirements for the minor must be met by registering for courses bearing University of Chicago course numbers.

Summary of Requirements for the Minor in Molecular Engineering Technology and Innovation

MENG 20000	Introduction to Emerging Technologies	100
2 to 5 additional courses in Molecular Engineering		200-500
0 to 3 elective courses selected in consultation with the IME adviser *		000-300
Total Units		600

* The following courses are pre-approved for the minor: BIOS 11140, BUSF 34103, BUSF 34106, BUSF 42703, ECON 22600, ECON 22650, ENST 23900, ENST 24705, ENST 26420, HIPS 17502, HIPS 21301, HIPS 25506, PBPL 21800, PBPL 23100, PBPL 24701, PBPL 29000, PHSC 12400, PHSC 12500. Students must secure approval before enrolling in courses that they wish to use as electives in the minor program and that are not on this pre-approved list.

Grading

In order to qualify for the BS degree, a GPA of 2.0 or higher (with no grade lower than C-) is needed in all courses required in the major. Students majoring in Molecular Engineering must receive quality grades in all courses required in the degree program. All courses in the minors must be taken for quality grades. Non-majors and non-minors may take Molecular Engineering courses on a P/F basis; only grades of C- or higher constitute passing work.

Honors

Students who pursue a substantive research project with a faculty member of the Institute for Molecular Engineering are encouraged to write and defend an honors thesis based on their work. Students who wish to be considered for honors are expected to complete their arrangements with the director of undergraduate studies before the end of their third year and to register for one quarter of MENG 29700 Undergraduate Research for Molecular Engineering during their third or fourth years.

To be eligible to receive honors, students in the BS degree program must write a creditable honors paper describing their research. The paper must be submitted before the deadline established by the director of undergraduate studies and must be approved by the department chairperson. In addition, an oral presentation of the research is required. The research paper or project used to meet this requirement may not be used to meet the BA/BS paper or project requirement in another major.

To earn a BS degree with honors in Molecular Engineering, students must also have an overall GPA of 3.0 or higher.

Molecular Engineering Courses

MENG 20000. 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
Prerequisite(s): Completion of the general education requirements in mathematics and physical or biological sciences
Equivalent Course(s): MENG 30000

MENG 20200. Introduction to Materials Science and Engineering. 100 Units.
Synthesis, processing and characterization of new materials are the pervasive, fundamental necessities for molecular engineering. Understanding how to design and control structure and properties of materials at the nanoscale is the essence of our research and education program. This course will provide an introduction to molecularly engineered materials and material systems. The course starts with atomic-level descriptions and means of thinking about the structure of materials, and then builds towards understanding nano- and meso-scale materials architectures and their structure-dependent thermal, electrical, mechanical, and optical properties. Strategies in materials processing (heat treatment, diffusion, self-assembly) to achieve desired structure will also be introduced. In the latter part of the course, applications of the major concepts of the course will be studied in quantum materials, electronic materials, energy-related materials, and biomaterials.
Instructor(s): Paul Nealey Terms Offered: Winter
Prerequisite(s): Completion of the general education requirements in mathematics and physical or biological sciences

MENG 21100. Molecular Science and Engineering of Water. 100 Units.
This course will cover the properties of the water molecule, hydrogen bonding, clusters, supercritical water, condensed phases, solutions, confined and interfacial water, clathrates, and nucleation. In addition, methods of water purification, water splitting and fuel cells, water in atmospheric and climate science, and water in biology, health and medicine will be discussed.
Instructor(s): James Skinner Terms Offered: Autumn
Prerequisite(s): MENG 26201 or CHEM 26200 or PHYS 19700 (or concurrent)
Equivalent Course(s): MENG 31100

