Twin Cities Campus

Biomedical Engineering M.S.

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: Master's
- Requirements for this program are current for Spring 2019
- Length of program in credits: 30
- This program does not require summer semesters for timely completion.
- Degree: Master of Science

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 to the degree objectives.

Program Delivery

This program is available:
- via classroom (the majority of instruction is face-to-face)
- partially online (between 50% to 80% of instruction is online)

Prerequisites for Admission

The preferred undergraduate GPA for admittance to the program is 3.20.

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 1 year of college-level physics, preferably calculus-based.

There are no minimum GPA, GRE, or English language test score requirements. A GPA of at least 3.2 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:
The fall application deadline for M.S. applicants is March 31. Local applicants applying for the program as part-time students may, under certain circumstances, be considered for spring admission. Application instructions are available at http://bme.umn.edu/grad/appinfo.html.

Students applying through the Combined B.Bm.E./M.S. Program (see below, under Program Sub-Plans) should refer to the application instructions and deadline information at http://bme.umn.edu/grad/appcombined.html.

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

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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.

Program Requirements

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 advisor. Students must submit a written report of approximately 10 double-spaced pages per credit to the advisor, who will assign a letter grade for BMEn 8820 based on the report. The report must then be defended before the student's committee.

Plan C: Plan C requires 8 to 30 major credits and 0 to 22 credits outside the major.The is no final exam.

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 2.80 is required for students to remain in good standing.

The MS program requires a minimum of 30 total credits in mathematics, biology, biomedical engineering, and relevant areas of science and engineering.

PLAN A
BMEn Core - 6 credits
BMEn Seminars - 2 credits
Biology Electives - 6 credits
Technical Electives - 6 credits
Thesis - 10 credits

PLAN B
BMEn Core - 6 credits
BMEn Seminars - 2 credits
Biology Electives - 6 credits
Technical Electives - 9 credits
Free Electives - 5 credits
Capstone Project - 2 credits

PLAN C
BMEn Core - 6 credits
BMEn Seminars - 2 credits
Biology Electives - 6 credits
Technical Electives - 9 credits
Free Electives - 7 credits

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

Math/Statistics (Plans A, B, and C) - Included in the Core/Elective requirements listed above must be a minimum of 3 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.

8000 Level (Plans A and B only) - Core/Elective coursework must include at least 3 credits at the 8000 level, from any department (does not need to be BMEn). Credits of seminar, directed research, internship, project, thesis, and/or independent study cannot be used to fulfill this requirement. Plan C students are not required to complete 8000-level coursework.

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.

BMEn Core
Take 6 or more credit(s) from the following:

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- BMEN 5001 - Advanced Biomaterials (3.0 cr)
- BMEN 5101 - Advanced Bioelectricity and Instrumentation (3.0 cr)
- BMEN 5201 - Advanced Biomechanics (3.0 cr)
- BMEN 5311 - Advanced Biomedical Transport Processes (3.0 cr)
- BMEN 5351 - Cell Engineering (3.0 cr)
- BMEN 5401 - Advanced Biomedical Imaging (3.0 cr)
- 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 8151 - Biomedical Electronics and Implantable Microsystems (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)

BME Seminar

Seminars are 1 credit per semester, repeatable for credit, and may be taken in any order.
Take 2 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.
Take 6 or more credit(s) from the following:

- BIOC 5216 - Current Topics in Signal Transduction (2.0 cr)
- BIOC 5444 - Muscle (3.0 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 5501 - Biology for Biomedical Engineers (3.0 cr)
- BMEN 5701 - Cancer Bioengineering (3.0 cr)
- BMEN 8041 - Advanced Tissue Engineering Lab (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 8008 - Mammalian Gene Transfer and Genome Engineering (2.0 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 5245 - Introduction to Drug Design (3.0 cr)
- MEDC 8461 - Design of Cancer Therapeutics (3.0 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 8009 - Biochemical Aspects of Normal and Abnormal Cell Growth and Cell Death (2.0 cr)
- MLSP 5111 - Concepts of Diagnostic Microbiology (3.0 cr)
- MLSP 5511 - Principles of Immunobiology (3.0 cr)
- MPHY 5172 - Radiation Biology (3.0 cr)
- NEUR 5230 - Cerebrovascular Hemodynamics and Diseases I (4.0 cr)
- NSC 5461 - Cellular and Molecular Neuroscience (3.0 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)
- NSC 8221 - Neurobiology of Pain and Analgesia (3.0 cr)
- NSCI 5101 - Neurobiology I: Molecules, Cells, and Systems (3.0 cr)
- OBIO 8012 - Basic Concepts in Skeletal Biology (2.0 cr)
- OBIO 8028 - Molecular Basis of Cellular and Microbial Adhesion (2.0 cr)
- PHAR 5700 - Applied Fundamentals of Pharmacotherapy (3.0 cr)

