Biomedical Engineering

Department of Biomedical Engineering

School of Engineering and Applied Sciences
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Overview

The Department of Biomedical Engineering offers a BS in biomedical engineering. Biomedical engineers combine the problem solving ability of engineers with the knowledge of the biological and medical fields to develop new solutions for improving human health, healthcare, and quality of life for all people. Biomedical engineers work in research and development, product design, manufacturing, operations, service, technical sales and marketing, consulting, education, and environmental problem solving.

The undergraduate program provides the scope of knowledge and training for employment in the field and also forms the basis for further study at the graduate level. The curriculum emphasizes four main areas (Imaging, Tissue Engineering, Sensor Materials and Devices, and Computation), and allows for students to obtain depth in areas of their choice through technical electives. The Department of Biomedical Engineering brings together faculty members from many disciplines to provide an education that will enable our graduates to succeed.

Biomedical Engineering Program Educational Objectives:
The recent graduate shall:

- Demonstrate expertise and career advancement in their field through the application of fundamental knowledge (mathematics and science) and skills (problem solving), and engineering tools;
- Communicate effectively by contributing to conference presentations, journal publications, industrial and internal documents, patent applications, reports, and/or scholarly journal papers;
- Contribute to the achievement of their organization's goals as an effective leader and/or effective team member; and
- Be engaged in their profession and life-long learning by using their knowledge and expertise to aid civic institutions, educational organizations, and professional societies.

The program is designed to serve both students who intend to enter industry directly and others who plan to continue their education through formal graduate study, including medical school.

About our Degrees

The biomedical engineering BS degree prepares students for graduate study and/or professional practice. The degree program will pursue accreditation by the Accreditation Board of Engineering and Technology (ABET) as soon as allowed.

Acceptance Criteria - BS
See the School of Engineering and Applied Sciences for acceptance information.

Degree Requirements

Please see Degrees and Policies.

About our Courses

Suggested Introductory Courses

- BE 201 Principles of Biomedical Engineering
- BE 202 Applied Medical and Engineering Biology
- CHE 107 General Chemistry for Engineers
- EAS 140 Engineering Principles
- EAS 202 Engineering Impact on Society
- MTH 141-MTH 142 College Calculus I - II
- PHY 107-PHY 108 General Physics I - II

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The typical class size for:
Biomedical Engineering Freshman/introductory courses: 50
Sophomore/intermediate courses: 30-50
Upper level/advanced courses: 10-30

In the Department of Biomedical Engineering, what do teaching assistants (TAs) do?

TAs assist professors in all courses with laboratory and recitation sections. They frequently lead small group discussion sections. TAs may also assist with grading.

For course descriptions, please see Courses.

About our Faculty

Faculty Specializations

See http://www.bme.buffalo.edu/people/full_time/index.php for descriptions of the specializations of our faculty.

The director of undergraduate studies, Albert H. Titus, may be contacted at ahtitus@buffalo.edu.

See a list of our Undergraduate Faculty.

Acceptance Information

For acceptance information please see the Undergraduate Catalog entry for the School of Engineering and Applied Sciences.

Transfer Policy

Transfer students must first apply to the university and meet the university transfer admission requirements before consideration for admission to the Department of Biomedical Engineering. Biomedical engineering courses completed at other colleges and offered as substitutes for UB courses are evaluated individually by the BE Undergraduate Director; determination is made by an evaluation of the student's transcripts, course content, contact hours, and grades earned. Most courses taken from an ABET-accredited college-level Biomedical Engineering department are acceptable. Evaluations for transfer credits of general education, basic science, and engineering science courses completed at other universities and colleges are done through the Office of Undergraduate Education, School of Engineering and Applied Sciences, 410 Bonner Hall. For more information, see the School of Engineering and Applied Sciences.

Extracurricular Activities

- Robotics Club
- Society of Women Engineers
- Student Chapter of the Biomedical Engineering Society (BMES)
- Tau Beta Pi

See the UB Student Association.

Practical Experience and Special Academic Opportunities

Undergraduate Research and Practical Experience

Undergraduate Research
As part of their undergraduate education, students are required to participate in research opportunities through BE 498.