MENG 21400. Introduction to Applications of Quantum Mechanical Methods to Materials Design. 100 Units.
Introduction to quantum chemistry and density functional theory (DFT) methods to model the properties of molecules and materials. Brief description of numerical techniques to solve the basic equations of quantum chemistry and DFT. Coupling of DFT with molecular dynamics for finite temperature properties. Applications to the description and design of structural properties of materials and molecules, spectroscopic properties (interaction of materials with electromagnetic fields), and transport properties (electronic and heat transport) from first principles.
Instructor(s): Giulia Galli Terms Offered: Autumn
Prerequisite(s): CHEM 26100 or PHYS 23400 or instructor consent

MENG 21600. Bioengineering Kinetics. 100 Units.
This course focuses on the kinetics of biochemical reactions at the molecular level. It aims to address basic questions at the interface between molecular engineering and cell biology. This course will equip students with knowledge and tools to quantitatively solve problems in biochemical systems at dynamics and equilibrium of molecular reactions.
Instructor(s): Jun Huang Terms Offered: Spring
Prerequisite(s): Completion of the first two quarters of a Biological Fundamentals Sequence

MENG 21900. Biological Physics. 100 Units.
This course is an introduction to the physics of living matter. Its goal is to understand the design principles from physics that characterize the condensed and organized matter of living systems. Topics include: basic structures of proteins, nucleotides, and biological membranes; application of statistical mechanics to diffusion and transport; hydrodynamics of low Reynolds number fluids; thermodynamics and chemical equilibrium; physical chemistry of binding affinity and kinetics; solution electrostatics and depletion effect; biopolymer mechanics; cellular mechanics and motions; molecular motors.
Instructor(s): A. Murugan Terms Offered: Spring
Prerequisite(s): PHYS 13300 or PHYS 14300
Note(s): Students majoring in Physics may use this course either as a Physics elective OR as a upper level elective in the Biological Sciences major.
Equivalent Course(s): PHYS 25500, BIOS 21506

MENG 22100. Chemical Kinetics and Reaction Engineering. 100 Units.
This course introduces the fundamental concepts of reaction kinetics, from the molecular mechanisms and reaction rates of chemical reactions to its applied aspects in the reaction engineering of complex chemical systems. Course topics will include elementary reactions and rate laws, collision theory, transition state theory, reaction dynamics, complex reacting systems, the steady-state hypothesis, heterogeneous catalysis, and diffusion-limited systems. The course will draw upon examples of industrial-scale chemical processes to consider the impact of kinetics on the engineering of batch and continuous-flow reactors.
Instructor(s): Xiaoying Liu Terms Offered: Spring
Prerequisite(s): MENG 26102 and MENG 26201

MENG 22500. Introduction to Polymer Science and Engineering. 100 Units.
This course introduces polymer materials and properties with a special emphasis on how these principles are applied in engineering applications. The course will cover a general overview to polymers, basic terminology and definitions, their classification, and their applications. The mechanistic and kinetic behavior of the major classes of polymerization reactions (step-growth, chain addition, and "living" polymerization) will be introduced with respect to control over polymer structure/architecture, size, and properties. The course will also discuss polymer properties, polymer thermodynamics, and basic structure-property relationships that provide polymers with their unique characteristics compared to small molecules. Techniques for characterizing the chemical and physical properties of polymer solutions and melts will be introduced, including osmometry, viscometry, rheometry, gel permeation chromatography, and NMR and IR spectroscopy. Engineering and processing of polymers will be presented in the context of modern, real-world applications (e.g., in structural materials, packaging, membranes, and lithography).
Instructor(s): Stuart Rowan, Paul Nealey Terms Offered: Autumn
Prerequisite(s): MENG 26201 or CHEM 26200
Equivalent Course(s): MENG 32510

MENG 22530. Advanced Polymer Physics. 100 Units.
This course is an advanced introduction to polymer physics 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; polymer brushes; thermodynamics and dynamics of polymers, polymer blends and polymer solutions; phase equilibria; networks, gels, and rubber elasticity; linear viscoelasticity; and thermal and mechanical properties.
Equivalent Course(s): MENG 32530

MENG 23100. 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): Juan Hernandez-Ortiz Terms Offered: Winter
Prerequisite(s): MATH 20000-20100 or PHYS 22000-22100, and CHEM 11300/12300 or PHYS 13300/14300
Equivalent Course(s): MENG 33100