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- 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 5444 - Muscle (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 5200 - Introduction to Neuromodulation (1.0 - 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)
- SLHS 5808 - Pathophysiology of Hearing Disorders (3.0 cr)

Technical Electives

PLAN A students must take 6 or more Technical Elective credits. PLAN B and PLAN C students must take 9 or more Technical Elective credits. Additional courses may be approved by the director of graduate studies.

Take 6 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 5351 - Protein Engineering (3.0 cr)
- BIOC 5352 - Biotechnology and Bioengineering for Biochemists (3.0 cr)
- BIOC 5528 - Spectroscopy and Kinetics (4.0 cr)
- BIOC 8005 - Biochemistry: Structure and Catalysis (2.0 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)
- BMEN 5421 - Introduction to Biomedical Optics (3.0 cr)
- BMEN 5601 - Cardiovascular Devices (1.0 cr)
- BMEN 8001 - Polymeric Biomaterials (3.0 cr)
- BMEN 8101 - Biomedical Digital Signal Processing (3.0 cr)
- BMEN 8151 - Biomedical Electronics and Implantable Microsystems (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)
- CHEM 8157 - Bioanalytical 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 5103 - Operating Systems (3.0 cr)

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- CSCI 5211 - Data Communications and Computer Networks (3.0 cr)
- CSCI 5451 - Introduction to Parallel Computing: Architectures, Algorithms, and Programming (3.0 cr)
- CSCI 5511 - Artificial Intelligence I (3.0 cr)
- CSCI 5521 - Machine Learning Fundamentals (3.0 cr)
- CSCI 5523 - Introduction to Data Mining (3.0 cr)
- CSCI 5525 - Machine Learning: Analysis and Methods (3.0 cr)
- CSCI 5551 - Introduction to Intelligent Robotic Systems (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 5542 - Adaptive Digital Signal Processing (3.0 cr)
- EE 5545 - Digital Signal Processing Design (3.0 cr)
- EE 5561 - Image Processing and Applications: From linear filters to artificial intelligence (3.0 cr)
- EE 5601 - Introduction to RF/Microwave Engineering (3.0 cr)
- EE 5621 - Physical Optics (3.0 cr)
- EE 8591 - Predictive Learning from Data (3.0 cr)
- HINF 5430 - Foundations of Health Informatics I (3.0 cr)
- HINF 5431 - Foundations of Health Informatics II (3.0 cr)
- HUMF 5001 - Foundations of Human Factors/Ergonomics (3.0 cr)
- HUMF 5211 - Human Factors and Work Analysis (4.0 cr)
- IE 5111 - Systems Engineering I (2.0 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)
- KIN 5001 - Foundations of Human Factors/Ergonomics (3.0 cr)
- KIN 5643 - Applied Motion Capture and Movement Analysis Technology (3.0 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 8254 - Fundamentals of Microelectromechanical Systems (MEMS) (4.0 cr)
- ME 8341 - Conduction (3.0 cr)
- ME 8342 - Convection (3.0 cr)
- ME 8343 - Radiation (3.0 cr)
- ME 8345 - Computational Heat Transfer and Fluid Flow (3.0 cr)
- MPHY 5170 - Radiation Therapy Physics I (3.0 cr)
- MPHY 5178 - Physical Principles of Magnetic Resonance Imaging (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)
- NSCI 5300 *{Inactive}*(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)
- PSY 5038W - Introduction to Neural Networks [WI] (3.0 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)
•PUBH 7475 - Statistical Learning and Data Mining (3.0 cr)
•RSC 5135 - Advanced Biomechanics I: Kinematics (3.0 cr)
•RSC 5235 - Advanced Biomechanics II: Kinetics (3.0 cr)
•RSC 5841 - Applied Data Acquisition and Processing (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

PLAN A students are not required to take any Free Electives; PLAN B students must take at least 5 credits; PLAN C students must take at least 7 credits. Additional courses may be approved by the director of graduate studies.

