Biomedical Engineering

<table>
<thead>
<tr>
<th>Degrees Offered</th>
<th>MSBME, PhD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Website</td>
<td><a href="http://www.uab.edu/bme">www.uab.edu/bme</a></td>
</tr>
<tr>
<td>Program Director</td>
<td>Jack M. Rogers, PhD</td>
</tr>
<tr>
<td>Program Administrator</td>
<td>Keri Dickens</td>
</tr>
<tr>
<td>E-mail</td>
<td><a href="mailto:uabbmegrad@uab.edu">uabbmegrad@uab.edu</a></td>
</tr>
<tr>
<td>Phone</td>
<td>(205) 996-6936</td>
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</tbody>
</table>

Biomedical engineering (BME) is the application of engineering principles and technology to the solution of problems in the life sciences and medicine. UAB is a top-20 institution for NIH funding, and BME graduate students have many opportunities to conduct cutting-edge multidisciplinary research. BME researchers enjoy collaborations across UAB’s very active medical and dental schools as well as with researchers across the United States and beyond.

The BME Department offers the PhD degree and thesis- and non-thesis-based MS degrees. Students enrolled in UAB’s MD/PhD or DMD/PhD programs may receive the PhD portion of their training in the Biomedical Engineering department. Students in any BME graduate program who are interested in the commercialization of biomedical technology are encouraged to complete the 12-hour Graduate Certificate in Technology Commercialization and Entrepreneurship that is offered by the Collat School of Business (https://www.uab.edu/business/home).

Admitted students begin Fall term, with rare exceptions for other start dates. For full consideration, applications should be submitted by the priority deadline of January 15. Applications submitted as late as the UAB Graduate School’s Fall deadline may be considered depending on the availability of positions.

A minimum score of 80 on the TOEFL (minimum of 18 on each subscore) or 6.5 on the IELTS is required for international students whose native language is not English. Additional details on the BME graduate programs are available in the current BME Graduate Student Handbook available at uab.edu/bme.

Students entering the MSBME program normally have earned a bachelor's degree in Biomedical Engineering, another engineering discipline, or a closely-related field. Students with undergraduate degrees in the physical sciences, life sciences, or mathematics will also be considered for admission; however, such students must demonstrate preparation for the BME graduate curriculum.

Admission to the MS program is competitive. Successful applicants typically have an undergraduate GPA of at least 3.5 (on a 4-point scale). However, applications are reviewed holistically and applicants with lower grades may be admitted based on factors such as strong GRE scores, research experience, or professional experience.

Scores on the GRE General Test are not required (but are accepted) for applicants who receive a BS degree from a program accredited by the Engineering Accreditation Committee of ABET (http://www.abet.org), or from other programs with reciprocal agreement under the Washington Accord (http://www.ieagreements.org/accords/washington/). The GRE General Test is required for all other applicants.

Fast Track Master of Science in Biomedical Engineering

UAB BME undergraduate students with significant research experience may begin work toward their MSBME degree while still undergraduates. To be considered for this program, students must have junior level standing (more than 60 hours completed), have completed at least 3 of the required junior-level BME courses, and have a UAB GPA of at least 3.5. Applicants are expected to have already selected a research mentor for their graduate studies, which will typically be a continuation of their undergraduate research. Application to the program is through the normal UAB Graduate School application portal. One of the letters of recommendation must be from the research mentor. Once enrolled in the program, before completing their undergraduate degree, students may take graduate courses that will be applied to the MSBME degree. Note that coursework may not be applied toward both the undergraduate and graduate degrees. Students may pursue either the Plan I or Plan II MSBME option.

Additional Academic Policies

Students must maintain an overall GPA of 3.20 to remain in good academic standing in the BME Graduate Program.

Special Topics (590/690/790) courses and Independent Study (591/691/791) courses are reviewed for degree applicability for each program in the School of Engineering. No more than 6 combined hours of Special Topics and/or Independent Study courses will be applied to the MSBME without appeal to and approval from the Program Director.

The School of Engineering offers similar courses at the 400/500 and 600/700 levels. While the higher numbered course has more advanced content, there is a significant overlap in topics. Therefore, students are not allowed to take a 500-level or 700-level course for credit if they have previously taken the related 400-level or 600-level course, respectively.

MSBME Plan I (Thesis Option)

The Plan I Master’s degree requires completion of at least 30 semester hours of graduate work.