MENG 23110. Applied Mathematical Methods for Pattern Formation in Soft Matter. 100 Units.
Pattern formation in soft matter will be studied with computational techniques. Linear algebra methods will be applied to the solution of partial differential equations related to stability of such patterns. Methods suited to nonlinear effects, such as Galerkin grid-free methods among others, will be presented and used to study spatial modulation of ideal linear patterns, nonlinear saturation of exponential growth, and non-potential evolution equations. Familiarity with linear algebra and some background in computer programming are expected as prerequisites.
Equivalent Course(s): MENG 33110

MENG 23310. Experimental Techniques and Advanced Instrumentation. 100 Units.
This course aims to provide students with a knowledge of state-of-the-art experimental measurement techniques and laboratory instrumentation for applications in broad scientific research environments, as well as industrial and general engineering practice. Topics include atomic-scale structural and imaging methods, electronic transport in low dimensional matter, magnetic and optical characterization of materials. Basic concepts in electronic measurement such as lock-in amplifiers, spectrum and network analysis, noise reduction techniques, cryogenics, thermometry, vacuum technology, as well as statistical analysis and fitting of data will also be discussed.
Instructor(s): David Awschalom Terms Offered: Spring
Prerequisite(s): Completion of PHYS 23400 & PHYS 23500 for undergraduates
Equivalent Course(s): MENG 33310

MENG 23330. Physics of Solid-State Nano-electronic Devices. 100 Units.
This course covers the fundamental concepts needed to understand nano-electronic solid-state devices. After an overview of the basic properties of semiconductors and electronic transport in semiconductors, the p-n junction, the metal-insulator-semiconductor (MIS) structure and diode are introduced. Following this, we will describe the physics behind four types of devices that all of us use every day and which have collectively changed the world: transistors, light emitting diodes (LEDs), lasers, and solid state memories. We will study the field effect transistor (FET) and describe metal-oxide-semiconductor-field-effect-transistor (MOSFET) technology, then introduce the light-emitting diode (LED) and the semiconductor injection laser. Following this, we will cover the physics behind some of the most common memories used today: the dynamic random access memory (DRAM) and Flash memories. Some simple circuits using these solid-state elements will be covered if time permits. The course is specifically tailored for undergraduate students, however it is also appropriate for graduate students who have less exposure to device physics and would like to learn about the subject.
Instructor(s): Supratik Guha Terms Offered: Autumn
Prerequisite(s): CHEM 26200 or PHYS 23500 or instructor consent
Equivalent Course(s): MENG 33330

MENG 23400. Applied Probability For Engineers. 100 Units.
Not offered in 2018-19 academic year.
Equivalent Course(s): MENG 33400

MENG 23500. Foundations of Quantum Optics. 100 Units.
Quantum optics seeks to illuminate the fundamental quantum mechanics of the interaction of light and matter. These principles can form the basis for quantum technologies in areas such as cryptography, computation, and metrology. This course provides a foundation in the fundamental principles and applications of quantum optics. Topics to be discussed may include Fermi's Golden Rule, interaction of two-level atoms and light, spontaneous emission, Rabi oscillations, classical and non-classical photon statistics, beam splitters, atom cavity interaction, vacuum-Rabi splitting, coherence, entanglement, and teleportation. The course will assume that students are comfortable with single-particle quantum mechanics at the level of a typical introductory graduate-level course.
Instructor(s): Alex High Terms Offered: Winter
Prerequisite(s): Equivalent to PHYS 23400-23500 or CHEM 26100
Equivalent Course(s): MENG 33500

MENG 23700. Quantum Computation. 100 Units.
This course provides an introduction to the fundamentals of quantum information to students who have not had training in quantum computing or quantum information theory. Some knowledge of quantum mechanics is expected, including bra-ket notation and the time-dependent form of Schrodinger's equation. Students will learn how to carry out calculations and gain a fundamental grasp of topics that will include some or all of: Entanglement, teleportation, quantum algorithms, cryptography, and error correction.
Instructor(s): Andrew Cleland Terms Offered: Winter
Prerequisite(s): PHYS 22100 or equivalent
Equivalent Course(s): MENG 33700

