

# **BIOMEDICAL ENGINEERING UNDERGRADUATE CURRICULUM**

2005-2006 (as of 9/16/05)

## **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**

The Biomedical Engineering Department is committed to the highest standard of education that enables and inspires students to:

1. Gain a solid foundation in fundamental disciplines of biomedical engineering.
2. Be capable of applying analytical and computational principles and approaches to biomedical experimentation and modeling.
3. Be capable of formulating hypotheses, modeling biomedical problems, designing and performing fundamental experiments, and conducting data measurements and interpretations.
4. Be capable of applying engineering principles and approaches to biological and medical problems.
5. Recognize the importance of and conduct team work in biomedical engineering professions and industries.
6. Understand the professional, social, and ethical responsibilities of biomedical engineers.
7. Gain effective communication skills.
8. Gain a strong foundation in humanities and social sciences.
9. Recognize the importance of and conduct life-long learning and self-education.
10. Understand the impact of bioengineering education and research on global science and economy.

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

**I. MATHEMATICS (4 courses)**

MATH	214 – 1, 2, 3	Calculus
MATH	215	Multiple Integration and Vector Calculus

**II. BASIC SCIENCES (4 courses)**

PHYSICS	135-2,3	General Physics <i>and</i>
CHEM	102, 103	General Chemistry (CHEM 101, when needed, can be taken as a technical elective or an unrestricted elective)
		<i>or</i>
CHEM	171, 172	Accelerated Chemistry

**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)**

GEN ENG	106-1, 2	Engineering Design and Communication (0.5 each) plus English 106-1,2 (0.5 each)
Speech	102 or 103	

**V. BASIC ENGINEERING (5 courses from 6 areas, no more than one course per area)**

**A. Thermodynamics**

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

**B. Fluid and Solid Mechanics**

BMD_ENG	270	Introductory Biomedical Fluid Mechanics
BMD_ENG	271	Introduction to Biomechanics
CHEM ENG	321	Fluid Mechanics
CIV ENG	216	Mechanics of Materials
MECH ENG	241	Fluid Mechanics I

**C. Material Science**

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

#### **D. Electrical Science**

BMD_ENG	221	Analysis and Simulation of Biological System
ECE	202	Introduction to Electrical Engineering
ECE	270	Applications of Electronic Devices

#### **E. Computer Engineering**

ECE	203	Introduction to Computer Engineering
ECE	328	Numerical Methods for Engineers

#### **F. Probability, Statistics, and Quality Control**

BMD_ENG	220	Introduction to Biostatistics
ECE	302	Probability Systems and Random Signals
IEMS	201	Introduction to Statistics
IEMS	303	Statistics I
MECH ENG	359	Reliability Engineering

#### **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, and laboratory biology. These requirements can be satisfied through the BME curriculum and by judicious use of electives.

#### **A. Core - 7 courses**

CHEM	210-1, 2	Organic Chemistry
BIOL SCI	210-2	Biology

Take two of the following three courses:

BMD_ENG	301	Systems Physiology I
BMD_ENG	302	Systems Physiology II
BMD_ENG	303	Systems Physiology III

Take both of the following courses:

BMD_ENG	308	Biomedical Engineering Laboratory
BMD_ENG	390	Biomedical Engineering Design

#### **B. Areas of specialization - 9 courses**

Each student in the Biomedical Engineering Program completes his/her course of study either by selecting one of the following areas of specialization or by selecting a special set of courses, which must be submitted by the end of the sophomore year 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 an area of specialization by petition.

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

## 1. Electronic Instrumentation (Professor Sahakian)

### a. Computer Applications

Take BMD ENG 221 or ECE 202 under Basic Engineering V-D

Take ECE 203 under Basic Engineering V-E

Take BMD ENG 220 or ECE 302 under Basic Engineering V-F

ECE	205	Fundamentals of Computer System Software
ECE	230	Programming for Computer Engineers
ECE	303	Advanced Digital Logic Design
BMD_ENG	320	Biomedical Signals and Images
BMD_ENG	383	Cardiovascular Instrumentation

Take one of the following pair of classes

ECE	346	Microprocessor System Design <i>and</i>
ECE	347	Microprocessor System Projects
ECE	361	Computer Architecture <i>and</i>
ECE	362	Computer Architecture Project
ECE	391	VLSI Systems Design <i>and</i>
ECE	392	VLSI Systems Design Projects

Two technical electives

### b. Electronic Instrumentation

Take BMD\_ENG 221 or ECE 202 under Basic Engineering V-D

Take ECE 203 under Basic Engineering V-E

Take BMD\_ENG 220 or ECE 302 under Basic Engineering V-F

Take one of the following two courses:

BMD_ENG	320	Biomedical Signals and Imaging
ECE	222	Fundamentals of Signals and Systems

Take all of the following courses:

ECE	221	Fundamentals of Circuits
ECE	223	Fundamentals of Solid State Engineering
ECE	225	Fundamentals of Electronics
ECE	230	Programming for Computer Engineers
ECE	303	Advanced Digital Logic Design
BMD_ENG	383	Cardiovascular Instrumentation