A Graduate Thesis Committee consisting of at least three faculty members should be formed. At least one committee member must have a primary BME appointment and one must have a primary appointment outside of BME. A student is eligible for admission to candidacy after (1) a written thesis proposal has been orally presented to the committee and approved and (2) completion of Responsible Conduct of Research (RCR) (https://www.uab.edu/research/administration/resources/Pages/RCR-Training.aspx) training. Admission to candidacy must take place at least one semester before the student may graduate. A written thesis embodying the results of the student’s original research must then be publicly defended, approved by the committee, and submitted to the Graduate School.

Upon completing a Plan I MSBME degree, a student may petition to continue their graduate training in the BME PhD program. This does not require a new application to the UAB Graduate School.

Master of Science in Biomedical Engineering

MSBME Plan I (Thesis Option) - 30 hours
School is not required.

The Plan II Master’s degree requires completion of at least 33 semester hours of graduate work. MSBME Plan II also requires completion of a research project and submission of a written project report approved by the student's research advisor. Submission of the project reports to the Graduate School is not required.

MSBME Plan II (Non-Thesis Option) - 33 hours

The Plan II Master’s degree requires completion of at least 33 semester hours of graduate-level work. It also requires completion of a research project and submission of a written project report approved by the student’s research advisor. Submission of the project report to the Graduate School is not required.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Hours</th>
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<tbody>
<tr>
<td>BME 617 Engineering Analysis</td>
<td>3</td>
</tr>
<tr>
<td>or ME 661 Math Methods in EGR I</td>
<td></td>
</tr>
<tr>
<td>BME 670 Quantitative Physiology</td>
<td>3</td>
</tr>
<tr>
<td>BST 621 Statistical Methods I</td>
<td>3</td>
</tr>
<tr>
<td>BME Elective 500-697</td>
<td>3</td>
</tr>
<tr>
<td>Life Science Elective at the 500+ level</td>
<td>3</td>
</tr>
<tr>
<td>BME/EGR/Math/Life Science Elective at the 500+ level</td>
<td>3</td>
</tr>
<tr>
<td>BME 601 Seminar in Biomedical Engineering (Must be taken three times)</td>
<td>1</td>
</tr>
<tr>
<td>BME 601 Seminar in Biomedical Engineering</td>
<td>1</td>
</tr>
<tr>
<td>BME 698 Non-Thesis Research</td>
<td>3</td>
</tr>
<tr>
<td>BME 699 Thesis Research</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>

1. One 3 hour course from another discipline (e.g., MBA) may substitute with approval of the BME Graduate Program Director.
2. Students in the Graduate Certificate in Technology Commercialization and Entrepreneurship program are encouraged to choose BME 630 Engineering Design and Commercialization as an elective.
3. An additional 3 hour BME/EGR/Science Elective (500+ level) may substitute.
4. Taken after admission to candidacy.

PhD Program

Students entering the doctoral program will possess a BS, MS, or be currently enrolled in the DMD/PhD or MD/PhD program at UAB.

PhD students normally have earned a bachelor's degree in Biomedical Engineering, another engineering discipline, or a closely-related field. Students with undergraduate degrees in the physical sciences, life sciences, or mathematics will also be considered for admission; however, such students must demonstrate preparation for the BME graduate curriculum.

Admission to the BME PhD program is competitive. Students applying through the UAB Graduate School must submit scores from the GRE General Test. Successful applicants will typically have scores of at least 156 (Verbal) and 159 (Quantitative), 3.5 or greater GPA from their previous degree(s) (on a 4-point scale), and significant research experience.

Students admitted to the doctoral program typically receive a competitive stipend that includes payment of tuition.

In addition to completing coursework requirements (see below), doctoral students must form a Graduate Dissertation Committee consisting of at least five faculty members, including the primary research mentor. At least one committee member must have a primary BME appointment and two must have a primary appointment outside of BME. A written dissertation proposal must be orally presented to the committee and approved, at which time the student is admitted to candidacy. This must take place at least two semesters before the student may graduate.