MENG 23800. Introduction to Nanofabrication. 100 Units.
This course will cover the fundamentals of nanofabrication from a practical viewpoint and will be very useful for students planning on pursuing research involving semiconductor processing technology, as well as broader topics such as microelectromechanical systems (MEMS), quantum devices, optoelectronics, and microfluidics. This course will cover the theory and practice of lithographic patterning; physical and chemical vapor deposition; reactive plasma etching; wet chemical processing; characterization techniques; and other special topics related to state-of-the-art processes used in research and development of nanoscale devices. A good grounding in introductory chemistry and physics is expected.
Instructor(s): Peter Duda Terms Offered: Winter
Prerequisite(s): PHYS 13300 and CHEM 10200 or equivalent
Equivalent Course(s): MENG 33800

MENG 24100-24200. 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 behavior of gases, liquids, and solids from knowledge of intermolecular interactions.

MENG 24100. Selec Tpcs Molec Engineering: Molecular/Materials Modelling I. 100 Units.
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 Terms Offered: Winter
Prerequisite(s): MATH 20000 and MATH 20100, or PHYS 22000 and PHYS 22100
Equivalent Course(s): MENG 34100

MENG 24200. Selected Topics in Molecular Engineering: Molecular/Materials Modelling II. 100 Units.
Quantum mechanical methods, including quantum chemistry, density functional theory (DFT) and many body perturbation theory to simulate the properties of molecules and materials. Numerical algorithms and techniques to solve approximate forms of the Schroedinger and Boltzmann Equations to model structural and transport properties of molecules and materials. Coupling of DFT with molecular dynamics and advanced sampling methods to study finite temperature properties. Coupling of DFT with spin Hamiltonians to study dynamical spin correlations in materials. Examples of applications to materials for energy conversion, and quantum information technologies.
Instructor(s): Giulia Galli Terms Offered: Spring
Prerequisite(s): MENG 24100
Equivalent Course(s): MENG 34200

MENG 24200. Selected Topics in Molecular Engineering: Molecular/Materials Modelling II. 100 Units.
Quantum mechanical methods, including quantum chemistry, density functional theory (DFT) and many body perturbation theory to simulate the properties of molecules and materials. Numerical algorithms and techniques to solve approximate forms of the Schroedinger and Boltzmann Equations to model structural and transport properties of molecules and materials. Coupling of DFT with molecular dynamics and advanced sampling methods to study finite temperature properties. Coupling of DFT with spin Hamiltonians to study dynamical spin correlations in materials. Examples of applications to materials for energy conversion, and quantum information technologies.
Instructor(s): Giulia Galli Terms Offered: Spring
Prerequisite(s): MENG 24100
Equivalent Course(s): MENG 34200

MENG 24300. The Engineering and Biology of Tissue Repair. 100 Units.
In this course, students will gain an understanding of the science and application of tissue engineering, a field that seeks to develop technologies for restoring lost function in diseased or damaged tissues and organs. The course will first introduce the underlying cellular and molecular components and processes relevant to tissue engineering: extracellular matrices, cell/matrix interactions such as adhesion and migration, growth factor biology, stem cell biology, inflammation, and innate immunity. The course will then discuss current approaches for engineering a variety of tissues, including bone and musculoskeletal tissues, vascular tissues, skin, nerve, and pancreas. Students will be assessed through in-class discussions, take-home assignments and exams, and an end-of-term project on a topic of the student's choice.
Instructor(s): Jeffrey Hubbell Terms Offered: Spring
Prerequisite(s): BIOS 20186 or BIOS 20234
Equivalent Course(s): BIOS 21507, MPMM 34300, MENG 34300