Take 0 or more credit(s) from the following:

•BMEN 8402 - New Product Design and Business Development (4.0 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)
•PHYS 5401 *{Inactive}*(4.0 cr)
•PSY 5036W - Computational Vision [WI] (3.0 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)
•**Additional Bio/Tech/Core**
  •Any course(s) from the BMEn Core, Biology Elective, and/or Technical Elective lists that are not being used toward another degree requirement.
•**Coursework Relevant to Science and Technology**
  Max 3 credits in coursework relevant to science and technology (e.g., public policy, ethical/historical aspects, etc).
  Take 0 - 3 credit(s) from the following:
  •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 5325 - Biomedical Ethics (3.0 cr)
  •BTHX 5650 - Disability Ethics (3.0 cr)
  •BTHX 8120 - Dying in Contemporary Medical Culture (2.0 cr)
  •MILI 6235 - Pharmaceutical Industry: Business and Policy (2.0 cr)
  •MILI 6995 - Medical Industry Valuation Laboratory (2.0 cr)
  •PHAR 5204 - Drugs and the US Healthcare System (3.0 cr)

Math-/Statistics-Intensive

Included in the Core and/or Elective coursework must be at least 3 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. Additional courses may be approved by the director of graduate studies.

Take 3 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)

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•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)
•CSCI 5521 - Machine Learning Fundamentals (3.0 cr)
•CSCI 5525 - Machine Learning: Analysis and Methods (3.0 cr)
•EE 5251 - Optimal Filtering and Estimation (3.0 cr)
•EE 5531 - Probability and Stochastic Processes (3.0 cr)
•EE 5542 - Adaptive Digital Signal Processing (3.0 cr)
•EE 5545 - Digital Signal Processing Design (3.0 cr)
•EE 5561 - Image Processing and Applications: From linear filters to artificial intelligence (3.0 cr)
•EE 5601 - Introduction to RF/Microwave Engineering (3.0 cr)
•EE 5621 - Physical Optics (3.0 cr)
•EE 8591 - Predictive Learning from Data (3.0 cr)
•IE 5522 - Quality Engineering and Reliability (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)
•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 8342 - Convection (3.0 cr)
•ME 8343 - Radiation (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)
•PHM 8431 - Controlled Drug and Gene Delivery: Materials, Mechanisms, and Models (4.0 cr)
•PSY 5038W - Introduction to Neural Networks [WI] (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)
•PUBH 7475 - Statistical Learning and Data Mining (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/Project Requirements

PLAN A

Take 10 or more credit(s) from the following:
•BMEN 8777 - Thesis Credits: Master's (1.0 - 18.0 cr)

-OR-

PLAN B

Take 2 or more credit(s) from the following:
•BMEN 8820 - Plan B Project (2.0 - 3.0 cr)

Program Sub-plans

A sub-plan is not required for this program.
Students may not complete the program with more than one sub-plan.

Combined B.Bm.E./M.S.

The College Science & Engineering offers an early-admission opportunity for eligible University of Minnesota B.Bm.E. students also interested in completing the Biomedical Engineering MS degree (Plan A or Plan B only). The Early Admission sub-plan, also referred to as the Combined B.Bm.E./MS Biomedical Engineering program, enables B.Bm.E. majors to take 3-16 credits toward the MS

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requirements during their senior (fourth) year, in addition to the courses required for the B.Bm.E. degree. The MS degree may then be completed in the fifth year of study. Students are NOT permitted to count a single course toward both the undergraduate and graduate degrees; each course must be counted either toward the B.Bm.E. requirements or the MS requirements.

Interested B.Bm.E. students should visit the program website at http://bme.umn.edu/grad/appcombined.html for detailed application and admission information, deadlines, and instructions.

Students admitted to the Combined B.Bm.E./M.S. must maintain timely degree progress to ensure that all undergraduate degree requirements are completed by the end of their fourth year. They must also be able to take additional courses during their senior year, beyond those required by the B.Bm.E. curriculum, to be eligible for this program.

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