Biomedical Engineering

Chair: Jianyi Zhang, MD, PhD

Associate Chair of Education: Alan Eberhardt, PhD

Degree Offered
Bachelor of Science in Biomedical Engineering

Accreditation
The Bachelor of Science in Biomedical Engineering degree program is accredited by the Engineering Accreditation Commission of ABET, under the commission's General Criteria and Program Criteria for Bioengineering and Biomedical and Similarly Named Engineering Programs.

Website
https://www.uab.edu/engineering/bme/undergraduate

Program Director
Alan Eberhardt, PhD

Email
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Phone
205-934-8420

Biomedical engineering (BME) is the application of engineering principles and technology to the solution of problems in the life sciences and medicine. Biomedical engineers create knowledge and develop technologies that improve healthcare delivery and patient outcomes with an emphasis on reducing healthcare costs. Graduates create and apply knowledge at the interface of life sciences and engineering for the benefit of society. The BME undergraduate program prepares graduates to be immediately productive and able to adapt to a rapidly changing environment. In addition to the Blazer Core, the curriculum includes engineering core courses, mathematics, calculus-based physics, biology, chemistry, humanities, social and behavioral sciences, biomedical engineering core courses and electives. The curriculum culminates in a capstone design experience where student teams apply knowledge to solve real-world engineering problems. A bachelor’s degree in BME from UAB provides a foundation in biomedical implants and devices, biomaterials, biocomputing, biotransport, and biomedical instrumentation to compete in an increasingly technical medical field, and also prepares students for graduate school, medical school, or professional school.

Vision
To be an internationally recognized, research-oriented Department of Biomedical Engineering: a top choice for undergraduate and graduate education.

Mission
The Department of Biomedical Engineering provides leadership in teaching the principles of engineering and biology and in conducting research that will translate new discoveries in biological engineering science to the fields of public health and clinical medicine. These efforts will enable us to identify new solutions to critical challenges in health care and the life sciences.

Program Educational Objectives
Graduates of the Biomedical Engineering undergraduate program will have:

1. Gained admission to graduate or professional school, or gained employment in engineering and/or health related professions and service
2. Pursued opportunities for professional growth, development, and

Student Outcomes
Upon completion of the BSBME degree program, our graduates will have:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Academic Warning, Probation, and Readmission

BME students must maintain an institutional (UAB) GPA of at least 2.50. First-term BME freshmen students who have an institutional GPA below 2.50 will be placed on academic warning in BME. If their institutional GPA is not at least 2.50 after the next term enrolled, they will be placed on academic probation in BME. BME undergraduates (other than first-term freshmen) who do not have an institutional GPA of at least 2.50 will be placed on BME academic probation. If at the end of the next term in which they enroll, their institutional GPA is not at least 2.50, they will be reclassified as Undeclared Engineering. To be re-admitted to the BME program, a student must have an institutional GPA of at least 3.00 and make a formal application for readmission.

Program and Graduation Requirements
BME students must have an institutional GPA of at least 2.50 and have completed at least 64 hours of coursework applicable to their degree before they may register for 300-level and 400-level BME courses. BME students must also have an institutional GPA of 2.50 or higher and have earned a grade of C or better in all BME courses to graduate.

Please note the Residency Requirement on the Majors tab.

Please refer to the School of Engineering Overview for School policies related to admission, reasonable progress requirements, and graduation.
Non-Majors Enrolled in BME Coursework

In addition to fulfilling course prerequisites, non-BME students (including students seeking a BME minor) who wish to enroll in 300-level and 400-level BME courses must have an institutional (UAB) GPA of at least 3.00 or permission of the BME Undergraduate Program Director. Non-BME majors may not enroll in BME 423, BME 498, or BME 499.

BME Minors

Please refer to the Minors tab on the School of Engineering’s Overview page in this catalog for information specific to BME minors.

