Biomedical Engineering

Chair: Jianyi Zhang, M.D., Ph.D.

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. 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 interdisciplinary teams apply knowledge to solve real-world engineering problems. A bachelor’s degree in BME from UAB provides a foundation in medical devices, biomedical implants, biomaterials, and biomedical instrumentation to compete in an increasingly technical medical field, and also prepares students for graduate school, medical school, or professional school.

The Biomedical Engineering program is currently accredited by the Engineering Accreditation Commission (EAC) of ABET, http://www.abet.org.

Freshmen with an ACT score of 28 or higher (or SAT equivalent) and a high school GPA of 3.20 or higher may be admitted directly to the Biomedical Engineering program. Please refer to the School of Engineering overview for policies regarding admission; change of major; transfer credit; transient status; dual degree programs; reasonable progress; academic warning, probation, and suspension; reinstatement appeals; and graduation requirements.

BME students must maintain an institutional (UAB) GPA of at least 3.00. First-term BME freshmen students who have an institutional GPA below 3.00 will be placed on academic warning in BME. If their institutional GPA is not at least 3.0 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 3.00 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 3.00, they will be reclassified as Pre-General Engineering. To be re-admitted to the BME program, a student must have an institutional GPA of at least 3.20 and make a formal application for readmission.

BME students must have an institutional GPA of at least 3.00 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 3.00 or higher and have earned a grade of C or better in all BME courses to graduate.

In addition to fulfilling course prerequisites, non-BME students (including pre-BME students and 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 as well as permission of the BME Undergraduate Advisor. Non-BME majors may not enroll in BME 423, BME 498, or BME 499. In addition, a minimum overall GPA of 3.00 is required for all engineering coursework applied to a BME minor. Transfer students seeking a BME minor must take at least nine (9) semester hours and earn a minimum GPA of 3.00 in UAB engineering courses attempted before enrolling in BME courses.

Vision

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

Mission

To improve healthcare by making scientific discoveries, solving problems and advancing technology using quantitative methods; to prepare graduates to succeed in the evolving fields of biomedical engineering and biotechnology.

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
2. Pursued opportunities for professional growth, development, and service

Bachelor of Science in Biomedical Engineering

Major in Biomedical Engineering

Requirements

<table>
<thead>
<tr>
<th>Hours</th>
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<tbody>
<tr>
<td>Core Curriculum as Specified for Engineering Majors</td>
</tr>
<tr>
<td>Area I: Written Composition (6 hrs)</td>
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<tr>
<td>Area II: Humanities and Fine Arts (9 hrs)</td>
</tr>
<tr>
<td>Area III: Natural Sciences and Mathematics (12 hrs)</td>
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<tr>
<td>MA 125 Calculus I</td>
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<tr>
<td>PH 221 General Physics I</td>
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<tr>
<td>&amp; 221L and General Physics Laboratory I</td>
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<tr>
<td>&amp; 221R and General Physics I Recitation</td>
</tr>
<tr>
<td>PH 222 General Physics II</td>
</tr>
<tr>
<td>&amp; 222L and General Physics Laboratory II</td>
</tr>
<tr>
<td>&amp; 222R and General Physics II - Recitation</td>
</tr>
<tr>
<td>Area IV: History, Social, and Behavioral Sciences (9 hrs)</td>
</tr>
<tr>
<td>Other Required Courses</td>
</tr>
<tr>
<td>BME 210 Engineering in Biology</td>
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<tr>
<td>BME 310 Biomaterials</td>
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<tr>
<td>BME 312 Biocomputing</td>
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<tr>
<td>BME 313 Bioinstrumentation</td>
</tr>
<tr>
<td>BME 333 Biomechanics of Solids</td>
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<tr>
<td>BME 340 Bioimaging</td>
</tr>
<tr>
<td>BME 350 Biological Transport Phenomena</td>
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<tr>
<td>BME 401 Undergraduate Biomedical Engineering Seminar</td>
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<tr>
<td>BME 423 Living Systems Analysis and Biostatistics</td>
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<tr>
<td>BME 498 Capstone Design I Product Development</td>
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<td>BME 499 Capstone Design II</td>
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<tr>
<td>BY 123 Introductory Biology I</td>
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<tr>
<td>&amp; 123L and Introductory Biology I Laboratory</td>
</tr>
<tr>
<td>BY 210 Genetics</td>
</tr>
<tr>
<td>BY 409 Principles of Human Physiology</td>
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<tr>
<td>&amp; 409L and Principles of Human Physiology Laboratory</td>
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<tr>
<td>CE 210 Statics</td>
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</tbody>
</table>