Additionally, the Center for Undergraduate Research and Creative Activity (CURCA) serves as a clearing house for information regarding undergraduate research opportunities at UB. These opportunities are can provide the opportunity to participate in research leading to publications and/or presentations. Alternately, research activities may instead be arranged directly between students and faculty members within the department. Students may also complete a senior thesis or project on their research, if appropriate.

Work experience is available through the Engineering Career Institute program in the School of Engineering and Applied Sciences, as well as departmental co-op and internship classes. The Engineering Career Institute (EAS 396, 1 academic credit) provides career-effectiveness skills

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and co-op placement assistance during the junior year. This may be followed by one to three co-op work experiences (EAS 496, 2 academic credit hours). Descriptions of co-op courses may be found at http://undergrad-catalog.buffalo.edu/academicprograms/eas.shtml.

Independent Study

Approval is required to use BE 499 Independent Study as a senior technical elective. See the requirements for approval at: http://www.bme.buffalo.edu/IndependentStudy.htm.

Career Information and Further Study

Biomedical engineers are employed in many areas, both public and private. For example, biomedical engineers are employed in companies designing and testing new devices and systems. They are employed at universities and hospitals as researchers and support personnel. They are also employed at government regulatory agencies, helping to develop and standards for product testing and safety. Because of their training in both the engineering and medical disciplines, biomedical engineers are often in the role of interfacing between these two fields.

Salary Information
The mean starting salary for biomedical engineers is approximately $56,000 per year. From the Bureau of Labor Statistics, the latest data on mean overall salaries for biomedical engineers is $84,780, with a 25%-75% range of $62,070 to $103,570.

Nationally about a third of biomedical engineering students go on to graduate school in engineering or related disciplines, about a third go on to medical school, and about a third go directly to industry.

Degrees Offered

Undergraduate: BS

Links to Further Information About this Program

- Undergraduate Catalog
- Undergraduate Admissions
- Graduate Admissions
- Department of Biomedical Engineering
- School of Engineering and Applied Sciences

Biomedical Engineering - B.S.

Acceptance Criteria

See the School of Engineering and Applied Sciences Acceptance Information section.

Required Courses

CHE 107 General Chemistry for Engineers
CHE 108 General Chemistry for Engineers
EAS 140 Engineering Principles
EAS 202 Engineering Impact on Society
EAS 230 Engineering Computations
EAS 305 Applied Probability
BE 201 Principles of Biomedical Engineering
BE 202 Applied Medical & Engineering Biology
BE 301 BME Laboratory I
BE 302 BME Laboratory II
BE 304 Principles of Medical Imaging
BE 305 Biomaterials and Mechanics
BE 307 Biomedical Circuits and Signals
BE 308 Biofluidmechanics
BE 309 Biomedical Chemical Principles 1 or CHE 201 Organic Chemistry
BE 310 Biomedical Chemical Principles 2 or CHE 204 Organic Chemistry
BE 403 Biomedical Instrumentation
BE 405 Transport Processes in BME
BE 406 Biomedical Systems Engineering

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BE 494 Senior Design Project
BE 498 Undergraduate Research
IE 436 Work Physiology
MTH 141 College Calculus I
MTH 142 College Calculus II
MTH 241 College Calculus III
MTH 306 Introduction to Differential Equations
PHY 107 General Physics I
PHY 108 General Physics II
PHY 158 General Physics II Lab
Two Engineering track courses (sequential)
Three technical upper-division electives

Summary
Total required credit hours for the major: 112

See Baccalaureate Degree Requirements for general education and remaining university requirements.

Recommended Sequence of Program Requirements

FIRST YEAR
Fall CHE 108, EAS 140, MTH 141
Spring EAS 202, CHE 107, MTH 142, PHY 107

SECOND YEAR
Fall BE 201, MTH 241, PHY 108/PHY 158
Spring BE 202, EAS 230, MTH 306, Engineering Track #1

THIRD YEAR
Fall BE 301, BE 305, BE 307, BE 309, Engineering Track #2
Spring BE 302, BE 304, BE 308, BE 310, EAS 305

FOURTH YEAR
Fall BE 403, BE 405, BE 498, IE 436, one technical elective
Spring BE 406, BE 494, Two technical electives

Electives and Course Groupings

Technical Electives (minimum 9 credits)

A total of three technical electives is required. All must be upper-division technical electives.