Bachelor of Science in Biomedical Engineering

Major in Biomedical Engineering

Requirements Hours

Blazer Core Requirements 43

CH 115 General Chemistry I
& 115R and General Chemistry I Recitation
& CH 116 and General Chemistry I Laboratory

EGR 103 Computer Aided Graphics and Design

EGR 200 Introduction to Engineering 1

EH 101 English Composition I

EH 102 English Composition II

MA 125 Calculus I
& 125L and Calculus I Lab

PH 221 General Physics I
& 221L and General Physics Laboratory I
& 221R and General Physics I Recitation

PH 222 General Physics II
& 222L and General Physics Laboratory II
& 222R and General Physics II - Recitation

Academic Foundations: Reasoning

Thinking Broadly: History & Meaning

Thinking Broadly: Creative Arts

Thinking Broadly: Humans & Their Societies

City as a Classroom 2

Other Required Courses 70

BME 310 Biometrics

BME 210 Engineering in Biology

BME 312 Biocomputing

BME 313 Bioinstrumentation

BME 333 Biomechanics of Solids

BME 350 Biological Transport Phenomena

BME 370 Integrated Physiology

BME 401 Undergraduate Biomedical Engineering Seminar

BME 423 Living Systems Analysis and Biostatistics

BME 498 Capstone Design I Product Development

BME 499 Capstone Design II

BY 115 Human Anatomy
& 115L and Human Anatomy Laboratory
or BY 210 Genetics
and Genetics Laboratory
& 210L

BY 123 Introductory Biology I
& 123L and Introductory Biology I Laboratory

CE 210 Statics

BME Minors

Please refer to the Minors tab on the School of Engineering’s Overview page in this catalog for information specific to BME minors.

Bachelor of Science in Biomedical Engineering

Major in Biomedical Engineering

Requirements Hours

Blazer Core Requirements 43

CH 115 General Chemistry I
& 115R and General Chemistry I Recitation
& CH 118 and General Chemistry I Laboratory

EE 312 Electrical Systems

EGR 150 Computer Methods in Engineering

EGR 194 Engineering Explorations

EGR 265 Math Tools for Engineering Problem Solving 3

MA 126 Calculus II

MA 260 Introduction to Linear Algebra

ME 215 Dynamics
& 215R and Dynamics Recitation

MSE 280 Engineering Materials

Biomedical Engineering Electives 9

BME 221 Clinical Innovation I

BME 289 Undergraduate Research in Biomedical Engineering I 4

BME 389 Undergraduate Research in Biomedical Engineering II 4

BME 420 Implant-Tissue Interactions

BME 424 Current Topics in Stem Cell Engineering

BME 435 Tissue Engineering

BME 443 Medical Image Processing

BME 444 Machine Learning for Biomedical Engineering Applications

BME 450 Computational Neuroscience

BME 462 Cardiac Electrophysiology

BME 471 Continuum Mechanics of Solids

BME 489 Undergraduate Research in Biomedical Engineering III 4

BME 490 Special Topics in Biomedical Engineering

BME 491 Individual Study in Biomedical Engineering 5

BME 494 Honors Research I 5, 6

Engineering/Math/Science Electives 7

Select six credit hours from the following or from the list of Biomedical Engineering electives above

BY 271 Biology of Microorganisms
& 271L and Biology of Microorganisms Laboratory

BY 311 Molecular Genetics

BY 330 Cell Biology

BY 362 Neurobiology

CE 337 Hydraulics

CE 345 Transportation Engineering

CE 360 Structural Analysis

CE 395 Engineering Economics

CE 420 Advanced Mechanics

CE 433 Solid and Hazardous Wastes Management

CH 235 Organic Chemistry I
& 235R and Organic Chemistry I Recitation

CH 237 Organic Chemistry II
& 237R and Organic Chemistry II Recitation

CH 355 Quantitative Analysis

CH 460 Fundamentals of Biochemistry

MA 313 Patterns, Functions and Algebraic Reasoning

MA 360 Scientific Programming

MA 361 Mathematical Modeling

MA 453 Fourier Analysis

MA 485 Probability

ME 360 Introduction to Mechatronic Systems Engineering

ME 370 Kinematics and Dynamics of Machinery

ME 371 Machine Design

ME 464 Introduction to Finite Element Method
## Residency Requirement

In addition to UAB's residency requirement, to earn a bachelor of science in biomedical engineering from UAB, the BME department requires that students complete the following courses at UAB:

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 423 Living Systems Analysis and Biostatistics</td>
<td>3</td>
</tr>
<tr>
<td>BME 498 Capstone Design I Product Development</td>
<td>3</td>
</tr>
<tr>
<td>BME 499 Capstone Design II</td>
<td>3</td>
</tr>
<tr>
<td>Additional 400-level BME Elective</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>12</strong></td>
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</tbody>
</table>

### Concentration in Biomechanics

Students seeking the degree of BSBME may add a concentration in Biomechanics by appropriate selection of their Mathematics/Science Engineering Electives (3 credit hours), Engineering Elective (3 credit hours), and BME Electives (6 credit hours).