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<td>BME Elective (500-697)</td>
<td>3</td>
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<tr>
<td>BME/EGR/MA/Life Science Elective (500+ level)</td>
<td>9</td>
</tr>
<tr>
<td>Life Science (500+ level)</td>
<td>3</td>
</tr>
<tr>
<td>BME 601 Seminar in Biomedical Engineering (Must be taken three times)</td>
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<td>BME 698 Non-Thesis Research</td>
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<tr>
<td><strong>Total Hours</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>

1. One 3 hour course from another discipline (e.g., MBA) may substitute for 3 of these hours with approval of the BME Graduate Program Director.
2. Students in the Graduate Certificate in Technology Commercialization and Entrepreneurship program are encouraged to choose BME 630 Engineering Design and Commercialization as an elective.
3. An additional BME/EGR/Science Elective (500+ level) may substitute for 3 of these hours.
A written dissertation embodying the results of the student’s original research must then be publicly defended, approved by the committee, and submitted to the Graduate School.

Publication Requirement. Original peer-reviewed research articles in reputable journals are the standard for demonstrating scientific productivity. The research conducted by BME doctoral students is expected to result in such publications. Before their degree is awarded, students are required to have at least one “first-author” journal article that has been published (or accepted for publication) and a second that has been submitted to a journal. Typically, a student’s doctoral research will result in at least three first-author articles. Many students will be co-authors on collaborative research articles and may also share authorship on review articles, book chapters, conference proceedings, and other forms of scientific communication. Although these works bolster the student’s scientific credentials, they do not count toward the BME publication requirement. In some cases, first-authorship of an article is shared among multiple individuals. In these cases, the article may count toward the publication requirement of only one BME doctoral student.

Additional Academic Policies

Students must maintain an overall GPA of 3.20 to remain in good academic standing in the BME Graduate Program.

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Coursework for PhD After BS Degree

Students entering the PhD program with a BS degree are required to complete at least 72 semester hours of graduate work.

Coursework for PhD After MS Degree

Students entering the PhD program with an MS degree or those entering the PhD portion of the DMD/PhD or MD/PhD program are required to complete at least 51 additional semester hours of graduate work.

Courses

BME 520. Implant-Tissue Interactions. 3 Hours.
An overview of implant biocompatibility including tissue histology, histopathology of implant response and the regulatory process for medical devices.

BME 524. 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.
BME 535. 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.

BME 543. Medical Image Processing. 3 Hours.
Fundamental topics of medical image processing to practical applications using conventional computer software.

BME 550. 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 a systems approach throughout. Homework includes simulations.

BME 561. Bioelectric Phenomena. 3 Hours.
Quantitative methods in the electrophysiology of neural, cardiac and skeletal muscle systems.

BME 562. Cardiac Electrophysiology. 3 Hours.
Experimental and computational methods in cardiac electrophysiology, ionic currents, action potentials, electrical propagation, the electrocardiogram, electromechanical coupling, cardiac arrhythmias, effects of electric fields in cardiac tissue, defibrillation, and ablation.

BME 571. Continuum Mechanics of Solids. 3 Hours.
Matrix and tensor mathematics, fundamentals of stress, momentum principles, Cauchy and Piola-Kirchhoff stress tensors, static equilibrium, invariance, measures of strain, Lagrangian and Eulerian formulations, Green and Almansistrain, deformation gradient tensor, infinitesimal strain, constitutive equations, finite strain elasticity, strain energy methods, 2-D Elasticity, Airy Method, viscoelasticity, mechanical behavior of polymers.

BME 572. 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.

BME 590. Special Topic in Biomedical Engineering. 1-3 Hour.
Special Topic in Biomedical Engineering.

BME 591. Individual Study in Biomedical Engineering. 1-6 Hour.
Individual Study in Biomedical Engineering.

BME 601. Seminar in Biomedical Engineering. 1 Hour.
Current topics in biomedical engineering technology and applications.

BME 617. Engineering Analysis. 3 Hours.
Advanced ordinary differential equations, transform techniques, scalar and vector field theory, partial differential equations (heat, wave, Laplace).
Prerequisites: MA 750

BME 623. Wound Healing. 3 Hours.
Study of principles of healing, methods to enhance, and clinical applications.

BME 630. Engineering Design and Commercialization. 3 Hours.
The purpose of this course is to introduce students to the process of innovating medical technologies and better prepare them for a career in the medical technology industry. Students will learn aspects of biomedical product development from needs finding, invention, intellectual property, and regulatory processes.

BME 664. Neural Computation. 3 Hours.
This course examines the principal theoretical underpinnings of computation in neural networks. Emphasis will be placed on understanding the relationship between the different approaches: dynamical systems, statistical mechanics, logic, Kalman filters, and likelihood/Bayesian estimation.

BME 665. Computational Vision. 3 Hours.
This course approaches the study of biological and artificial vision from a theoretical perspective beginning with a comparative survey of visual systems and then examining vision algorithms and architectures.

