BIOENGINEERING

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http://bioengineering.illinois.edu

For the Degree of Bachelor of Science in Bioengineering

Bioengineers use tools from biology, chemistry, physics and math to solve engineering problems that arise in biological systems related to biomaterials, biomechanics and prosthetics, tissue engineering, molecular modeling, imaging, bioinformatics, nanomedicine, synthetic biology, and drug delivery. The goal of research and education in bioengineering is to advance fundamental understanding of how human biological systems function, and to develop effective technology-based solutions to the wide spectrum of societal needs in human development and disease diagnosis, treatment, and prevention.

The Bioengineering department (BIOE) aims to graduate students who:

• Enter into industry jobs in prominent companies as engineers who work in the areas of:
  • Medical device design
  • Manufacturing
  • Quality control
  • Marketing
  • And work toward the advancement of medicine
• Pursue graduate studies in bioengineering-related fields such as:
  • Imaging and Sensing
  • Therapeutics
  • Tissue Engineering
  • Computational and Systems Biology
  • Biomechanics
• Broaden their education by attending professional school in areas of medicine, law, and business
• Maintain professional development through societal memberships and industry workshops

The curriculum includes integration of principles of biology and engineering in coursework such as biomechanics, modeling of human physiology, bioinstrumentation, and cell and tissue engineering. The curriculum is project-based and has a strong emphasis on systems-thinking as an approach to large-scale bioengineering problems. During the first and second years, students take fundamental courses introducing them to bioengineering as a field and introducing clinically relevant projects as learning experiences. The program also features hands-on laboratory courses for real-world experience throughout the curriculum. The final two years allow students to focus on a particular track of Bioengineering for further study. A year-long senior capstone design course provides experience in applying engineering fundamentals to biological problems submitted by faculty, clinicians, and industrial firms.

Overview of Curricular Requirements

The curriculum requires 128 hours for graduation and is organized as shown below.

Technical grade point average requirements for graduation and advanced-level course registration apply to students in this curriculum. These rules are summarized at the College of Engineering's Undergraduate Advising Website (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Undergrad+Advising+Home).

Orientation and Professional Development

These courses introduce the opportunities and resources your college, department, and curriculum can offer you as you work to achieve your career goals. They also provide the skills to work effectively and successfully in the engineering profession.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 120</td>
<td>Introduction to Bioengineering</td>
<td>1</td>
</tr>
<tr>
<td>ENG 100</td>
<td>Engineering Orientation</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total Hours</td>
<td>1</td>
</tr>
</tbody>
</table>

Foundation Mathematics and Science

These courses stress the basic mathematical and scientific principles upon which the engineering discipline is based.

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 102</td>
<td>General Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 103</td>
<td>General Chemistry Lab I</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 104</td>
<td>General Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 105</td>
<td>General Chemistry Lab II</td>
<td>1</td>
</tr>
<tr>
<td>MATH 221</td>
<td>Calculus I</td>
<td>1</td>
</tr>
<tr>
<td>MATH 231</td>
<td>Calculus II</td>
<td>3</td>
</tr>
<tr>
<td>MATH 241</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 285</td>
<td>Intro Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 211</td>
<td>University Physics: Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 212</td>
<td>University Physics: Elec &amp; Mag</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total Hours</td>
<td>30</td>
</tr>
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</table>

1 MATH 220 may be substituted, with four of the five credit hours applying toward the degree. MATH 220 is appropriate for students with no background in calculus.

Bioengineering Technical Core

These courses stress fundamental concepts and basic laboratory techniques that comprise the common intellectual understanding of bioengineering.