MENG 24310. Cellular Engineering. 100 Units.
Cellular engineering is a field that studies cell and molecule structure-function relationships. It is the development and application of engineering approaches and technologies to biological molecules and cells. This course is intended to be a bridge between engineers and biologists, to quantitatively study cells and molecules and develop future clinical applications. Topics include fundamental cell and molecular biology; immunology and biochemistry, receptors, ligands, and their interactions; nanotechnology/biomechanics; enzyme kinetics; molecular probes; cellular and molecular imaging; single-cell genomics and proteomics; genetic and protein engineering; and drug delivery and gene delivery.
Instructor(s): Jun Huang Terms Offered: Winter
Prerequisite(s): Completion of the first two quarters of a Biological Fundamentals Sequence
Equivalent Course(s): MOMN 34310, MENG 34310, BIOS 21508

MENG 24500. Microfluidics and Its Applications. 100 Units.
Precision control of fluids at the micrometer scale (hence microfluidics) provides unprecedented capabilities in manipulation and analysis of cells and proteins. Moreover, fluids and particles behave in fundamentally different ways when confined to small dimensions, making microfluidics an interesting topic of basic research. This course aims to provide students with theoretical knowledge and practical skills on the use of microfluidics for the manipulation and analysis of physical, chemical, and biological systems. We will first survey theoretical concepts regarding microfluidics. We will then focus on design considerations and fabrication methods for multi-layer microfluidic chips using PDMS soft-lithography. We will learn how to fabricate, multiplex, and control PDMS membrane valves and integrate them into high-throughput analytical systems. We will survey recent developments in microfluidics and its scientific and industrial applications. Biological systems analysis in cell sorting, culture, cell signaling, single molecule detection, digital nucleic acid and protein quantification, and biosensing are some of the applications we will cover. This course will have a laboratory component where students will design, fabricate, and use microfluidic devices and therefore acquire hands-on skills in microfluidic engineering.
Instructor(s): Savas Tay Terms Offered: Spring
Prerequisite(s): MATH 13300 (or higher), or MATH 13200 (or higher) plus BIOS 20151 or BIOS 20152 or BIOS 20236
Equivalent Course(s): MENG 34500

MENG 24600. Quantitative Systems Biology. 100 Units.
This course aims to provide students with knowledge on the use of modern methods for the analysis, manipulation, and modeling of complex biological systems, and to introduce them to some of the most important applications in quantitative and systems biology. We will first survey theoretical concepts and tools for analysis and modeling of biological systems like biomolecules, gene networks, single cells, and multicellular systems. Concepts from information theory, biochemical networks, control theory, and linear systems will be introduced. Mathematical modeling of biological interactions will be discussed. We will then survey quantitative experimental methods currently used in systems biology. These methods include single cell genomic, transcriptomic, and proteomic analysis techniques, in vivo and in vitro quantitative analysis of cellular and molecular interactions, single molecule methods, live cell imaging, high throughput microfluidic analysis, and gene editing. Finally, we will focus on case studies where the quantitative systems approach made a significant difference in understanding of fundamental phenomena like signaling, immunity, and development, and diseases like infection, autoimmunity, and cancer.
Instructor(s): Savas Tay Terms Offered: Winter
Prerequisite(s): Completion of the first two quarters of a Biological Fundamentals Sequence
Equivalent Course(s): MENG 34600

MENG 25100. Electrochemical Principles and Methods. 100 Units.
This course will cover topics related to basic electrochemical principles, methodologies, and systems. In particular, students will be given an overview of fundamental concepts related to electrochemical potential, electric double layer, electrode kinetics, and mass transport processes. In addition, the application of key electrochemical experimental methods will be covered. A few examples include cyclic voltammetry, AC impedance spectroscopy, and the rotating disk electrode. Throughout the course, students will apply basics principles of thermodynamics, kinetics, and transport phenomena. Lastly, a brief overview of traditional electrochemical systems and emerging technologies related to energy storage and conversion (e.g., lithium-ion batteries, flow batteries, and fuel cells) and bioelectronics applications will be discussed.
Instructor(s): Shrayesh Patel Terms Offered: Spring
Prerequisite(s): Undergraduates must have completed MENG 26102 AND MENG 26201
Equivalent Course(s): MENG 35100