Engineering Tracks

Engineering Track 1 and Engineering Track 2 are elective courses that allow BE students to take two courses in their general areas of interest in Engineering. The courses should be 200 or 300 level courses. Allowed courses are: (EE 202 and EE 203, Circuits 1 and 2), (CE 212 Fundamental Principles of Chemical Engineering and CE 304 Chemical Engineering Thermodynamics- Note that these must be taken in Sophomore year), (EAS 207 Statics and, EAS 208 Dynamics or EAS 209 Mechanics of Solids).

BE 101: Biomedical Engineering Seminar

Credits: 1
Type: SEM

Current topics in biomedical engineering. Students attend weekly seminars and complete a final paper report on a topic related to biomedical engineering.

BE 201: Principles of Biomedical Engineering

Credits: 3
Type: LEC/REC

Introduces students to biomedical engineering. Provides an introduction to bioengineering labs and confidence in performing a lab, and provides competence in technical writing and an introduction to writing lab reports. Finally, students will learn how to assemble a poster presentation and gain an understanding of its important in conveying science and technological findings to their community.

BE 202: Applied Medical and Engineering Biology

Credits: 4
Type: LEC/REC

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Emphasizes foundations of our understanding of cells, cell organelles, membrane structure, bioenergetics, photosynthesis, cytoskeleton, cell matrix, cell cycle, protein trafficking, nucleic acids, and cell reproduction. Engineering applications of this material are stressed.

BE 301: Biomedical Engineering Lab 1

Credits: 3
Type: LEC/LAB

First in the series of two courses intended to expose junior-level students to BE lab techniques and analysis procedures. The labs are an extension of course material learned in a previous class in biomechanics and biomaterials as well as course material learned in a concurrent class in biomedical circuits and signals. Initial lab sessions will focus on lab safety, technical communications, and the statistical and error analysis of data. .

BE 302: Biomedical Engineering Lab 2

Credits: 1
Type: LEC/REC

Second in a series of two courses intended to expose junior-level to BE lab techniques and analysis procedures. The lab provides hands-on experience with cell culture technology with emphasis on the principles and practices of initiation, cultivation, maintenance, preservation of cell lines and applications. Biochemical and biophysical characteristics of cells in culture. Analysis of cell viability, growth and proliferation. Basic training in microscopy, spectrophotometry, and immunological methods. The lectures will focus on background material for the lab exercises as well as provide a forum for discussion of current research in BE.

BE 304: Principles of Medical Imaging

Credits: 3
Type: LEC/REC

A one semester course covering the basic aspects of medical imaging. The most commonly used imaging modalities (projection x-ray, computed tomography, nuclear medicine, magnetic resonance, ultrasound, and microscopy) are discussed in terms of the mathematics, the physical systems, data produced, and the quality of these data.

BE 305: Biomaterials and Mechanics

Credits: 3
Pre-requisites: PHY 108 or PHY 118, PHY 158, BE 201, Approved Biomedical Engineering Majors
Type: LEC/REC

Principles of fluid mechanics as applied in physiological systems with the primary focus on the human circulatory system. Prepares students for advanced topics in biofluids transport, cardiovascular biomechanics, and biofluids modeling.

BE 307: Biomedical Circuits and Signals

Credits: 3
Pre-requisites: PHY 108 or PHY 118, EAS 230, BE 201, PHY 158 ; Approved Biomedical Engineering Majors
Type: LEC/REC

Designed for BE juniors. Explores fundamental knowledge of biological signals and the circuitry and software used to acquire, analyze, and process these circuits and signals. Reviews basic properties of signals and systems, develops an in-depth knowledge of electronic circuit design, and exposes students to problem-oriented design with special emphasis on problems particular to biomedical applications, and integrates the physiological concepts with electronic design to prepare the students for solving problems in any area of biomedical engineering. Teaches LabView, a graphical programming tool for virtual instrumentation. Students will develop skills to analyze, design, and build both real and virtual instruments for biomedical research applictions and prototyping of medical devices.

