

BIOENGINEERING, MSE

The Bioengineering master's program provides an interdisciplinary education in scientific and engineering fundamentals, with an emphasis on new developments in the field of Bioengineering. The primary goal of the Penn Bioengineering master's program is to provide students with a customized curriculum designed to prepare them to function creatively and independently in industry, research and development, government or academia.

The master's degree program provides rigorous and advanced training in engineering with a focus on biological and medical sciences. The flexible curriculum allows students to select their own graduate coursework in math, biomedical sciences, bioengineering, and other science and engineering disciplines. The University of Pennsylvania has a "one university" philosophy, and students may register for courses from any School in the University. Our students typically take courses in the Schools of Engineering, Arts and Sciences, and Medicine.

Bioengineering master's degree candidates select either the thesis or non-thesis degree track during their first year, in consultation with the Director of Master's Advising. Students typically complete their degree program in twelve to eighteen months.

The MSE in Bioengineering is a "terminal degree," meaning that students interested in pursuing a PhD must apply to the program through the PhD graduate admissions process.

For more information: <http://www.be.seas.upenn.edu/current-students/masters/degree-requirements.php>

Curriculum

A total of 10 course units are required for the MSE degree.^{1,2}

Course Code	Title	Course Units
Required Courses ³		
Select 1	Math course	1
Select 1	Biological Science course	1
Select 2	Bioengineering graduate courses ⁴	2
Select 3	SEAS and or Biomedical Science electives	3
Select 1	general elective ⁵	1
Thesis/Non Requirements		
BE 5970	Master's Thesis Research (or Science and Engineering electives)	2
Total Course Units		10

Thesis Option Requirements

If you choose to write a thesis, you will enroll in 2 units of thesis research, BE 5970 Master's Thesis Research (<http://www.be.seas.upenn.edu/current-students/masters/forms.php>).

Be sure to read the Master's Thesis Guidelines (<http://www.be.seas.upenn.edu/current-students/masters/degree-requirements-/>). In choosing the thesis option, your thesis advisor may provide additional guidance on course selection and will supervise your thesis research. The director of the bioengineering MSE program will help you find a mentor, traditionally selected from the Bioengineering Graduate Group. (<http://www.be.seas.upenn.edu/about-research/grad-group.php>)

Non-Thesis Option Requirements

If you choose not to write a thesis, you will enroll in an additional 2 course units (2 CU) of science and engineering electives (of which 1 may be BE 5990 Master's Independent Study (<http://www.be.seas.upenn.edu/current-students/masters/forms.php>))

1

The program director helps you develop a program of study for the fall and spring semester of your first year. You can also access a list of suggested graduate courses broken down by discipline. (<http://www.be.seas.upenn.edu/current-students/masters/courses.php>)

2

The Master's Student CPG worksheet (http://www.be.seas.upenn.edu/current-students/masters/documents/MastersCPGInstructions_2014_000.pdf) (accessible through Penn In Touch) helps you design an individualized curriculum that leads to you successfully completing the program. Please complete the CPG worksheet and allow at least 48 hours for review and approval. Once your course selection is approved, you will be permitted to register through Penn In Touch (https://medley.isc-seo.upenn.edu/penn_portal/intouch/splash.html).

3

Must be taken by students in both the thesis and non-thesis tracks. All courses must be 5000 level or above.

4

Select any BE courses

5

Select from any science or engineering discipline

Concentrations

Code	Title	Course Units
Biomedical Data Science and Computational Medicine		
Employs concepts and infrastructure from computer science and broad-based principles from engineering, applied mathematics, physics, and chemistry, to navigate large data sets of biological information and model biomolecules to gain insight into complex biological systems.		
BE 5970	Master's Thesis Research	
BE 5040	Biological Data Science II: Data Mining Principles for Epigenomics	
BE 5210	Brain-Computer Interfaces	
BE 5300	Theoretical and Computational Neuroscience	
BE 5410	Engineering and Biological Principles in Cancer	
BE 5590	Multiscale Modeling of Chemical and Biological Systems	
BE 5660	Networked Neuroscience	
BE 5680	Causality for Medicine and Biology	
CIS 5210	Artificial Intelligence	
CIS 5200	Machine Learning	
CIS 5450	Big Data Analytics	
CBE 5250	Molecular Modeling and Simulations	
ESE 3050	Foundations of Data Science	
GCB 5350	Introduction to Bioinformatics	

Code	Title	Course Units
GCB 5360/ BIOL 4536	Fundamentals of Computational Biology	
Biomedical Devices		
Design of instruments, implants or other biotechnologies that are used to diagnose, prevent, or treat disease. They require design, fabrication, manufacturing and interfacing with biological systems.		
BE 5970	Master's Thesis Research	
BE 5020	From Biomedical Science to the Marketplace	
BE 5140	Rehab Engineering and Design	
BE 5180	Optical Microscopy	
BE 5210	Brain-Computer Interfaces	
BE 5510	Biomicrofluidics	
BE 5700	Biomechanics	
ESE 5050/ MEAM 5130	Feedback Control Design and Analysis	
ESE 5290	Introduction to Micro- and Nano-electromechanical Technologies	
MEAM 5140	Design for Manufacturability	
MEAM 5200	Introduction to Robotics	

