Twin Cities Campus

Biomedical Engineering Ph.D.

Department of Biomedical Engineering
College of Science and Engineering

Link to a list of faculty for this program.

Contact Information:
Biomedical Engineering Graduate Program, 7-105 Nils Hasselmo Hall, 312 Church Street S.E., Minneapolis, MN 55455 (612-624-8396; fax: 612-626-6583)
Email: bmengp@umn.edu
Website: http://bme.umn.edu/grad

- Program Type: Doctorate
- Requirements for this program are current for Spring 2018
- Length of program in credits: 54
- This program requires summer semesters for timely completion.
- Degree: Doctor of Philosophy

Along with the program-specific requirements listed below, please read the General Information section of the catalog website for requirements that apply to all major fields.

Biomedical engineering is the application of engineering principles and methods to problems in biology and medicine. The discipline includes the study of fundamental processes in biology and physiology, the study of the diagnosis and treatment of disease and injury, and the design and development of medical devices and techniques. Students take courses in mathematics, biology, biomedical engineering, and areas of science and engineering that are relevant for the degree objectives.

Program Delivery

This program is available:
- via classroom (the majority of instruction is face-to-face)

Prerequisites for Admission

The preferred undergraduate GPA for admittance to the program is 3.50.

A baccalaureate degree in engineering or in a physical or biological science is required.

Other requirements to be completed before admission:
Applicants with an engineering degree do not need to complete any specific coursework prior to applying. Applicants without an engineering degree must complete (1) math coursework through Calculus I, Calculus II, Linear Algebra, and Differential Equations; and (2) at least one year of college-level physics, preferably calculus-based.

There are no minimum required GPA, GRE, or English language test scores. A GPA of at least 3.5 on a 4.0 scale is preferred, but not required. Applicants with a lower GPA may still apply, but they will have a much lower chance of admission.

Special Application Requirements:
Fall application deadline is December 31. PhD applications are not accepted for the spring or summer terms. See http://bme.umn.edu/grad/appinfo.html for additional application information.

Applicants must submit their test score(s) from the following:
- GRE

International applicants must submit score(s) from one of the following tests:
- TOEFL
- IELTS

The preferred English language test is Test of English as Foreign Language

Key to test abbreviations(GRE, TOEFL, IELTS).

For an online application or for more information about graduate education admissions, see the General Information section of the catalog website.

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Program Requirements

9 to 30 credits are required in the major.
0 to 21 credits are required outside the major.
24 thesis credits are required.

Plan A: Plan A requires 8 to 20 major credits, 0 to 12 credits outside the major, and 10 thesis credits.The final exam is oral.

Plan B: Plan B requires 10 to 30 major credits and 0 to 20 credits outside the major.The final exam is oral. A capstone project is required.
Capstone Project: The Plan B Project (BMEn 8820, minimum of 2 credits) should entail approximately 50-75 hours of work per credit, performed in collaboration with a faculty adviser. Students must submit a written report of approximately 10 double-spaced pages per credit to the adviser, who will assign a letter grade for BMEn 8820 based on the report. The report must then be defended before the student's committee.

This program may be completed with a minor.

Use of 4xxx courses toward program requirements is permitted under certain conditions with adviser approval.

A minimum GPA of 3.00 is required for students to remain in good standing.

The Ph.D. program requires 30 credits of coursework in mathematics, biology, biomedical engineering, and relevant areas of science and engineering.

BMEn Core - 6 credits
BMEn Seminars - 3 credits
Biology Electives - 6 credits
Technical Electives - 9 credits
Free Electives - 6 credits

A single course may NOT be counted simultaneously toward more than one of the requirements listed above.

INCLUDED in the Core/Elective requirements listed above must be a minimum of 6 credits designated as Math-/Statistics-Intensive. These are not additional credits but will overlap with coursework already satisfying the BMEn Core, Technical Elective, and/or Free Elective requirements.

Approved courses for each category are listed below. All coursework (excluding seminars and internships) must be taken for a letter grade (A-F). A minimum grade of B- is required for coursework to be counted toward degree requirements.

In addition to the 30 credits of coursework, 24 thesis credits (BMEn 8888) are required.