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<tbody>
<tr>
<td>BIOE 201</td>
<td>Conservation Principles Bioeng</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 202</td>
<td>Cell &amp; Tissue Engineering Lab</td>
<td>2</td>
</tr>
<tr>
<td>BIOE 205</td>
<td>Signals &amp; Systems in Bioengrg</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 206</td>
<td>Cellular Bioengineering</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 220</td>
<td>Bioenergetics</td>
<td>4</td>
</tr>
<tr>
<td>BIOE 301</td>
<td>Introductory Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 302</td>
<td>Modeling Human Physiology</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 303</td>
<td>Quantitative Physiology Lab</td>
<td>2</td>
</tr>
<tr>
<td>BIOE 310</td>
<td>Comp Tools Bio Data</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 360</td>
<td>Transport &amp; Flow in Bioengrg</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 414</td>
<td>Biomedical Instrumentation</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 415</td>
<td>Biomedical Instrumentation Lab</td>
<td>2</td>
</tr>
</tbody>
</table>

Information listed in this catalog is current as of 03/2017
BIOE 420  Intro Bio Control Systems  3  RHET 105  Writing and Research  4
BIOE 435  Senior Design I  2  Advanced Composition. May be satisfied by completing
BIOE 436  Senior Design II  2  a course in either the liberal education or free elective
categories which has the Advanced Composition designation.
BIOE 476  Tissue Engineering  3  Total Hours  4
CHEM 232  Elementary Organic Chemistry  1  
CS 101  Intro Computing: Engrg & Sci  3
MCB 150  Molec & Cellular Basis of Life  4
Total Hours  54 1  May be taken for 4 credit hours; the extra hour may be used to help meet
free elective requirements.

Track Electives
Students must complete 15 hours of study which show coherence, focus,
and purpose within a bioengineering context. Students may choose from
among the following pre-approved tracks:
• Biomechanics
• Cell and Tissue Engineering
• Computational and Systems Biology
• Imaging and Sensing
• Therapeutics Engineering

Alternately a student may devise a special track and set of courses which
must be approved by the Bioengineering Department. In either case,
overage hours in required courses may be counted toward the 15-hour
minimum.

Track electives selected from a departmentally approved list 15
of track elective courses. 1

1 List of track elective courses. (http://bioengineering.illinois.edu/
undergraduate-programs/track-electives)

Liberal Education
The liberal education courses (https://wiki.cites.illinois.edu/wiki/display/
ugadvise/Liberal+Education+Electives) develop students’ understanding
of human culture and society, build skills of inquiry and critical thinking,
and lay a foundation for civic engagement and lifelong learning.

Electives from the campus General Education Social and 6
Behavioral Sciences list.

Electives from the campus General Education Humanities and 6
the Arts list.

Electives either from a list approved by the college, or from
the campus General Education lists for Social and Behavioral
Sciences or Humanities and the Arts.

Total Hours 18

Students must also complete the campus cultural studies requirement
by completing (i) one western/comparative culture(s) course and (ii) one
non-western/U.S. minority culture(s) course from the General Education
cultural studies lists. Most students select liberal education courses that
simultaneously satisfy these cultural studies requirements. Courses from
the western and non-western lists that fall into free electives or other
categories may also be used satisfy the cultural studies requirements.

Composition
These courses teach fundamentals of expository writing.

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<tr>
<td>BIOE 205</td>
<td>Signals Systems in Bioengrg</td>
<td>3</td>
</tr>
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<td>CHEM 232</td>
<td>Elementary Organic Chemistry I</td>
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<tr>
<td>BIOE 415</td>
<td>Biomedical Instrumentation Lab</td>
<td>2</td>
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<tr>
<td>Track elective &amp;1</td>
<td></td>
<td>3</td>
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<tr>
<td>Liberal education elective &amp;1</td>
<td></td>
<td>3</td>
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<tr>
<td>BIOE 360</td>
<td>Transport Flow in Bioengrg</td>
<td>3</td>
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**Semester Hours**: 17

**Second Semester**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>BIOE 199</td>
<td>Undergraduate Open Seminar</td>
<td>1 to 5 Hours</td>
</tr>
<tr>
<td>BIOE 201</td>
<td>Conservation Principles Bioeng</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 202</td>
<td>Cell &amp; Tissue Engineering Lab</td>
<td>2</td>
</tr>
<tr>
<td>Liberal education elective &amp;2</td>
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<td>3</td>
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</table>