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Electives. The curriculum culminates in a capstone design experience where interdisciplinary teams apply knowledge to solve real-world engineering problems.
CH 115 General Chemistry I
& 115R and General Chemistry I Recitation
& CH 116 and General Chemistry I Laboratory
CH 117 General Chemistry II
& 117R and General Chemistry II Recitation
& CH 118 and General Chemistry II Laboratory
EE 312 Electrical Systems
EGR 110 Introduction to Engineering I
& EGR 111 and Introduction to Engineering II
or EGR 210 Introduction to Engineering
EGR 150 Computer Methods in Engineering
EGR 265 Math Tools for Engineering Problem Solving
MA 126 Calculus II
MA 260 Introduction to Linear Algebra
ME 102 Engineering Graphics
ME 215 Dynamics
& 215R and Dynamics Recitation
MSE 280 Engineering Materials
Biomedical Engineering Electives
BME 420 Implant-Tissue Interactions
BME 435 Tissue Engineering
BME 443 Medical Image Processing
BME 450 Computational Neuroscience
BME 461 Bioelectric Phenomena
BME 462 Cardiac Electrophysiology
BME 471 Continuum Mechanics of Solids
BME 472 Industrial Bioprocessing and Biomanufacturing
BME 490 Special Topics in Biomedical Engineering
BME 491 Individual Study in Biomedical Engineering 1
BME 494 Honors Research 1, 2
Engineering/Math/Science Electives 3
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 280 Biology of Aging
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 Transforms
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
MSE 281 Physical Materials I
& 281L and Physical Materials I Laboratory
MSE 380 Thermodynamics of Materials
MSE 401 Materials Processing
MSE 430 Polymeric Materials
& 430L and Polymeric Materials Laboratory
PH 475 Introduction to Biophysics I
PH 487 Nanoscale Science and Applications
RHB 400 Introduction to Rehabilitation Science
Total Hours 128
1 With approval of the BME Undergraduate Program Director; a maximum of 3 hours of BME 491 or BME 494 may be used for elective credit
2 Student must be enrolled in BME Honors Program
3 Other elective courses may be selected with the approval of the BME Undergraduate Program Director

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).

Requirements

<table>
<thead>
<tr>
<th>Required Courses</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>BME 408 Advanced Biological Transport Phenomena</td>
<td>3</td>
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<tr>
<td>BME 417 Engineering Analysis</td>
<td>3</td>
</tr>
<tr>
<td>BME 471 Continuum Mechanics of Solids</td>
<td>3</td>
</tr>
<tr>
<td>ME 464 Introduction to Finite Element Method</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Hours 12

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 Elective (3 credit hours), Engineering Elective (3 credit hours), and BME Electives (6 credit hours).

Requirements

<table>
<thead>
<tr>
<th>Required Courses</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>BME 420 Implant-Tissue Interactions</td>
<td>3</td>
</tr>
<tr>
<td>BME 435 Tissue Engineering</td>
<td>3</td>
</tr>
<tr>
<td>MSE 281 Physical Materials I</td>
<td>4</td>
</tr>
<tr>
<td>MSE 408 Nanobiomaterials</td>
<td>3</td>
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</tbody>
</table>

Elective Courses

Select one of the following:

<table>
<thead>
<tr>
<th>elective courses</th>
<th>Hours</th>
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<tbody>
<tr>
<td>BY 311 Molecular Genetics</td>
<td></td>
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<tr>
<td>BY 330 Cell Biology</td>
<td></td>
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<tr>
<td>BY 431 Principles of DNA Technology</td>
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<td>MSE 381 Physical Materials II</td>
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<td>MSE 382 Mechanical Behavior of Materials</td>
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<td>MSE 401 Materials Processing</td>
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<tr>
<td>MSE 408 Nanobiomaterials</td>
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<td>MSE 413 Composite Materials</td>
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<td>MSE 430 Polymeric Materials</td>
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<td>MSE 464 Metals and Alloys</td>
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</table>
Minor in Biomedical Engineering

Offered through the Department of Biomedical Engineering

Not available to Biomedical Engineering Undergraduate Students

Requirements

<table>
<thead>
<tr>
<th>Hours</th>
<th>Grade Requirement</th>
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<tbody>
<tr>
<td></td>
<td>A minimum GPA of 3.00 is required for all engineering coursework. Transfer students must earn a minimum GPA of 3.00 in UAB engineering courses attempted.</td>
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</table>

Required Biomedical Engineering Courses

<table>
<thead>
<tr>
<th>Hours</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>BME 210 Engineering in Biology 3</td>
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<td></td>
<td>BME 401 Undergraduate Biomedical Engineering Seminar 1</td>
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Required Introduction to Engineering Course(s)