BMEn 8000-Level Core
Take 6 or more credit(s) from the following:
- BMEN 8001 - Polymeric Biomaterials (3.0 cr)
- BMEN 8041 - Advanced Tissue Engineering Lab (3.0 cr)
- BMEN 8101 - Biomedical Digital Signal Processing (3.0 cr)
- BMEN 8201 - Advanced Tissue Mechanics (3.0 cr)
- BMEN 8381 - Bioheat and Mass Transfer (3.0 cr)
- BMEN 8421 - Biophotonics (3.0 cr)
- BMEN 8431 - Controlled Drug and Gene Delivery: Materials, Mechanisms, and Models (4.0 cr)
- BMEN 8501 - Dynamical Systems in Biology (3.0 cr)
- BMEN 8502 - Physiological Control Systems (3.0 cr)
- BMEN 8511 - Systems and Synthetic Biology (3.0 cr)

BMEn Seminars
Seminars are 1 credit per semester, repeatable for credit, and may be taken in any order. Another department/program graduate seminar may be substituted for 1 credit of this requirement, with prior approval from the Director of Graduate Studies.
Take 3 or more credit(s) from the following:
- BMEN 8601 - Biomedical Engineering Seminar (1.0 cr)
- BMEN 8602 - Biomedical Engineering Seminar (1.0 cr)

Biology Electives
Additional courses may be approved by the Director of Graduate Studies.

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Take 6 or more credit(s) from the following:
•BIOC 5216 - Current Topics in Signal Transduction (2.0 cr)
•BIOC 6021 - Biochemistry (3.0 cr)
•BIOC 8002 - Molecular Biology and Regulation of Biological Processes (3.0 cr)
•BIOC 8216 - Signal Transduction and Gene Expression (3.0 cr)
•BMEN 5444 *{Inactive}*(3.0 cr)
•BMEN 5501 - Biology for Biomedical Engineers (3.0 cr)
•BMEN 5701 - Cancer Bioengineering (3.0 cr)
•CGSC 8041 - Cognitive Neuroscience (4.0 cr)
•CPMS 5101 - Introduction to Clinical Physiology and Movement Science (3.0 cr)
•EEB 5371 - Principles of Systematics (3.0 cr)
•GCD 5036 - Molecular Cell Biology (3.0 cr)
•GCD 8103 - Human Histology (5.0 cr)
•GCD 8131 - Advanced Molecular Genetics and Genomics (3.0 cr)
•GCD 8151 - Cellular Biochemistry and Cell Biology (2.0 - 4.0 cr)
•GCD 8161 - Advanced Cell Biology and Development (2.0 cr)
•MEDC 8760 - Design of Peptidomimetics (2.0 cr)
•MICA 8002 - Structure, Function, and Genetics of Bacteria and Viruses (4.0 cr)
•MICA 8003 - Immunity and Immunopathology (4.0 cr)
•MICA 8004 - Cellular and Cancer Biology (4.0 cr)
•MICA 8007 - Cell Biology and Biochemistry of the Extracellular Matrix (3.0 cr)
•MICA 8009 - Biochemical Aspects of Normal and Abnormal Cell Growth and Cell Death (2.0 cr)
•NSC 5540 - Survey of Biomedical Neuroscience (2.0 cr)
•NSC 5561 - Systems Neuroscience (4.0 cr)
•NSC 5661 - Behavioral Neuroscience (2.0 cr)
•NSC 5667 *{Inactive}*(2.0 - 3.0 cr)
•NSC 8211 - Developmental Neurobiology (2.0 - 4.0 cr)
•NSCI 5101 - Neurobiology I: Molecules, Cells, and Systems (3.0 cr)
•OBIO 8012 - Basic Concepts in Skeletal Biology (2.0 cr)
•PHSL 5061 - Principles of Physiology for Biomedical Engineering (4.0 cr)
•PHSL 5115 - Clinical Physiology I (3.0 cr)
•PHSL 5116 - Clinical Physiology II (3.0 cr)
•PHSL 5510 - Advanced Cardiac Physiology and Anatomy (2.0 - 3.0 cr)
•PHSL 5525 - Anatomy and Physiology of the Pelvis and Urinary System (1.0 - 2.0 cr)
•PSY 5015 - Cognition, Computation, and Brain (3.0 cr)
•PSY 5062 - Cognitive Neuropsychology (3.0 cr)
•PSY 8041 - Proseminar in Perception (3.0 cr)
•RSC 5231 - Clinical Biomechanics (2.0 - 5.0 cr)
•RSC 5281 - Physiology for Physical Rehabilitation (2.0 - 4.0 cr)
•RSC 8282 - Problems in Human Movement (4.0 cr)
•SCB 8181 - Stem Cell Biology (3.0 cr)