**Semester Hours**: 17

**Third Year**

**First Semester**

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<tr>
<td>BIOE 220</td>
<td>Bioenergetics</td>
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**Semester Hours**: 17

**Fourth Year**

**First Semester**

<table>
<thead>
<tr>
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<th>Course Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>BIOE 202</td>
<td>Cell Tissue Engineering Lab</td>
<td>2</td>
</tr>
<tr>
<td>Liberal education elective &amp;2</td>
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**Semester Hours**: 17

**Second Semester**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 198</td>
<td>Special Topics</td>
<td>1 to 3 Hours</td>
</tr>
<tr>
<td>BIOE 201</td>
<td>Conservation Principles Bioeng</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 202</td>
<td>Cell &amp; Tissue Engineering Lab</td>
<td>2</td>
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<tr>
<td>Free electives</td>
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<td>6</td>
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</table>

**Semester Hours**: 14

**Total Hours**: 128

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1. MATH 220 may be substituted, with four of the five credit hours applying toward the degree. MATH 220 is appropriate for students with no background in calculus.
2. RHET 105 may be taken in the first or second semester of the first year as authorized. The alternative is MCB 150.

3. Liberal education electives (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Liberal+Education+Electives) must include 6 hours of social & behavioral sciences and 6 hours of humanities & the arts course work from the campus General Education lists. The remaining 6 hours may be selected from a list maintained by the college, or additional course work from the campus General Education lists for social & behavioral sciences or humanities & the arts. Students must also complete the campus cultural studies requirement by completing (i) one western/comparative culture(s) course and (ii) one non-western/U.S. minority culture(s) course from the General Education cultural studies lists. Most students select liberal education courses that simultaneously satisfy these cultural studies requirements. Courses from the western and non-western lists that fall into free electives or other categories may also be used satisfy the cultural studies requirements. May be taken for 4 credit hours; the extra hour may be used to help meet free elective requirements.

4. To be selected from a departmentally approved listed or track elective courses (http://bioengineering.illinois.edu/undergraduate-programs/track-electives) if a pre-approved track is chosen. Alternately a student may devise a special track which must be approved by the Bioengineering Department.

5. BIOE Class Schedule (https://courses.illinois.edu/schedule/DEFAULT/DEFAULT/BIOE)

**Courses**

- **BIOE 100** Bioengineering Freshman Seminar credit: 0 Hours.
- **BIOE 120** Introduction to Bioengineering credit: 1 Hour.
- **BIOE 198** Special Topics credit: 1 to 3 Hours.
- **BIOE 199** Undergraduate Open Seminar credit: 1 to 5 Hours.
- **BIOE 201** Conservation Principles Bioeng credit: 3 Hours.
- **BIOE 202** Cell & Tissue Engineering Lab credit: 2 Hours.

Prerequisites and requirements for each course are provided within the document.
BIOE 205  **Signals & Systems in Bioengr**  credit: 3 Hours.
Introduction to signals and linear systems with examples from biology and medicine. Linear systems and mathematical models of systems, including differential equations, convolution, Laplace transforms, Fourier series and transforms, and discrete representations. Class examples and coursework apply general techniques to problems in biological signal analysis, including circuits, enzyme kinetics, and physiological system analysis. Use of Matlab and Simulink software to understand more complex systems. Prerequisite: CS 101, MATH 285, and PHYS 212.

BIOE 206  **Cellular Bioengineering**  credit: 3 Hours.
Molecular and cellular biology focusing on instrumentation and measurement techniques: gene expression, translation, and regulation; cellular energetics and enzyme kinetics; membrane transport and cell signaling; cytoskeleton and the cell cycle; cell biology fundamentals emphasizing modern imaging and measurement systems to quantify cellular function. Credit is not given for both BIOE 206 and MCB 252. Prerequisite: MCB 150.