Two technical electives

## 2. Biomechanics and Rehabilitation (Professors Ameer, Childress, Glucksberg, Hartmann, Johnson, Liu, MacIver, Mockros, Perreault)

Take BMD\_ENG 250 or CHEM 342 under Basic Engineering V-A

Take BMD\_ENG 271 under Basic Engineering V-B

BMD_ENG	270	Introductory Biomedical Fluid Mechanics
BMD_ENG	346	Tissue Engineering
BMD_ENG	366	Biomechanics of Movement
BMD_ENG	371	Mechanics of Biological Tissue

Take three of the following courses:

BMD_ENG	321	Theory and Control of Biological Systems
BMD_ENG	344	Biological Performance of Materials
BMD_ENG	365	Human Limbs and their Artificial Replacements
BMD_ENG	372	Hemodynamics
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	390	Introduction to Dynamic Systems
MECH ENG	391	Fundamentals of Control Systems

Two technical electives

### 3. Transport Processes and Tissue Engineering (Professors Ameer, Johnson, Linsenmeier, Liu, Mockros)

Take BMD\_ENG 250 or CHEM 342 under Basic Engineering V-A

Take BMD\_ENG 270 or MECH ENG 241 or CHEM ENG 321 under Basic Engineering V-B

Take BMD\_ENG 302 and BMD\_ENG 303 under BME Core VIII-A

BMD_ENG	346	Tissue Engineering
BMD_ENG	350	Transport Fundamentals
BMD_ENG	271	Introduction to Biomechanics

Take one of the following courses

BMD_ENG	377	Intermediate Fluid Mechanics in Engineering and Biology
CHEM ENG	371	Transport Phenomena in Living Systems

Take three 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
BMD_ENG	344	Biological Performance of Materials
BMD_ENG	371	Mechanics of Biological Tissue
BMD_ENG	372	Hemodynamics
BMD_ENG	377	Intermediate Fluid Mechanics in Engineering and Biology
CHEM ENG	371	Transport Phenomena in Living Systems
BIOL SCI	315	Cell Biology
BIOL SCI	390	Molecular Biology

Two technical electives

### 4. Biological Materials and Biotechnology (Professors Ameer, Kelso, Liu, Messersmith, Wu)

Take BMD\_ENG 250 or CHEM 342 under Basic Engineering V-A

Take BMD\_ENG 270 under Basic Engineering V-B

Take MAT SCI 201 under Basic Engineering V-C

BMD_ENG	314	Models in Biochemistry and Molecular Biology
BMD_ENG	317	Biochemical Sensors
BMD_ENG	343	Biomaterials and Medical Devices
BMD_ENG	350	Transport Fundamentals

Take one of the following courses:

BMD_ENG	344	Biological Performance of Materials
MAT SCI	331	Physical Properties of Polymers

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	333	Modern Optical Microscopy and Imaging
BMD_ENG	346	Tissue Engineering
CHEM ENG	371	Transport Phenomena in Living Systems
BIOL SCI	301	Biochemistry
BIOL SCI	315	Cell Biology
BIOL SCI	390	Molecular Biology

Two technical electives

#### **5. Biomedical Signals and Images** (Professors Backman, Carroll, Kertesz, Li, Troy, Walsh)

Take BMD\_ENG 221 under Basic Engineering V-D

Take BMD\_ENG 301 and 302 under BME core VIII-A

BMD_ENG	320	Biomedical Signals and Imaging
BMD_ENG	325	Introduction to Medical Imaging

Take one of the following courses:

BMD_ENG	321	Theory and Control of Biological Systems
ECE	360	Introduction to Feedback Systems
MECH ENG	391	Fundamentals of Control Systems I

Take four 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	338	Interaction of Laser Radiation with Tissue
BMD_ENG	383	Cardiovascular Instrumentation
BMD_ENG	384	Biomedical Computing
BMD_ENG	495	Biomedical Imaging Principles and Applications
ECE	328	Numerical Methods for Engineers
ECE	359	Digital Signal Processing

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	221	Analysis and Simulation of Biological Systems
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	308	Biomedical Engineering Laboratory (with labs 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	320	Biomedical Signals and Imaging (with design)
BMD_ENG	321	Theory and Control of Biological Systems (with design)
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	338	Interaction of Laser Radiation with Tissue (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	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	372	Hemodynamics
BMD_ENG	377	Intermediate Fluid Mechanics in Engineering and Biology
BMD_ENG	379	Artificial Organs (with design)
BMD_ENG	383	Cardiovascular Instrumentation (with design)
BMD_ENG	384	Biomedical Computing (with design)
BMD_ENG	390	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	420	Biostatistics for Experimenters
BMD_ENG	445	Macromolecular Biomaterials
BMD_ENG	466	Neuromuscular Biomechanics
BMD_ENG	469	Neural Control and Mechanics of Movement

**Special Topics in BME:**

BMD_ENG	395	Advanced BME Design (with design)
BMD_ENG	395	Bioprocess Technology
BMD_ENG	395	Modern Optical Microscopy and Imaging