BME 670. Quantitative Physiology. 3 Hours.
Study of physiological problems using advanced mathematical techniques. Topics covered include: mechanics, fluid dynamics, transport, electrophysiology of cell membranes, and control systems.
Prerequisites: BME 517 [Min Grade: C] or ME 661 [Min Grade: C] or ME 761 [Min Grade: C]

BME 672. Cellular Therapy. 3 Hours.
Introduction to research in cellular therapy, its clinical applications, and its potential for commercialization. Students will learn fundamental mechanisms, become familiar with the progress of several successful therapies that use human T cells and stem cells, and learn the challenges and opportunities for future biopharmaceutical and biotechnology industries.

BME 673. Lab Rotation. 3 Hours.
Entering BME graduate students will work in the laboratories of 2 or 3 potential research mentors. The duration of each rotation period will be by mutual agreement between student and faculty but must be at least 4 weeks. The goal is for students to match with their primary research mentor by the end of the course.

BME 680. Biomolecular Modeling. 3 Hours.
Molecular modeling principles and applications. Students will perform hands-on exercises using molecular modeling tools and software. Students will learn the critical relationships among structure, function, and thermodynamic driving forces in structural biology and become able to utilize molecular modeling techniques to explore biological phenomena at the molecular level.

BME 690. Special Topics in Biomedical Engineering. 1-6 Hour.
Special Topics in Biomedical Engineering.

BME 691. Individual Study in Biomedical Engineering. 1-6 Hour.
Individual Study in Biomedical Engineering.

BME 693. Internship in Biomedical Engineering. 1-6 Hour.

BME 697. Journal Club. 1-3 Hour.
Journal Club.


Prerequisites: GAC M

BME 701. Seminar in Biomedical Engineering. 1 Hour.
Current topics in biomedical engineering technology and applications.

BME 717. Engineering Analysis. 3 Hours.
Advanced ordinary differential equations, transform techniques, scalar and vector field theory, partial differential equations (heat, wave, Laplace).
Prerequisites: MA 750

BME 723. Wound Healing. 3 Hours.
Study of principles of healing, methods to enhance, and clinical applications.
BME 764. Neural Computation. 3 Hours.
This course examines the principal theoretical underpinnings
of computation in neural networks. Emphasis will be placed on
understanding the relationship between the different approaches:
dynamical systems, statistical mechanics, logic, Kalman filters, and
likelihood/Bayesian estimation.

BME 765. Computational Vision. 3 Hours.
This course approaches the study of biological and artificial vision from
a theoretical perspective. We begin with a comparative survey of visual
systems, and will examine vision algorithms and architectures.

BME 770. Quantitative Physiology. 3 Hours.
Study of physiological problems using advanced mathematical
techniques. Topics covered include: mechanics, fluid dynamics, transport,
electrophysiology of cell membranes, and control systems.
Prerequisites: BME 517 [Min Grade: C] or ME 661 [Min Grade: C] or
ME 761 [Min Grade: C]

BME 772. Cellular Therapy. 3 Hours.
Introduction to research in cellular therapy, its clinical applications,
and its potential for commercialization. Students will learn fundamental
mechanisms, become familiar with the progress of several successful
therapies that use human T cells and stem cells, and learn the challenges
and opportunities for future biopharmaceutical and biotechnology
industries.

BME 773. Lab Rotation. 3 Hours.
Entering BME graduate students will work in the laboratories of 2 or 3
potential research mentors. The duration of each rotation period will be
by mutual agreement between student and faculty, but must be at least
4 weeks. The goal is for students to match with their primary research
mentor by the end of the course.

BME 780. Biomolecular Modeling. 3 Hours.
Molecular modeling principles and applications. Students will perform
hands-on exercises using molecular modeling tools and software.
Students will learn the critical relationships among structure, function, and
thermodynamic driving forces in structural biology and become able to
utilize molecular modeling techniques to explore biological phenomena at
the molecular level.

BME 790. Special Topics in Biomedical Engineering. 1-6 Hour.
Special Topics in Biomedical Engineering.

BME 791. Individual Study in Biomedical Engineering. 1-6 Hour.
Individual Study in Biomedical Engineering.

BME 793. Internship in Biomedical Engineering. 1-6 Hour.

BME 797. Journal Club. 1-3 Hour.
Journal Club.


BME 799. Dissertation Research. 1-12 Hour.
Prerequisites: GAC Z