BIOE 220  **Bioenergetics**  credit: 4 Hours.
An integrative view of functional organization and energy transfer in biological systems. Emphasis on dynamics and kinetics of quantum, sub-molecular, and molecular interactions for metabolism. Topics include biomolecules of life, laws of thermodynamics, enzyme kinetics, protein-ligand binding, DNA binding, and modeling of molecular systems. Credit is not given for both BIOE 220 and ME 300, PHYS 214, or CHBE 321. Prerequisites: BIOE 201 and BIOE 206.

BIOE 297  **Individual Study**  credit: 1 to 4 Hours.
Special project or reading activity. May be repeated in the same or separate terms to a maximum of 12 hours. Prerequisite: Approved written application to department as specified by department or instructor.

BIOE 298  **Special Topics**  credit: 0 to 4 Hours.
Subject offerings of new and developing areas of knowledge in bioengineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary to a maximum of 8 hours.

BIOE 301  **Introductory Biomechanics**  credit: 3 Hours.
Structure and mechanics of biological systems. Statics, dynamics, stress-strain analysis, Newtonian mechanics, and continuum mechanics. Applications to bone, soft tissue, and cells. Prerequisite: PHYS 211.

BIOE 302  **Modeling Human Physiology**  credit: 3 Hours.
Description, quantification, and modeling of human physiological systems, based on systems fundamentals. Components, relationships, and homeostatic controls of neural, musculoskeletal, respiratory, cardiovascular, endocrine, digestion, and renal-filtration systems. Application of mathematical modeling and MATLAB simulation to further understanding of the systems and relate physiological consequences to changes in environment or component function. Prerequisite: CS 101, BIOE 205, MATH 285, and MCB 252 or BIOE 206.

BIOE 303  **Quantitative Physiology Lab**  credit: 2 Hours.
Experiments involving the modeling and measurement of animal and human physiology systems. Use of computer simulations to provide mathematical descriptions of physiology behavior. Calibration and validation of models through hands-on experiments. Focus on quantitative measurement of neural, cardiovascular, respiratory, muscular, and endocrine system functions. Prerequisite: BIOE 302.

BIOE 306  **Biofabrication Lab**  credit: 3 Hours.
Experiments involving design of bioreactors and microfluidic systems, advanced cell culture, and quantitative analysis techniques such as polymerase chain reaction and atomic force microscopy. Laboratory techniques relating to current literature and state of the art in the field of bioengineering. Prerequisite: BIOE 202. Departmental approval required for non-majors.

BIOE 310  **Comp Tools Bio Data**  credit: 3 Hours.
Fundamental and applied statistics, including probability distributions, parameter estimation, descriptive statistics, hypothesis testing, and linear regression. Statistical methods in genomics including sequence analysis, gene expression data analysis, human genomic variation, regulatory genomics, and cancer genomics. Credit is not given for both BIOE 310 and IE 300. Prerequisites: BIOE 205 and BIOE 206.

BIOE 360  **Transport & Flow in Bioengr**  credit: 3 Hours.
Fundamentals of fluid dynamics and mass transport applied to analysis of biological systems. Quantitative understanding of microscopic to macroscopic phenomena in biological systems related to their sensing by imaging techniques. Molecular phenomena in both healthy tissue and disease using examples from cardiovascular problems and cancer using ultrasound, optical and MRI techniques. Credit is not given for both BIOE 360 and any of CHBE 421, CHBE 451, or TAM 335. Prerequisites: BIOE 201 and BIOE 301.

BIOE 380  **Biomedical Imaging**  credit: 3 Hours.
Same as ECE 380. See ECE 380.

BIOE 397  **Individual Study**  credit: 1 to 4 Hours.
Special project or reading activity. May be repeated up to 8 hours in a term to a maximum of 12 total hours. Prerequisite: Approved written application to department as specified by department or instructor.