Technical Electives
Additional courses may be approved by the Director of Graduate Studies.
Take 9 or more credit(s) from the following:
•AEM 5401 - Intermediate Dynamics (3.0 cr)
•AEM 5451 - Optimal Estimation (3.0 cr)
•AEM 5501 - Continuum Mechanics (3.0 cr)
•AEM 5503 - Theory of Elasticity (3.0 cr)
•AEM 8511 - Advanced Topics in Continuum Mechanics (3.0 cr)
•AEM 8531 - Fracture Mechanics (3.0 cr)
•BIOC 5352 - Biotechnology and Bioengineering for Biochemists (3.0 cr)
•BIOC 5528 - Spectroscopy and Kinetics (4.0 cr)
•BMEN 5001 - Advanced Biomaterials (3.0 cr)
•BMEN 5041 - Tissue Engineering (3.0 cr)
•BMEN 5101 - Advanced Bioelectricity and Instrumentation (3.0 cr)
•BMEN 5111 - Biomedical Ultrasound (3.0 cr)
•BMEN 5151 - Introduction to BioMEMS and Medical Microdevices (2.0 cr)
•BMEN 5201 - Advanced Biomechanics (3.0 cr)
•BMEN 5311 - Advanced Biomedical Transport Processes (3.0 cr)
•BMEN 5321 - Microfluidics in Biology and Medicine (3.0 cr)
•BMEN 5351 - Cell Engineering (3.0 cr)
•BMEN 5401 - Advanced Biomedical Imaging (3.0 cr)
•BMEN 5411 - Neural Engineering (3.0 cr)
•BMEN 5412 - Neuromodulation (3.0 cr)
•BMEN 5413 - Neural Decoding and Interfacing (3.0 cr)

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- BMEN 5421 - Introduction to Biomedical Optics (3.0 cr)
- BMEN 8001 - Polymeric Biomaterials (3.0 cr)
- BMEN 8101 - Biomedical Digital Signal Processing (3.0 cr)
- BMEN 8201 - Advanced Tissue Mechanics (3.0 cr)
- BMEN 8381 - Bioheat and Mass Transfer (3.0 cr)
- BMEN 8401 - New Product Design and Business Development (4.0 cr)
- BMEN 8421 - Biophotonics (3.0 cr)
- BMEN 8431 - Controlled Drug and Gene Delivery: Materials, Mechanisms, and Models (4.0 cr)
- BMEN 8501 - Dynamical Systems in Biology (3.0 cr)
- BMEN 8502 - Physiological Control Systems (3.0 cr)
- BMEN 8511 - Systems and Synthetic Biology (3.0 cr)
- CHEM 8021 - Computational Chemistry (4.0 cr)
- CHEN 5751 - Biochemical Engineering (3.0 cr)
- CHEN 8101 - Fluid Mechanics (3.0 cr)
- CHEN 8201 - Applied Math (3.0 cr)
- CHEN 8221 - Synthetic Polymer Chemistry (4.0 cr)
- CHEN 8301 - Physical Rate Processes I: Transport (3.0 cr)
- CHEN 8402 - Statistical Thermodynamics and Kinetics (3.0 cr)
- CHEN 8754 - Systems Analysis of Biological Processes (3.0 cr)
- CSCI 5211 - Data Communications and Computer Networks (3.0 cr)
- CSCI 5511 - Artificial Intelligence I (3.0 cr)
- EE 5141 - Introduction to Microsystem Technology (4.0 cr)
- EE 5171 - Microelectronic Fabrication (3.0 cr)
- EE 5251 - Optimal Filtering and Estimation (3.0 cr)
- EE 5323 - VLSI Design I (3.0 cr)
- EE 5333 - Analog Integrated Circuit Design (3.0 cr)
- EE 5393 - Circuits, Computation, and Biology (3.0 cr)
- EE 5531 - Probability and Stochastic Processes (3.0 cr)
- EE 5621 - Physical Optics (3.0 cr)
- HINF 5430 - Foundations of Health Informatics I (3.0 cr)
- HINF 5431 - Foundations of Health Informatics II (3.0 cr)
- HUMF 5211 - Human Factors and Work Analysis (4.0 cr)
- IE 5111 - Systems Engineering I (2.0 cr)
- IE 5112 *{Inactive}*(3.0 cr)
- IE 5113 - Systems Engineering II (4.0 cr)
- IE 5511 - Human Factors and Work Analysis (4.0 cr)
- IE 5522 - Quality Engineering and Reliability (4.0 cr)
- IE 5541 - Project Management (4.0 cr)
- IE 5545 - Decision Analysis (4.0 cr)
- IE 5553 - Simulation (4.0 cr)
- MATH 5248 - Cryptology and Number Theory (4.0 cr)
- MATH 5445 - Mathematical Analysis of Biological Networks (4.0 cr)
- MATH 5447 - Theoretical Neuroscience (4.0 cr)
- MATH 5587 - Elementary Partial Differential Equations I (4.0 cr)
- MATH 5651 - Basic Theory of Probability and Statistics (4.0 cr)
- MATH 5652 - Introduction to Stochastic Processes (4.0 cr)
- MATH 8202 - General Algebra (3.0 cr)
- MATH 8253 - Algebraic Geometry (3.0 cr)
- MATS 8001 - Structure and Symmetry of Materials (3.0 cr)
- MATS 8002 - Thermodynamics and Kinetics (3.0 cr)
- MATS 8003 - Electronic Properties (3.0 cr)
- ME 5228 - Introduction to Finite Element Modeling, Analysis, and Design (4.0 cr)
- ME 5241 - Computer-Aided Engineering (4.0 cr)
- ME 5243 - Advanced Mechanism Design (4.0 cr)
- ME 5247 - Applied Stress Analysis (4.0 cr)
- ME 5281 - Feedback Control Systems (4.0 cr)
- ME 5286 - Robotics (4.0 cr)
- ME 5341 - Case Studies in Thermal Engineering and Design (4.0 cr)
- ME 5351 - Computational Heat Transfer (4.0 cr)
- ME 8341 - Conduction (3.0 cr)
- ME 8345 - Computational Heat Transfer and Fluid Flow (3.0 cr)
- MPHY 8147 - Advanced Physics of Magnetic Resonance Imaging (MRI) (3.0 cr)
- NSC 5202 - Theoretical Neuroscience: Systems and Information Processing (3.0 cr)
- PHM 8431 - Controlled Drug and Gene Delivery: Materials, Mechanisms, and Models (4.0 cr)
- PHYS 5081 - Introduction to Biopolymer Physics (3.0 cr)
- PHYS 5402 *{Inactive}*(4.0 cr)