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>BME 471 Continuum Mechanics of Solids</td>
<td>3</td>
</tr>
<tr>
<td>BME 617 Engineering Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ME 464 Introduction to Finite Element Method</td>
<td>3</td>
</tr>
<tr>
<td>RHB 490 Quantitative Biomechanics of Injury and Rehabilitation</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

### Concentration in Biomaterials/Tissue Engineering

Students seeking the degree of BSBME may add a concentration in Biomaterials/Tissue Engineering by appropriate selections of their Mathematics/Science/Engineering Electives (3 credit hours), Engineering Elective (3 credit hours), and BME Electives (6 credit hours).

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 420 Implant-Tissue Interactions</td>
<td>3</td>
</tr>
</tbody>
</table>
### Courses

**BME 011. Undergraduate Internship in BME. 0 Hours.**
Engineering internship experience in preparation for the student's intended career. Students in a university recognized cooperative education experience should register for COP 011 or COP 012.

**BME 210. Engineering in Biology. 3 Hours.**
Application of engineering to the study of biology on the cellular and molecular level. Engineering solutions in genomics, proteomics, and nanotechnology to investigate cellular and molecular processes.

**Prerequisites:** BY 123 [Min Grade: C]

**BME 221. Clinical Innovation I. 3 Hours.**
The goals of this class are to develop an understanding of the concept of clinical innovation and develop skills in written and oral communication of innovation in the context of a business proposal/presentation.

**BME 289. Undergraduate Research in Biomedical Engineering I. 1 Hour.**
Undergraduate research experiences in biomedical engineering. Must have sophomore standing.

**Prerequisites:** EGR 194 [Min Grade: C] or EGR 200 [Min Grade: C] or EGR 111 [Min Grade: C] or HC 111 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

**BME 310. Biomaterials. 3 Hours.**
Introduction to wide range of materials used for biomedical applications. Physical, chemical and mechanical properties of biomaterials.

**Prerequisites:** MSE 280 [Min Grade: C] and BME 210 [Min Grade: C]

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**BME 311. Biomaterials for Non-Majors. 3 Hours.**
Wide range of materials used for biomedical applications. Physical, chemical and mechanical properties of biomaterials.

**Prerequisites:** MSE 280 [Min Grade: C]

**BME 312. Biocomputing. 3 Hours.**
Introduction to computational techniques used in biomedical engineering.

**Prerequisites:** EGR 150 [Min Grade: C] and EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] and MA 252 [Min Grade: C]) and MA 260 [Min Grade: C](Can be taken Concurrently)

**BME 313. Bioinstrumentation. 3 Hours.**
An introduction to instrumentation used to make biological and physiological measurements. Techniques include acquisition and analysis of bioelectric signals and instrument control.

**Prerequisites:** EE 312 [Min Grade: C] and (MA 227 [Min Grade: C] and MA 252 [Min Grade: C] or EGR 265 [Min Grade: C])

**BME 333. Biomechanics of Solids. 3 Hours.**
Application of mechanics of solids principles to biomedical engineering problems; stress-strain of bone, viscoelasticity and constitutive equations of tissues, mechanics of the cell, introduction to molecular mechanics.

**Prerequisites:** CE 210 [Min Grade: C] or EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] and MA 252 [Min Grade: C]) and ME 215 [Min Grade: C](Can be taken Concurrently)

**BME 350. Biological Transport Phenomena. 3 Hours.**
Basic mechanisms and mathematical analysis of transport processes with biological and biomedical applications. Analysis of flow, transport and reaction processes for biological fluids and biological molecules with applications towards development of artificial organs, drug delivery systems and tissue engineering products.

**Prerequisites:** CE 210 [Min Grade: C] and EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] and MA 252 [Min Grade: C]) and BME 210 [Min Grade: C] and BME 370 [Min Grade: C](Can be taken Concurrently) or BY 409 [Min Grade: C](Can be taken Concurrently) and ME 215 [Min Grade: C](Can be taken Concurrently)

**BME 370. Integrated Physiology. 3 Hours.**
Integrated Physiology will introduce undergraduate students to mathematical models of major physiological systems. Basic anatomy will be reviewed in pre-recorded videos to be watched prior to coming to synchronous lectures. Lectures will include discussions, derivations of relevant equations, and development of models to demonstrate understanding of biological systems. In-class activities will be used as means to provide interactive content that will be assessed via Assignments and Exams. The course will culminate in a final project where teams of students select a pathological condition and model it in Matlab, including comparing to normal conditions and with currently-available clinical interventions. Open to junior and senior level Biomedical Engineering students.

