

BIOMEDICAL ENGINEERING UNDERGRADUATE CURRICULUM

2009-2010 (as of 6/30/09)

Undergraduate Program Mission Statement

To provide education that prepares students to lead, innovate, and self-educate through their careers in bioengineering and biomedical professions and industries.

Program Objectives

Career Preparation – Utilizing a knowledge base with a core foundation in engineering and biology, our students will be able to apply their skills to a variety of challenges in their chosen field. Our graduates will demonstrate innovation, creativity, adaptability, and critical thinking to solve problems in biomedical industry, medicine, academia, and consulting.

Professionalism – Our graduates will demonstrate leadership in their chosen fields, and make decisions that are socially and ethically responsible. Graduates will function effectively in multidisciplinary team environments and communicate effectively to a variety of audiences.

Life-long Learning - Our graduates will build and expand upon their undergraduate foundations by engaging in learning opportunities throughout their careers.

To obtain the B.S. in Biomedical Engineering, a student must obtain 18 course credits in engineering topics.

I. MATHEMATICS (4 courses)

MATH	220, 224, 230	Calculus
MATH	234	Multiple Integration and Vector Calculus

II. BASIC SCIENCES (4 courses)

PHYSICS	135-2,3	General Physics <i>and</i>
CHEM*	102, 103	General Chemistry <i>or</i>
CHEM*	171, 172	Accelerated Chemistry

*Chem 101 may be used as a technical elective.

III. ENGINEERING ANALYSIS (4 courses)

GEN ENG	205-1	Computational Methods and Linear Algebra
GEN ENG	205-2	Linear Algebra and Mechanics
GEN ENG	205-3	Dynamic System Modeling
GEN ENG	205-4	Differential Equations

IV. ENGINEERING DESIGN AND COMMUNICATION (3 courses)

IDEA	106-1, 2	Engineering Design and Communication (0.5 each) plus English 106-1,2 (0.5 each)
BMD_ENG	390-2	Biomedical Engineering Design Another capstone design course may be substituted for this course by petition.

V. BASIC ENGINEERING* (5 courses)

A. Thermodynamics - 1 course listed from those below

BMD_ENG	250	Thermodynamics
CHEM	342-1	Thermodynamics
MECH ENG	220	Thermodynamics I

B. Fluids and Solids - 2 courses as specified below

BMD_ENG	271	Introduction to Biomechanics <i>and</i>
BMD_ENG	270	Fluid Mechanics <i>or</i>
MECH ENG	241	Fluid Mechanics I

C. Material Science - 1 course listed from those below

MAT SCI	201	Principles of the Properties of Materials
MAT SCI	301	Chemical Aspects of Engineering Materials

D. Probability, Statistics, and Quality Control - 1 course listed from those below

BMD_ENG	220	Introduction to Biostatistics
IEMS	201	Introduction to Statistics
IEMS	303	Statistics I

MECH ENG 359 Reliability Engineering

* For those considering the Electronic Engineering track or the Computer Engineering track, see the note about basic engineering courses that precedes those track sections.

VI. SOCIAL SCIENCES/HUMANITIES THEME (7 courses)

VII. UNRESTRICTED ELECTIVES (5 courses)

VIII. BIOMEDICAL ENGINEERING PROGRAM (16 courses, none of which may be taken P/N)

Students seeking admission to dental or medical schools should familiarize themselves with the specific entrance requirements of those schools to which they intend to apply. In addition to the specifically required courses of the BME program, many professional schools also require additional courses in physics, organic and/or physical chemistry, biochemistry, and laboratory biology. These requirements can be satisfied through the BME curriculum and by judicious use of electives.

A. Core – 9 courses + 1 zero credit seminar

BMD_ENG	101	Introduction to Biomedical Engineering (zero credit seminar)
CHEM	210-1	Organic Chemistry
BIOL SCI	210-2	Biology
BMD_ENG	301	Systems Physiology I
BMD_ENG	302	Systems Physiology II
BMD_ENG	303	Systems Physiology III
BMD_ENG	305	Biomedical Signals Analysis
BMD_ENG	306	Biomedical Systems Analysis
BMD_ENG	307	Quantitative Experimentation and Design
BMD_ENG	390-1	Biomedical Engineering Design

B. Tracks - 7 courses

Each student in the Biomedical Engineering Program completes his/her course of study either by selecting one of the following tracks or by an alternate set of courses developed with his/her advisor and submitted by petition to and approved by the BME Undergraduate Committee. Students should also be aware that 395 Special Topics courses are offered each year in BME and other departments, and may be used to count toward a track by petition.

Technical electives in Biomedical Engineering may include: CHEM 101, BIOL SCI 210-1 and 3, CHEM 210-2 and 3, EECS 230, 300-level or higher courses in engineering, science or mathematics. Students are urged to choose technical electives that emphasize engineering design.