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•PSY 5065 - Functional Imaging: Hands-on Training (3.0 cr)
•PUBH 6415 *{Inactive}*(3.0 cr)
•PUBH 6450 - Biostatistics I (4.0 cr)
•PUBH 6451 - Biostatistics II (4.0 cr)
•PUBH 7440 - Introduction to Bayesian Analysis (3.0 cr)
•RSC 5135 - Advanced Biomechanics I: Kinematics (3.0 cr)
•RSC 5200 - Introduction to Neuromodulation (1.0 - 3.0 cr)
•RSC 5235 - Advanced Biomechanics II: Kinetics (3.0 cr)
•RSC 8135 - Human Kinematics (3.0 cr)
•RSC 8235 - Human Kinetics (3.0 cr)
•STAT 5021 - Statistical Analysis (4.0 cr)
•STAT 5101 - Theory of Statistics I (4.0 cr)
•STAT 5102 - Theory of Statistics II (4.0 cr)
•STAT 5302 - Applied Regression Analysis (4.0 cr)
•STAT 5303 - Designing Experiments (4.0 cr)

Free Electives

Additional courses may be approved by the DGS.
Take 6 or more credit(s) from the following:
•BMEN 8402 - New Product Design and Business Development (4.0 cr)
•BTHX 5100 - Introduction to Clinical Ethics (3.0 cr)
•BTHX 5120 - Dying in Contemporary Medical Culture (2.0 cr)
•BTHX 5210 - Ethics of Human Subjects Research (3.0 cr)
•BTHX 5300 - Foundations of Bioethics (3.0 cr)
•BTHX 8120 - Dying in Contemporary Medical Culture (2.0 cr)
•MILI 3589 - Medical Technology and Society [TS] (3.0 cr)
•MOT 5001 - Technological Business Fundamentals (2.0 cr)
•MOT 5002 - Creating Technological Innovation (3.0 cr)
•MOT 5003 - Technological Business Planning Workshop (1.0 cr)
•PDES 5701 - User-Centered Design Studio (4.0 cr)
•PDES 5702 - Visual Communication (3.0 cr)
•PDES 5704 - Computer-Aided Design Methods (3.0 cr)
•PHAR 5204 - Drugs and the US Healthcare System (3.0 cr)
•PHYS 5401 *{Inactive}*(4.0 cr)
•PUBH 6161 - Regulatory Toxicology (2.0 cr)
•PUBH 6414 - Biostatistical Literacy (3.0 cr)
•PUBH 7415 - Introduction to Clinical Trials (3.0 cr)
•RSC 5106 - Introduction to Rehabilitation Science (1.0 cr)
•Any course(s) from the BMEn Core, Biology Elective, and/or Technical Elective lists that are not being used toward another degree requirement.