**Prerequisites:** EGR 150 [Min Grade: C] and BME 210 [Min Grade: C]

**BME 389. Undergraduate Research in Biomedical Engineering II. 1-2 Hour.**
Undergraduate research experiences in biomedical engineering.

**BME 401. Undergraduate Biomedical Engineering Seminar. 1 Hour.**
Undergraduate seminar.
BME 420. Implant-Tissue Interactions. 3 Hours.
An overview of implant biocompatibility including tissue histology, histopathology of implant response and the regulatory process for medical devices. Emphasis placed on ethical issues related to design, development, and implementation of biomedical implants. Ethics and Civic Responsibility are significant components of this course.
Prerequisites: BME 310 [Min Grade: C] or BME 311 [Min Grade: C]

BME 423. Living Systems Analysis and Biostatistics. 3 Hours.
Basic concepts and techniques of measurement processing and analysis of data from living systems. Statistics, analysis of variance and regression analysis. Emphasis is placed on data analysis and presentation of group projects.
Prerequisites: BME 312 [Min Grade: C]

BME 424. Current Topics in Stem Cell Engineering. 3 Hours.
This course is designed for students interested in the field of stem cells, regenerative medicine, and tissue engineering using stem cells and stem cell derived cells. The course will introduce the role of stem cells in tissue growth and development, the theory behind the design and in vitro construction of tissue and organ replacements, and the applications of biomedical engineering principles to the treatment of tissue-specific diseases. Students will have hands on experience on culturing and analyzing stem cells, stem cell differentiation, analysis of functional and physiological properties of differentiated cells, and fabricating basic engineered-tissues.
Prerequisites: BY 123 [Min Grade: C] and (BY 210 [Min Grade: C] or BY 212 [Min Grade: C] or BY 115 [Min Grade: C])

BME 435. Tissue Engineering. 3 Hours.
Principles underlying strategies for regenerative medicine such as stem-cell based therapy, scaffold design, proteins or genes delivery, roles of extracellular matrix, cell-materials interactions, angiogenesis, tissue transplantation, mechanical stimulus and nanotechnology.
Prerequisites: BME 310 [Min Grade: C] or BME 311 [Min Grade: C]

BME 443. Medical Image Processing. 3 Hours.
Fundamental topics of medical image processing to practical applications using conventional computer software.
Prerequisites: BME 312 [Min Grade: C] (Can be taken Concurrently) and PH 222 [Min Grade: C]

BME 444. Machine Learning for Biomedical Engineering Applications. 3 Hours.
This course provides the introduction to the practical aspects of machine learning such that the students can apply some basic machine learning techniques in simple biomedical engineering problems. The course also provides the principle of machine learning ‘thinking process’ for the next machine learning – AI courses and more in-depth machine learning studies. By ‘thinking process’, at the beginning, it is better to view machine learning like human learning. Students who have experience with Data Mining may further understand the fundamental differences between Machine Learning and Data Mining, although these two fields share many concepts and techniques. Also, the student will learn fundamental theories in machine learning to be able to develop new machine learning techniques and research machine learning in biomedical engineering.
Prerequisites: EGR 150 [Min Grade: C]

BME 450. Computational Neuroscience. 3 Hours.
This course examines the computational principles used by the nervous system. Topics include: biophysics of axon and synapse, sensory coding (with an emphasis on vision and audition), planning and decision-making, and synthesis of motor responses. There will be an emphasis on systems approach throughout. Homework includes simulations.
Prerequisites: BME 312 [Min Grade: C]

BME 455. NextGen-BioMed Bootcamp. 3 Hours.
The course will provide students with a solid foundation in the principles, methods, and techniques used in biomedical research. The course will cover a range of topics, including experimental design, cell and molecular biology techniques, immunological techniques, animal models and in vivo studies, and laboratory safety and good laboratory practices.
Prerequisites: BME 210 [Min Grade: C] or BY 210 [Min Grade: C] or BY 330 [Min Grade: C]

BME 461. Bioelectric Phenomena. 3 Hours.
Quantitative methods in electrophysiology with focus on using simulations to examine responses in electrically excitable cell types.
Prerequisites: BME 312 [Min Grade: C]

BME 462. Cardiac Electrophysiology. 3 Hours.
Experimental and computational method on cardiac electrophysiology, ionic current, action potentials, electrical propagation, the electrocardiogram, electromechanical coupling, cardiac arrhythmias, effects of electric fields in cardiac tissue, defibrillation and ablation.
Prerequisites: BME 312 [Min Grade: C]