BE 308: Biofluid Mechanics

Credits: 3
Type: LEC/REC

Principles of fluid mechanics as applied in physiological systems with the primary focus on the human circulatory system. This course will prepare students for advanced topics in biofluids transport, cardiovascular biomechanics, and biofluids modeling.

BE 309: Biomedical Chemical Principles 1

Credits: 3
Type: LEC/REC

This course introduces basic concepts of biochemistry for biomedical engineering, with a focus on engineering solutions and applications.

BE 310: Biomedical Chemical Principles 2

Credits: 3
Type: LEC/REC

Fundamentals of biological chemistry and organic chemistry with a focus on applications and engineering design. Organic chemistry basics (i.e. carbon compounds) such as bonding, stereochemistry and reaction mechanism.

BE 403: Biomedical Instrumentation

Credits: 3
Pre-requisites: BE 302, BE 304, BE 307; Approved Biomedical Engineering Majors
Type: LEC/REC

Introduction to biomedical instrumentation covering clinical and research measurements. Covers topics in biomedical electronics, measurement techniques, understanding of transducers used in measurements and system for physical, optical, electrical, mechanical, thermal transductions mechanics. Specifically measurement techniques using biopotential electrodes, strain transducers, pressure sensors, flow sensors, biochemical sensors are discussed. Further, this course also introduces students to basic principles in data acquisition and signal processing of sensory data.

BE 405: Transport Processes in Biomedical Engineering

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Credits: 4
Pre-requisites: BE 310 or CHE 202 or CHE 204, BE 308; Approved Biomedical Engineering Majors
Type: LEC/REC

Covers the basic molecular mechanics of fluid and electrolyte transport across cell membranes and epithelia. Emphasizes the description of these mechanisms using mathematical formulations and computer modeling. Describes the extraction of parameters from experimental data. subjects include osmotic pressure, conversion of energy between electrical, chemical and physical quantities, application of these principles to ion homeostasis, transport and signaling. Also examines organ level applications in the neuronal action potential, cell volume regulation and water transport.

BE 406: Biomedical Systems Engineering

Credits: 3
Type: LEC/REC

Applies quantitative systems engineering tools to model cellular processes (e.g. metabolism, signal transduction) from large scale molecular datasets in order to predict cellular behavior and identify optimum strategies to alter it for therapeutic or other purposes. Emphasizes (i) the technologies used for global, cell-wide monitoring of cellular processes, and the associated mathematical and computational frameworks for analysis of this information, and (ii) the application of systems engineering principles and methodologies on the study of complex, large-scale biological systems.

BE 420: Biomaterials in Regenerative Medicine

Credits: 3
Pre-requisites: BE 305 And CHE 201 And CHE 203
Type: LEC

This course will introduce the concepts and approaches for biomaterial application in the field of regenerative medicine. Significance and role of biomaterials in tissue regeneration, drug delivery, sensors and imaging. Chemical, physical, thermal, mechanical properties of polymers, natural material, ceramics and metals as biomaterials Response of biomaterials. Material sources, scale-up, processing and manufacturability. Methodologies for scaffolding, surface modification and recognition, micro/nanoparticle fabrication. Current status of biomaterial development.

BE 460: Introduction to Magnetic Resonance Imaging

Credits: 3
Type: LEC

This course covers topics related to magnetic resonance imaging (MRI) including: Magnetic resonance signal generation and detection; spatial encodings; image formation and reconstruction; image contrasts; biomedical applications; advanced imaging techniques.

BE 494: Senior Capstone Design Project

Credits: 3
Type: SEM

Participation in group engineering design. By the end of the semester, students will design and demonstrate a biomedical-related device or system that is a culmination of their previous biomedical engineering courses. Weekly meetings allow students to discuss problems.

BE 498: Undergraduate Research

Credits: 3
Pre-requisites: BE 302, permission of instructor; Approved Biomedical Engineering Majors
Type: TUT

Students work with the faculty members on research problems. Topics vary by professor.