1. Biomechanics and Rehabilitation (Professors Ameer, Dhaher, Glucksberg, Hartmann, Johnson, Liu, MacIver, Murray, Perreault)

Take both of the following courses:

BMD_ENG	366	Biomechanics of Movement
BMD_ENG	371	Mechanics of Biological Tissue

Take one of the following courses:

BMD_ENG	346	Tissue Engineering
BMD_ENG	349	Bioregenerative Engineering

Take two of the following courses:

BMD_ENG	344	Biological Performance of Materials
BMD_ENG	365	Human Limbs and their Artificial Replacements
BMD_ENG	377	Intermediate Fluid Mechanics in Engineering and Biology
CIV ENG	327	Finite Element Methods in Mechanics
MECH ENG	315	Theory of Machines-Design
MECH ENG	362	Stress Analysis
MECH ENG	389	Molecular Machines in Biology
MECH ENG	391	Fundamentals of Control Systems
EECS	360	Introduction to Feedback Systems

Two technical electives

2. Transport Processes and Tissue Engineering (Professors Ameer, Ho, Johnson, Linsenmeier, Liu)

BMD_ENG	350	Transport Fundamentals
BMD_ENG	377	Intermediate Fluid Mechanics in Engineering and Biology

Take one of the following courses

BMD_ENG	346	Tissue Engineering
BMD_ENG	349	Bioregenerative Engineering

Take two of the following courses:

BMD_ENG	310	Molecular and Cellular Aspects of Bioengineering
BMD_ENG	315	Application of Genetic Engineering to Immunochemistry
BMD_ENG	317	Biochemical Sensors
BMD_ENG	343 ⁺	Biomaterials and Medical Devices
MAT SCI	370 ⁺	Biomaterials
BMD_ENG	344	Biological Performance of Materials
BMD_ENG	371	Mechanics of Biological Tissue
BIOL SCI	315*	Cell Biology
BIOL SCI	390*	Molecular Biology

*Only 1 of these courses may be counted toward the track

⁺ Only 1 of these courses may be counted toward the track

Two technical electives

3. Biological Materials and Molecular Engineering (Professors Ameer, Ho, Kelso, Liu, Messersmith, Szeifer, Wu)

BMD_ENG	314	Models in Biochemistry and Molecular Biology
BMD_ENG	317	Biochemical Sensors

Take one of the following courses:

BMD_ENG	343	Biomaterials and Medical Devices
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MAT SCI 370 Biomaterials

Take one of the following courses:

BMD_ENG 344 Biological Performance of Materials

MAT SCI 331 Physical Properties of Polymers

Take one of the following courses:

BMD_ENG 310 Molecular and Cellular Aspects of Bioengineering

BMD_ENG 315 Application of Genetic Engineering to Immunochemistry

BMD_ENG 333 Modern Optical Microscopy and Imaging

BMD_ENG 346 Tissue Engineering

BMD_ENG 349 Bioregenerative Engineering

BMD_ENG 350 Transport Fundamentals

BMD_ENG 377 Intermediate Fluid Mechanics in Engineering and Biology

MECH ENG 285 Nanotechnology – not offered in 08-09

CHEM ENG 379 Bioinformatics – not offered in 08-09

CHEM ENG 372 Interfacial Phenomena and Bionanotechnology

BIOL SCI 301 Biochemistry

BIOL SCI 315 Cell Biology

BIOL SCI 390 Molecular Biology

Two technical electives

4. Biomedical Signals and Images (Professors Backman, Carroll, D. Li, X. Li, Perreault, Troy, Walsh)

BMD_ENG 325 Introduction to Medical Imaging

EECS 302 Probabilistic Systems and Random Signals

Take one of the following:

BMD_ENG 327⁺ Magnetic Resonance Imaging

BMD_ENG 333⁺ Modern Optical Microscopy and Imaging

Take two of the following courses:

BMD_ENG 323 Visual Science

BMD_ENG 327⁺ Magnetic Resonance Imaging

BMD_ENG 333⁺ Modern Optical Microscopy and Imaging

BMD_ENG 383 Cardiovascular Instrumentation

BMD_ENG 495 Biomedical Imaging Principles and Applications

EECS 328 Numerical Methods for Engineers

EECS 360 Introduction to Feedback Systems

PHY 357 Bio-Photonics Laboratory

⁺ BME 327 and BME 333 are listed in 2 places in this track because both courses can count toward this track. Neither course may not be double-counted, however.

Two technical electives

The following 2 tracks allow alternate courses to be used for the basic engineering requirement to better prepare students for upper level courses within the track. These courses are listed below but must be approved by petition.