BME 471. Continuum Mechanics of Solids. 3 Hours.
Matrix and tensor mathematics, fundamentals of stress, momentum principles, Cauchy and Piola-Kirchoff stress tensors, static equilibrium, invariance, measures of strain, Lagrangian and Eulerian formulations, Green and Almansa strain, deformation gradient tensor, infinitesimal strain, constitutive equations, finite strain elasticity, strain energy methods, 2-D Elasticity, Airy Method, viscoelasticity, mechanical behavior of polymers.
Prerequisites: EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] and MA 252 [Min Grade: C]) and (BME 333 [Min Grade: C] or CE 220 [Min Grade: C])

BME 472. Industrial Bioprocessing and Biomanufacturing. 3 Hours.
This course will introduce students to the growing industries related to biomedical, biopharmaceutical and biotechnology. It is targeted to offer the students marketable skills to work in a vital area of economic growth and also convey some of the challenges and opportunities awaiting.
Prerequisites: BME 310 [Min Grade: C] (Can be taken Concurrently)

BME 489. Undergraduate Research in Biomedical Engineering III. 1-2 Hour.
Undergraduate research experiences in biomedical engineering. Must have senior standing.

BME 490. Special Topics in Biomedical Engineering. 1-3 Hour.
Special Topic in Biomedical Engineering.

BME 491. Individual Study in Biomedical Engineering. 1-6 Hour.
Individual Study in Biomedical Engineering.

BME 494. Honors Research I. 1-3 Hour.
Research experiences for undergraduates enrolled in the departmental honors program. The student should write a proposal and make a presentation based on the proposal.
Prerequisites: EGR 301 [Min Grade: C] or STH 201 [Min Grade: C]
BME 495. Honors Research II. 1-3 Hour.
Research opportunities for undergraduate students in the Biomedical Engineering Honors Program. Research areas include cardiac electrophysiology, brain imaging, biomedical implants, and tissue engineering.

Prerequisites: BME 494 [Min Grade: C]

BME 496. Biomedical Engineering Honors Seminar. 1 Hour.
Must be enrolled in an Honors Program.

Prerequisites: BY 123 [Min Grade: B] and BY 286 [Min Grade: B]

BME 498. Capstone Design I Product Development. 3 Hours.
Design and development of medical-products. Through experiential learning, students go through the early phases of engineering design innovation for medical products, starting with clinical immersion to determine a critical health-care need. Engineering students work in multidisciplinary teams that include students from the School of Business to develop design concepts for both a client-based prototype and a commercializable version. Designs take into account client needs as well as legal, regulatory, and marketing requirements. Business ethics are also covered. Emphasis is placed on communication in both oral and written format to targeted audiences.

Prerequisites: (BME 310 [Min Grade: C] and BME 312 [Min Grade: C]) or (BME 310 [Min Grade: C] and BME 313 [Min Grade: C]) or (BME 310 [Min Grade: C] and BME 333 [Min Grade: C]) or (BME 310 [Min Grade: C] and BME 350 [Min Grade: C]) or (BME 312 [Min Grade: C] and BME 313 [Min Grade: C]) or (BME 312 [Min Grade: C] and BME 333 [Min Grade: C]) or (BME 312 [Min Grade: C] and BME 350 [Min Grade: C]) or (BME 313 [Min Grade: C] and BME 333 [Min Grade: C]) or (BME 313 [Min Grade: C] and BME 350 [Min Grade: C]) or (BME 333 [Min Grade: C]) or (BME 370 [Min Grade: C])

BME 499. Capstone Design II. 3 Hours.
Capstone design project; a continuation of BME 498. Through experiential learning, student teams complete the engineering design process for their client-based prototype incorporating engineering standards and realistic constraints. Student teams develop a business plan to present to potential business partners and product development teams from established companies. Additional skills learned in this part of the design process include: development of business proposals, project planning and scheduling, project execution and resource scheduling, communication of design, and interim and final design reviews. Emphasis is placed on communication of design and design justification in both an oral and written format to targeted audiences.

Prerequisites: BME 498 [Min Grade: C] and BME 310 [Min Grade: C] and BME 312 [Min Grade: C] and BME 313 [Min Grade: C] and BME 333 [Min Grade: C](Can be taken Concurrently) and BME 350 [Min Grade: C](Can be taken Concurrently) and BME 423 [Min Grade: C](Can be taken Concurrently)