

# 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.<sup>1,2</sup>

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

## 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>))

- <sup>1</sup> 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>)
- <sup>2</sup> Please work with the BE master's administrator/program on the curriculum and course plan. Once your course selection is approved, you will be permitted to register through PATH (<https://path.at.upenn.edu/>).
- <sup>3</sup> Must be taken by students in both the thesis and non-thesis tracks. All courses must be 5000 level or above.
- <sup>4</sup> Select any BE 5000+ level courses

## Concentrations

Code	Title	Course Units
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### 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 5400	Principles of Molecular and Cellular Bioengineering	
BE 5590	Multiscale Modeling of Chemical and Biological Systems	
BE 5660	Networked Neuroscience	
CIS 5210	Artificial Intelligence	
BMIN 5030	Data Science for Biomedical Informatics	
CIS 5200	Machine Learning	
CIS 5450	Big Data Analytics	
GCB 5370	Advanced Computational Biology	
CBE 5250	Molecular Modeling and Simulations	
GCB 5360	Fundamentals of Computational Biology	
BBCB 6340	Cryo-Em	

Code	Title	Course Units
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### 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	
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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	Biomechatronics
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
BE 5280	Applied Medical Innovation I
BE 5290	Applied Medical Innovation II
BE 5850	Materials for Bioelectronics
ESE 5050	Feedback Control Design and Analysis
ESE 5290	Introduction to Micro- and Nano-electromechanical Technologies
ESE 5360	Nanofabrication and Nanocharacterization
HCMG 8530	Management and Strategy in Medical Devices and Technology
MEAM 5100	Design of Mechatronic Systems
MEAM 5140	Design for Manufacturability
MEAM 5200	Introduction to Robotics
MEAM 5750	Micro and Nano Fluidics
MEAM 5050	Mechanical Properties of Macro/Nanoscale Materials

Code	Title	Course Units
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#### 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
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#### 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 5470	Fundamental Techniques of Imaging
BE 5830	Physics of Medical / Molecular Imaging
BE 5840	The Mathematics of Medical Imaging and Measurement
BE 6500	Advanced Biomedical Imaging Applications
PHYS 5529	Modern Optics

Code	Title	Course Units
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#### 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 5580	Principles of Biological Fabrication
BE 5590	Multiscale Modeling of Chemical and Biological Systems
BE 5650	Developmental Engineering of Tissues
BE 5690	Systems Biology of Cell Signaling Behavior
CBE 5570	Stem Cells, Proteomics and Drug Delivery - Soft Matter Fundamentals
MEAM 6630	Mechanics of Macromolecules
CBE 5540	Engineering Biotechnology

Code	Title	Course Units
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#### 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/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	

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The degree and major requirements displayed are intended as a guide for students entering in the Fall of 2024 and later. Students should consult with their academic program regarding final certifications and requirements for graduation.

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