MENG 26010. Engineering Principles of Conservation. 100 Units.
This course is a precursor to both the thermodynamics and transport sequences. Students will be introduced to the mathematical framework of Reynold's transport theorem from a general perspective and in different forms (algebraic, integral and differential), and apply that framework to a wide variety of problems that involve changes in mass, energy, and momentum. Using scaling approximations and dimensional analysis to obtain an intuitive understanding of the mathematical framework will also be emphasized throughout. These concepts will then be carried over to, and reinforced in, the transport and thermodynamics courses that follow sequentially.
Instructor(s): Mark Stoykovich Terms Offered: Spring
Prerequisite(s): MATH 20100, 20500 or PHYS 22100, plus CHEM 11300 or PHYS 13300

MENG 26020. Engineering Electrodynamics. 100 Units.
This is an advanced course in electromagnetism with an engineering focus. Requires good preparation in freshman-level, calculus-based, electrostatics and magnetostatics; also preparation in vector calculus.
Instructor(s): Andrew Cleland Terms Offered: Spring
Prerequisite(s): PHYS 13300 or PHYS 14300, and MATH 20100 or PHYS 22100 or concurrent enrollment in MATH 20500 or MATH 20900

MENG 26030. Introduction to Engineering Analysis. 100 Units.
This course will expose students to enabling numerical algorithms and computational methods for molecular engineering. These numerical methods include root finding, solving systems of linear and non-linear equations, general minimization techniques, optimization strategies, and regression analysis. Numerical integration including Runge-Kutta methods, as well as methods for solving ODEs (i.e., initial value problems and boundary value problems) and PDEs, will also be introduced. A key focus of the course will be to introduce the students to basic structured programming in MATLAB or Python that will provide a foundational tool for applying such algorithms throughout the MENG coursework.
Instructor(s): Mark Stoykovich Terms Offered: Autumn
Prerequisite(s): MENG 26010 or MENG 26020

MENG 26101-26102. Transport Phenomena I: Forces + Flows; Transport Phenomena II.
The sequence will expose students to basic topics in continuum mechanics, with a focus on momentum transfer (part I) and energy and mass transfer (part II).

MENG 26101. Transport Phenomena I: Forces and Flows. 100 Units.
This course will expose students to basic topics in continuum mechanics, with a focus on momentum transfer. Course topics include an overview of tensor mathematics, forces and inertia, Bernoulli's Equation, Navier-Stokes Equations, and standard examples of Navier-Stokes flows, including Poiseuille flow, falling films, and flow around a sphere. For each of these topics, examples will be provided with dimensionless and scaling analysis to accompany problem solution. Analysis will include computation of approximate solutions, determination of when an approximate solution is adequate and, given the assumptions made, what the limitations of any solution are. Laboratory exercises in microfluidics will be included. (L)
Instructor(s): Shrayesh Patel Terms Offered: Autumn
Prerequisite(s): MENG 26010

MENG 26102. Transport Phenomena II. 100 Units.
This course will expose students to basic topics in continuum mechanics, with a focus on energy and mass transfer. Course topics include an overview of the physical and mathematical basis of diffusion, Fick's law and definition of fluxes for description in the form of differential equations, a reminder of the Reynolds Transport Theorem and differential forms for mass and energy transfer, mass balances in non-reacting systems (with multiple examples), mass balances with chemical reactions, energy balances, and combined energy and mass balances with chemical reactions.
Instructor(s): M. Tirrell, M. Swartz, A. Esser-Khan Terms Offered: Winter
Prerequisite(s): MENG 26101

MENG 26102. Transport Phenomena II. 100 Units.
This course will expose students to basic topics in continuum mechanics, with a focus on energy and mass transfer. Course topics include an overview of the physical and mathematical basis of diffusion, Fick's law and definition of fluxes for description in the form of differential equations, a reminder of the Reynolds Transport Theorem and differential forms for mass and energy transfer, mass balances in non-reacting systems (with multiple examples), mass balances with chemical reactions, energy balances, and combined energy and mass balances with chemical reactions.
Instructor(s): M. Tirrell, M. Swartz, A. Esser-Khan Terms Offered: Winter
Prerequisite(s): MENG 26101

MENG 26201-26202. Thermodynamics and Statistical Mechanics I-II.
This sequence covers Thermodynamics and Statistical Mechanics.