5. Computer Engineering (Professors Sahakian, X. Li)

V. Basic Engineering Courses:

EECS	202	Introduction to Electrical Engineering
EECS	203	Introduction to Computer Engineering
EECS	205	Fundamentals of Computer System Software

1 course from area VD - Probability, Statistics, and Quality Control
BME 250, BME 270, MECH ENG 241, or BMD_ENG 271

VIIIA. Core Courses – as listed

VIIIB. Track courses:

EECS	211	Programming for Computer Engineers (C++ programming)
EECS	303	Advanced Digital Logic Design
BMD_ENG	383	Cardiovascular Instrumentation

Take one of the following pair of classes

EECS	346	Microprocessor System Design <i>and</i>
EECS	347	Microprocessor System Projects (design, build, and embed a microprocessor)
EECS	361	Computer Architecture <i>and</i>
EECS	362	Computer Architecture Project
EECS	391	VLSI Systems Design <i>and</i>
EECS	392	VLSI Systems Design Projects (design an integrated circuit)

Two technical electives

6. Electrical Engineering (Professors Sahakian, X. Li)

V. Basic Engineering Courses

EECS	202	Introduction to Electrical Engineering
EECS	203	Introduction to Computer Engineering – this is a prereq for EECS 303

1 course from area VB – Fluids and Solids
1 course from area VC – Materials Science
1 course from area VD – Probability, Statistics, and Quality Control

VIIIA. Core Courses – as listed

VIIIB. Track courses

Take all of the following courses:

EECS	223	Fundamentals of Solid State Engineering
EECS	225	Fundamentals of Electronics
EECS	230	Programming for Computer Engineers
EECS	303	Advanced Digital Logic Design
BMD_ENG	383	Cardiovascular Instrumentation

Two technical electives

Biomedical Engineering Courses
Offered in the McCormick School of Engineering and Applied Sciences

BMD_ENG 101 Introduction to Biomedical Engineering
BMD_ENG 220 Introduction to Biostatistics
BMD_ENG 250 Biothermodynamics
BMD_ENG 270 Introductory Biomedical Fluid Mechanics (with labs)
BMD_ENG 271 Introduction to Biomechanics
BMD_ENG 301 Systems Physiology I (with design)
BMD_ENG 302 Systems Physiology II
BMD_ENG 303 Systems Physiology III
BMD_ENG 305 Biomedical Signals Analysis
BMD_ENG 306 Biomedical Systems Analysis
BMD_ENG 307 Quantitative Experimentation and Design
BMD_ENG 310 Molecular and Cellular Aspect of Bioengineering (with labs and design)
BMD_ENG 314 Models in Biochemistry and Molecular Biology
BMD_ENG 315 Applications of Genetic Engineering to Immunochemistry
BMD_ENG 317 Biochemical Sensors
BMD_ENG 323 Visual Science (with design)
BMD_ENG 325 Introduction to Medical Imaging
BMD_ENG 327 Magnetic Resonance Imaging
BMD_ENG 333 Modern Optical Microscopy and Imaging (with design)
BMD_ENG 343 Biomaterials and Medical Devices
BMD_ENG 344 Biological Performance of Materials
BMD_ENG 346 Tissue Engineering (with labs and design)
BMD_ENG 349 Bioregenerative Engineering (with labs and design)
BMD_ENG 350 Transport Fundamentals
BMD_ENG 365 Human Limbs and Their Artificial Replacements
BMD_ENG 366 Biomechanics of Movement
BMD_ENG 371 Mechanics of Biological Tissues
BMD_ENG 377 Intermediate Fluid Mechanics in Engineering and Biology
BMD_ENG 383 Cardiovascular Instrumentation (with design)
BMD_ENG 390-1 Biomedical Engineering Design (with design)
BMD_ENG 390-2 Biomedical Engineering Design (with design)
BMD_ENG 395 Special Topics in Biomedical Engineering (see list below)
BMD_ENG 401 Advanced Systems Physiology I (with design)
BMD_ENG 402 Advanced Systems Physiology II (with design)
BMD_ENG 403 Advanced Systems Physiology III
BMD_ENG 427 Advanced MR Imaging
BMD_ENG 441 Biointerface Science
BMD_ENG 442 Thermodynamics and Interactions at Biointerfaces
BMD_ENG 444 Nanomedicine
BMD_ENG 445 Macromolecular Biomaterials
BMD_ENG 450 Biomedical Transport Phenomena
BMD_ENG 460 Neural Engineering: Fundamentals
BMD_ENG 461 Neural Engineering: Computational Neuromechanics and Neuroethology
BMD_ENG 462 Neural Engineering: Sensory Acquisition through Movement
BMD_ENG 463 Systems Neuropathophysiology
BMD_ENG 464 Neuromechatronics
BMD_ENG 465 Biomechanical Modeling and Simulation of Human Movement
BMD_ENG 467 Biomedical Robotics
BMD_ENG 469 Neural Control and Mechanics of Movement
BMD_ENG 475 Cardiovascular Biology and Engineering
BMD_ENG 495 Advanced Special Topics in Biomedical Engineering (see list below)

Special Topics in BME:

BMD_ENG 495 Functional MRI