<table>
<thead>
<tr>
<th>Hours</th>
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<tbody>
<tr>
<td></td>
<td>EGR 110 Introduction to Engineering I 2</td>
</tr>
<tr>
<td></td>
<td>&amp; EGR 111 and Introduction to Engineering II</td>
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<td></td>
<td>or EGR 200 Introduction to Engineering</td>
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</tbody>
</table>

Biomedical Engineering Electives

Select three of the following courses:

<table>
<thead>
<tr>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>BME 310 Biomaterials</td>
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<tr>
<td></td>
<td>BME 312 Biocomputing</td>
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<td></td>
<td>BME 313 Bioinstrumentation</td>
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<td></td>
<td>BME 333 Biomechanics of Solids</td>
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<td></td>
<td>BME 340 Bioimaging</td>
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<td></td>
<td>BME 350 Biological Transport Phenomena</td>
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</tbody>
</table>

Biomedical Engineering Electives

Select two of the following courses:

<table>
<thead>
<tr>
<th>Hours</th>
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<tbody>
<tr>
<td></td>
<td>BME 420 Implant-Tissue Interactions</td>
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<tr>
<td></td>
<td>BME 423 Living Systems Analysis and Biostatistics</td>
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<td></td>
<td>BME 435 Tissue Engineering</td>
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<td></td>
<td>BME 443 Medical Image Processing</td>
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<tr>
<td></td>
<td>BME 450 Computational Neuroscience</td>
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<tr>
<td></td>
<td>BME 461 Bioelectric Phenomena</td>
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<tr>
<td></td>
<td>BME 471 Continuum Mechanics of Solids</td>
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</tbody>
</table>

Total Hours 21

Honors in Engineering

Purpose

The honors programs are intended to enrich educational opportunities for talented students in the School of Engineering.

Benefits

Students who complete an engineering honors program will have earned nine credit hours in honors coursework. Honors research beyond the required six hours may be applied as graduate credit. Three credit hours of honors research may be applied as an undergraduate elective according to departmental policy. Students who complete an honors program in engineering with a minimum cumulative GPA of 3.0 will receive a bachelor's degree "with Honors" in addition to any University honors designations.

Eligibility

In order to be eligible to participate in departmental honors programs, students must meet the following:

- Minimum institutional (UAB) GPA of 3.25 and minimum cumulative GPA of 3.0 (BME students must earn a minimum institutional (UAB) GPA and cumulative GPA of 3.75)
- Completion of MA 227 Calculus III or EGR 265 Math Tools for Engineering Problem Solving with a C or better
- Enrollment as a full-time UAB student for a minimum of one semester
- Departmental endorsement

Invitations are extended by the Dean’s office during spring semester of each year.

Requirements

Honors programs require nine credit hours of honors coursework.

- Students enroll in EGR 301 Honors Research I, a one-hour course, no later than junior year. Students participating in the Science and Technology Honors program are not required to take EGR 301.
- Students enroll in two one-hour seminars which can be taken at any time in their course of study.
- Students complete six hours of credit in departmental honors research.
- Individual programs may vary in the way credit is awarded. For information regarding departmental requirements, contact the departmental program director listed below.

Contact

Honors Programs are offered by all undergraduate degree programs in the School of Engineering.

- Biomedical Engineering (http://www.uab.edu/engineering/bme/undergraduate/honors) (Dr. Alan Eberhardt (aeberhar@uab.edu))
- Civil Engineering (http://www.uab.edu/engineering/home/14-departments-research/dept-civil-const-envir-eng/1298-honors-program) (Dr. Fouad Fouad (ffouad@uab.edu))
- Electrical Engineering (Dr. Leon Jololian)
- Materials and Science Engineering (https://www.uab.edu/engineering/mse/undergraduate/#honors) (Dr. Amber Genau (genau@uab.edu))
- Mechanical Engineering (http://catalog.uab.edu/undergraduate/jointprograms/biomedicalengineering/honors-in-engineering) (Dr. Pasquale Cinnella (pc1@uab.edu))

Curriculum for the Bachelor of Science in Biomedical Engineering (BSBME)

<table>
<thead>
<tr>
<th>Hours</th>
<th>First Term</th>
<th>Second Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CH 115 &amp; 115R &amp; CH 116</td>
<td>4 BY 123 &amp; 123L</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>EGR 110</td>
<td>1 CH 117 &amp; 117R &amp; CH 118</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>EH 101</td>
<td>3 EGR 111</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>MA 125</td>
<td>4 EH 102</td>
<td>3</td>
</tr>
</tbody>
</table>
ME 102 2 MA 126 4

14 16

Sophomore
First Term Hours Second Term Hours
BY 210 3 EGR 150 3
EGR 2652 4 BME 210 3
PH 221 4 CE 210 3
& 221L & 221R
MA 260 3 EE 312 3
MSE 280 3 PH 222 4
& 222L & 222R