Math-/Statistics-Intensive

Included in the Core and/or Elective coursework must be at least 6 credits designated as Math-/Statistics-Intensive. These are not additional credits but will overlap with coursework already satisfying the BMEn Core, Technical Elective, and/or Free Elective requirements.
Take 6 or more credit(s) from the following:
•AEM 5451 - Optimal Estimation (3.0 cr)
•AEM 5501 - Continuum Mechanics (3.0 cr)
•AEM 5503 - Theory of Elasticity (3.0 cr)
•AEM 8511 - Advanced Topics in Continuum Mechanics (3.0 cr)
•BMEN 5111 - Biomedical Ultrasound (3.0 cr)
•BMEN 5311 - Advanced Biomedical Transport Processes (3.0 cr)
•BMEN 8101 - Biomedical Digital Signal Processing (3.0 cr)
•BMEN 8201 - Advanced Tissue Mechanics (3.0 cr)
•BMEN 8381 - Bioheat and Mass Transfer (3.0 cr)
•BMEN 8431 - Controlled Drug and Gene Delivery: Materials, Mechanisms, and Models (4.0 cr)
•BMEN 8501 - Dynamical Systems in Biology (3.0 cr)
•BMEN 8502 - Physiological Control Systems (3.0 cr)
•CHEN 8101 - Fluid Mechanics (3.0 cr)
•CHEN 8201 - Applied Math (3.0 cr)
•CHEN 8402 - Statistical Thermodynamics and Kinetics (3.0 cr)
•CHEN 8754 - Systems Analysis of Biological Processes (3.0 cr)
•EE 5251 - Optimal Filtering and Estimation (3.0 cr)
•EE 5531 - Probability and Stochastic Processes (3.0 cr)
•EE 5621 - Physical Optics (3.0 cr)
•IE 5522 - Quality Engineering and Reliability (4.0 cr)

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- MATH 5248 - Cryptology and Number Theory (4.0 cr)
- MATH 5445 - Mathematical Analysis of Biological Networks (4.0 cr)
- MATH 5447 - Theoretical Neuroscience (4.0 cr)
- MATH 5587 - Elementary Partial Differential Equations I (4.0 cr)
- MATH 5651 - Basic Theory of Probability and Statistics (4.0 cr)
- MATH 5652 - Introduction to Stochastic Processes (4.0 cr)
- MATH 8202 - General Algebra (3.0 cr)
- MATH 8253 - Algebraic Geometry (3.0 cr)
- ME 5228 - Introduction to Finite Element Modeling, Analysis, and Design (4.0 cr)
- ME 5351 - Computational Heat Transfer (4.0 cr)
- ME 8341 - Conduction (3.0 cr)
- ME 8345 - Computational Heat Transfer and Fluid Flow (3.0 cr)
- PHM 8431 - Controlled Drug and Gene Delivery: Materials, Mechanisms, and Models (4.0 cr)
- PUBH 6450 - Biostatistics I (4.0 cr)
- PUBH 6451 - Biostatistics II (4.0 cr)
- PUBH 7440 - Introduction to Bayesian Analysis (3.0 cr)
- STAT 5021 - Statistical Analysis (4.0 cr)
- STAT 5101 - Theory of Statistics I (4.0 cr)
- STAT 5102 - Theory of Statistics II (4.0 cr)
- STAT 5302 - Applied Regression Analysis (4.0 cr)
- STAT 5303 - Designing Experiments (4.0 cr)

Thesis Credits

Take 24 credits after passing preliminary oral exam

BMEN 8888 - Thesis Credit: Doctoral (1.0 - 24.0 cr)

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