MENG 26201. Thermodynamics and Statistical Mechanics I. 100 Units.
This course will include an introduction to postulates of thermodynamics, thermodynamic properties of pure substances, and engineering applications relying on thermodynamic cycles (including engines, heat pumps, and refrigeration). An introduction to statistical mechanics and its connection to molecular thermodynamics will also be included among the course topics. (L)
Instructor(s): Juan de Pablo Terms Offered: Winter
Prerequisite(s): MENG 26030

MENG 26202. Thermodynamics and Statistical Mechanics II. 100 Units.
This course will address the thermodynamics of mixtures. It will include an introduction to phase transformations in mixtures and engineering applications (including separation processes), an introduction to molecular models and simple statistical mechanical theories of mixtures, and the prediction of thermodynamic properties from molecular models. (L)
Instructor(s): Mark Stoykovich Terms Offered: Spring
Prerequisite(s): MENG 26201

MENG 26202. Thermodynamics and Statistical Mechanics II. 100 Units.
This course will address the thermodynamics of mixtures. It will include an introduction to phase transformations in mixtures and engineering applications (including separation processes), an introduction to molecular models and simple statistical mechanical theories of mixtures, and the prediction of thermodynamic properties from molecular models. (L)
Instructor(s): Mark Stoykovich Terms Offered: Spring
Prerequisite(s): MENG 26201

MENG 27100. Biological Materials. 100 Units.
In this course, students will gain an understanding of the science and application of biomaterials, a field that utilizes fundamental principles of materials science with cell biology for applications in therapeutics and diagnostics. The course will introduce the basic classes of biomaterials, considering metals used in medicine, ceramics and biological inorganic materials such as hydroxyapatite, and polymers used in medicine. The basis of protein adsorption modulating biological interactions with these materials will be elaborated. Examples to be covered in the course will include polymers used in drug delivery, polymers used in protein therapeutics, polymers used in degradable biomaterial implants, polymers used in biodiagnostics, and hybrid and polymeric nanomaterials used as bioactives and bioactive carriers. An emphasis in the course will be placed on bioactive materials development. Students will be assessed through in-class discussions, take-home assignments and exams, and an end-of-term project on a topic of the student's choice.
Instructor(s): Jeffrey Hubbell Terms Offered: Autumn
Prerequisite(s): Undergraduates must have completed BIOS 20186 and BIOS 20187. This course does not meet the requirements for the Biological Sciences major.
Equivalent Course(s): MENG 37100

MENG 27200. Electronic and Quantum Materials for Technology. 100 Units.
This is a one-quarter introductory course on the science and engineering of electronic and quantum materials. The intended audience is upper-level undergraduate students and first-year graduate students in Molecular Engineering and other related fields, including Chemistry and Physics. We will learn the basics of electrical and optical properties of electronic materials, including semiconductors, metals, and insulators starting from a simple band picture, and will discuss how these materials enable modern electronic and optoelectronic devices and circuitry. We will also explore the modern synthesis techniques for these materials and the effects of reduced dimensions and emergent quantum properties. No comprehensive exposure to quantum mechanics, thermodynamics, or advanced mathematical skills will be assumed, even though working knowledge of these topics will be helpful.
Instructor(s): Jiwoong Park Terms Offered: Spring
Prerequisite(s): CHEM 26200 or PHYS 23500 or instructor consent
Equivalent Course(s): MENG 37200