17 16

Junior
First Term Hours Second Term Hours
BME 310 3 BME 333 3
BME 312 3 BME 340 3
BME 313 3 BME 350 3
BY 409 4 BME 423 3
& 409L & 423L
ME 215 3 Core Curriculum Area II:
Humanities and Fine Art8
Core Curriculum Area IV:
History, Social, and Behavioral
Science8

3 3

Second Term Hours

Senior
First Term Hours Second Term Hours
BME 498 3 BME 499 3
BME 4015 1 Biomedical Engineering Elective
BME/Engineering/Math/Science Elective2,3
3 Core Curriculum Area II:
Humanities and Fine Art8
Core Curriculum Area IV:
History, Social, and Behavioral
Science8

3 3

BME/Engineering/Math/Science Elective2,3
3 Core Curriculum Area IV:
History, Social, and Behavioral
Science8

BME Elective 3

16 15

Total credit hours: 128

1 Transfer students may substitute EGR 200 for EGR 110 and EGR 111.
2 May substitute MA 227 and MA 252 for EGR 265 and one BME/Engineering/Math/Science Elective.
3 Students using this curriculum as a pre-health professional program (pre-med, pre-dental, or pre-optometry) may use CH 235 or CH 237 or CH 460 for this elective.
4 Please refer to the Core Curriculum as specified for engineering majors.
5 Seminar may be taken during any semester.

Courses

BME 011. Undergraduate Coop/Internship in BME. 0 Hours.
Engineering workplace experience in preparation for the student's intended career.

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 process.
Prerequisites: BY 123 [Min Grade: C] and PH 222 [Min Grade: C] (Can be taken Concurrently) and BY 210 [Min Grade: C](Can be taken Concurrently)

BME 289. Undergraduate Research in Biomedical Engineering I. 1 Hour.
Undergraduate research experiences in biomedical engineering. Must have sophomore standing.
Prerequisites: 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]) and PH 221 [Min Grade: C](Can be taken Concurrently)

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]

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: (BME 150 [Min Grade: C] or EGR 150 [Min Grade: C]) and (EGR 265 [Min Grade: C] or MA 285 [Min Grade: C] or 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 several imaging modalities.
Prerequisites: EE 312 [Min Grade: C] and (MA 227 [Min Grade: C] and MA 252 [Min Grade: C] or MA 225 [Min Grade: C]) or HC 111 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [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: EGR 265 [Min Grade: C](Can be taken Concurrently) or MA 227 [Min Grade: C](Can be taken Concurrently) and MA 252 [Min Grade: C](Can be taken Concurrently) and ME 215 [Min Grade: C](Can be taken Concurrently)

BME 340. Biomeaging. 3 Hours.
Overview of diagnostic imaging including major imaging modalities such as X-Ray/CT, Nuclear Imaging, Ultrasound, Magnetic Resonence and in vivo molecular imaging approaches. Physical principles of image formation, image interpretation and patient safety.
Prerequisites: EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] and MA 252 [Min Grade: C]) and BME 210 [Min Grade: C] and EE 312 [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: EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] and MA 252 [Min Grade: C]) and BME 210 [Min Grade: C](Can be taken Concurrently) and BY 409 [Min Grade: C](Can be taken Concurrently) and ME 215 [Min Grade: C](Can be taken Concurrently)

BME 389. Undergraduate Research in Biomedical Engineering II. 1 Hour.
Undergraduate research experiences in biomedical engineering. Must have junior standing.
Prerequisites: BME 210 [Min Grade: C]

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 writing lab reports in a style similar to research papers. BME 423L must be taken concurrently.
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]

BME 435. Tissue Engineering. 3 Hours.
Principles underlining 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: EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] or MA 252 [Min Grade: C]) and PH 222 [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 461. Bioelectric Phenomena. 3 Hours.
Quantitative methods in electrophysiology of neural, cardiac, and skeletal muscle systems.
Prerequisites: PH 222 [Min Grade: C] and 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 Almansi 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) or BY 330 [Min Grade: C](Can be taken Concurrently) or CH 460 [Min Grade: C](Can be taken Concurrently)

BME 489. Undergraduate Research in Biomedical Engineering. 1-3 Hour.
Undergraduate research experiences in biomedical engineering.
Prerequisites: BME 210 [Min Grade: C]

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.
**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 multi-disciplinary 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] (Can be taken Concurrently) and BME 312 [Min Grade: C] (Can be taken Concurrently) and BME 313 [Min Grade: C] (Can be taken Concurrently) and BME 333 [Min Grade: C] (Can be taken Concurrently)

**BME 499. Capstone Design II. 3 Hours.**
Capstone design project; a continuation of BME 498. Through experiential learning, student teams consisting of engineering and business students 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 ME 102 [Min Grade: C]