Code	Title	Course Units
Cellular/Tissue Engineering and Biomaterials		
Engineering of synthetic and/or biological materials to support or manipulate cellular or tissue growth. Constructs are used to understand cell behavior, as tissue implants or as platforms for therapeutic applications.		
BE 5970	Master's Thesis Research	
BE 5400	Principles of Molecular and Cellular Bioengineering	
BE 5530	Principles, Methods, and Applications of Tissue Engineering	
BE 5580	Principles of Biological Fabrication	
BE 5650	Developmental Engineering of Tissues	
BE 5690	Systems Biology of Cell Signaling Behavior	
BE 5780	Principles of Controlled Release Systems	
CBE 5570	Stem Cells, Proteomics and Drug Delivery - Soft Matter Fundamentals	
MEAM 5140	Design for Manufacturability	

Code	Title	Course Units
Biomedical Imaging and Radiation Physics		
Physics of medical and biological imaging modalities, the use and effects of radiation in imaging and therapy, methodologies for image acquisition and processing, development of computer-based imaging theory and analysis methods, and the development and use of contrast media and molecular imaging agents.		
BE 5970	Master's Thesis Research	
BE 5180	Optical Microscopy	
BE 5370	Biomedical Image Analysis	

BE 5460	Fundamental Techniques of Imaging I
BE 5470	Fundamental Techniques of Imaging 2
BE 5810	Techniques of Magnetic Resonance Imaging
BE 5830	Physics of Medical / Molecular Imaging
BE 5840	The Mathematics of Medical Imaging and Measurement
BMB 6010	Fundamentals of Magnetic Resonance
BE 6500	Advanced Biomedical Imaging Applications
PHYS 5529	Modern Optics

Code	Title	Course Units
Systems and Synthetic Biology		
Understanding the nature of molecular and cellular processes and how individual biological entities interact to produce function at the cellular and organism level. It also includes the development of new devices, biomolecules, or biomimetics to control or manipulate these interactions to introduce new functionality, improve function and/or impair function.		
BE 5970	Master's Thesis Research	
BE 5400	Principles of Molecular and Cellular Bioengineering	
BE 5410	Engineering and Biological Principles in Cancer	
BE 5540	Engineering Biotechnology	
BE 5580	Principles of Biological Fabrication	
BE 5590	Multiscale Modeling of Chemical and Biological Systems	
BE 5650	Developmental Engineering of Tissues	
BE 5670	Mathematical Computation Methods for Modeling Biological Systems	
BE 5680	Causality for Medicine and Biology	
BE 5690	Systems Biology of Cell Signaling Behavior	
CBE 5570	Stem Cells, Proteomics and Drug Delivery - Soft Matter Fundamentals	
MEAM 6630	Mechanics of Macromolecules	

Code	Title	Course Units
Neuroengineering		
Neuroengineering involves the confluence of neuroscience, device development, computation, and mathematics in an effort to better understand, track, and modulate neural function in health, disease, and degeneration.		
BE 5970	Master's Thesis Research	
BE 5210	Brain-Computer Interfaces	
BE 5300	Theoretical and Computational Neuroscience	
BE 5660	Networked Neuroscience	
NGG 5720	Electrical Language of Cells	
NGG 5730	Systems Neuroscience	

Code	Title	Course Units
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Multiscale Biomechanics

Understand how biomolecules, cells, tissues, or living subjects interact mechanically with their environment and to use this knowledge to understand disease and repair processes and/or to guide the design of technological solutions to rehabilitate subjects with injuries or disabilities.

BE 5970	Master's Thesis Research	
BE 5100	Biomechanics and Biotransport	
BE 5140	Rehab Engineering and Design	
BE 5500	Continuum Tissue Mechanics	
BE 5700	Biomechatronics	
BE 5610	Musculoskeletal Biology and Bioengineering	
MSE 6500	Mechanics of Soft and Biomaterials	

Code	Title	Course Units
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Therapeutics, Drug Delivery and Nanomedicine

Encompasses drug discovery, drug design, manufacturing, preparation of micro- and nanodelivery platforms, gene and cell therapy, innovations in targeting, controllable drug release, biodegradation and the mathematical modeling of these systems.

BE 5970	Master's Thesis Research	
BE 5540	Engineering Biotechnology	
BE/CBE 5550	Nanoscale Systems Biology	
BE 5620	Drug Discovery and Development	
BE 5780	Principles of Controlled Release Systems	
CBE 5570	Stem Cells, Proteomics and Drug Delivery - Soft Matter Fundamentals	
CBE 5640	Drug Delivery Systems: Targeted Therapeutics and Translational Nanomedicine	

The degree and major requirements displayed are intended as a guide for students entering in the Fall of 2022 and later. Students should consult with their academic program regarding final certifications and requirements for graduation.