MENG 27300. Polymer Physics. 100 Units.
This course is an advanced introduction to polymer physics 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; polymer brushes; thermodynamics and dynamics of polymers, polymer blends and polymer solutions; phase equilibria; networks, gels, and rubber elasticity; linear viscoelasticity; and thermal and mechanical properties.
Instructor(s): Paul Nealey, Stuart Rowan Terms Offered: Spring
Prerequisite(s): MENG 22500
Equivalent Course(s): MENG 32500

MENG 27320. Polymer Synthesis. 100 Units.
This course introduces the most important polymerization reactions, focusing on their reaction mechanisms and kinetic aspects. Topics include free radical and ionic chain polymerization, step-growth polymerization, ring-opening, insertion, controlled addition polymerization, crosslinking and chemical modification of preformed polymers.
Instructor(s): Stuart Rowan Terms Offered: Winter
Prerequisite(s): CHEM 22000 and CHEM 22100
Equivalent Course(s): MENG 32520

MENG 29500. Engineering Design. 300 Units.
This 300 unit "immersion" design course teaches students how to bring combinations of the fundamental science and engineering pieces of the curriculum together to solve open-ended and challenging engineering problems. It also serves as a vehicle to teach other equally important non-technical skills.
Instructor(s): Mark Stoykovich Terms Offered: Winter. To be offered for the last time in 2018-2019.
Prerequisite(s): Instructor consent required

MENG 29511-29512. Engineering Design I-II.
The project-based design courses combine fundamental science and engineering skills to solve open-ended and challenging engineering problems selected among those encountered in the biology, chemical and soft materials, and quantum fields. Specific objectives for the courses include learning how to define a technical problem and how to propose solutions, applying scientific and engineering knowledge to solve real-world problems, and developing an operating plan with defined sub-tasks and project timelines. Additional emphasis will be placed on enhancing skills to communicate results clearly and concisely to various audiences, access and manage resources to achieve objectives, work as part of a team, and interact with external mentors and project managers. These courses also serve as a vehicle to teach other equally important non-technical skills, such as professional and ethical responsibilities in engineering and the impact of engineering in a societal context.

MENG 29511. Engineering Design I. 100 Units.
First quarter of Engineering Design.
Instructor(s): Mark Stoykovich, Xiaoying Liu Terms Offered: Autumn
Prerequisite(s): Instructor consent required

MENG 29512. Engineering Design II. 100 Units.
Second quarter of Engineering Design.
Instructor(s): Mark Stoykovich, Xiaoying Liu Terms Offered: Winter
Prerequisite(s): Completion of MENG 29511

MENG 29512. Engineering Design II. 100 Units.
Second quarter of Engineering Design.
Instructor(s): Mark Stoykovich, Xiaoying Liu Terms Offered: Winter
Prerequisite(s): Completion of MENG 29511

MENG 29700. Undergraduate Research for Molecular Engineering. 100 Units.
IME faculty will offer one-quarter research experiences for all students enrolled in the minor. A quality grade will be given based on performance in this course. In order to assign a quality grade, an agreement between the sponsoring IME faculty member and each student will be made that includes: (1) the content and scope of the project, (2) expectations for time commitment, (3) a well-defined work plan with timelines for particular experiments or calculations to be accomplished (in a true research experience of the sort we intend to offer, of course, timelines for results can't be constructed in advance), and (4) a summary of academic goals-such as demonstrating knowledge of the literature and developing communication skills (e.g., though presentations at group meetings).
Instructor(s): IME Faculty Terms Offered: Autumn Spring Winter
Prerequisite(s): Faculty Consent
Note(s): If a student cannot engage an IME faculty research sponsor on their own, the student should consult with the Director of Undergraduate Studies, Institute for Molecular Engineering, Professor Paul Nealey.

Font Notice

This document should contain certain fonts with restrictive licenses. For this draft, substitutions were made using less legally restrictive fonts. Specifically:

Times was used instead of Trajan.

Times was used instead of Palatino.

The editor may contact Leepfrog for a draft with the correct fonts in place.