BIOE 398  **Special Topics**  credit: 1 TO 4 Hours.
Subject offerings of new and developing areas of knowledge in bioengineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary to a maximum of 8 hours.

BIOE 410  **Computational Cancer Biology**  credit: 3 Hours.
Mathematical modeling of the process of carcinogenesis as somatic cell evolution. Focus on current research topics in cancer biology using data from next-generation sequencing technologies. Overview of database resources and algorithmic and modeling methods relating to biological problems. 3 undergraduate hours. No graduate credit. Prerequisite: BIOE 206, CS 101, MATH 285.

BIOE 414  **Biomedical Instrumentation**  credit: 3 Hours.
Engineering aspects of the detection, acquisition, processing, and display of signals from living systems; biomedical sensors for measurements of biopotenitals, ions and gases in aqueous solution, force, displacement, blood pressure, blood flow, heart sounds, respiration, and temperature; therapeutic and prosthetic devices; medical imaging instrumentation. Same as ECE 414. 3 undergraduate hours. 3 graduate hours. Prerequisite: BIOE 205, ECE 205 or ECE 210.

BIOE 415  **Biomedical Instrumentation Lab**  credit: 2 Hours.
Laboratory to accompany BIOE 414. Use of sensors and medical instrumentation for static and dynamic biological inputs. Measurement of biomedical signals. 2 undergraduate hours. 2 graduate hours. Same as ECE 415. Prerequisite: Credit or concurrent registration in BIOE 414.

BIOE 416  **Biosensors**  credit: 3 Hours.
Same as ECE 416. See ECE 416.
BIOE 420  Intro Bio Control Systems  credit: 3 Hours.
Systems engineering approach to modeling physiological systems to examine natural biological control systems, homeostasis, and control through external medical devices. Introduces open loop and closed loop feedback control; Laplace and Fourier analysis of system behavior; impulse and steady state responses; physiological modeling and system identification; and stability. Includes biological systems for endocrine function, muscle position, neuronal circuits, and cardiovascular function. Mathematical modeling, Matlab and Simulink simulation, and physiological measurements to relate control systems to maintenance of internal environment. 3 undergraduate hours. No graduate credit. Credit is not given for BIOE 420 if credit for AE 353, ECE 486, GE 320, or ME 340 has been earned. Prerequisites: BIOE 205, BIOE 302, BIOE 303, BIOE 414, BIOE 415.

BIOE 430  Intro Synthetic Biology  credit: 3 or 4 Hours.
Introduction to the field of synthetic biology. Engineering applications of biomolecular systems and cellular capabilities for a variety of application biological background of gene regulation, experimental methods for circuit engineering, and mathematical basis for circuit modeling. Examples in biofuels, biomedicine, and other areas will be discussed. 3 undergraduate hours. 4 graduate hours. Prerequisite: BIOE 206 or MCB 252; and MATH 285.

BIOE 435  Senior Design I  credit: 2 Hours.
Capstone bioengineering design activity to develop solutions to projects provided by academia, industry, or clinical settings, utilizing principles of design, engineering analysis, and functional operation of engineering systems. Concept-design, safety, human-factors, quality, and Six-Sigma considerations. Initial solution proposals meeting professional technical-writing and communication standards. Concluded in BIOE 436. 2 undergraduate hours. No graduate credit. Prerequisite: BIOE 301, BIOE 414, and BIOE 415.

BIOE 436  Senior Design II  credit: 2 Hours.
Continuation of BIOE 435. Design teams finalize concepts, evaluate alternatives, model and analyze solutions, build and test a final product, and present the results professionally to project sponsors. 2 undergraduate hours. No graduate credit. Prerequisite: BIOE 435.

BIOE 461  Cellular Biomechanics  credit: 4 Hours.
Same as TAM 461. See TAM 461.

BIOE 467  Biophotonics  credit: 3 Hours.
Same as ECE 467. See ECE 467.

BIOE 473  Biomaterials Laboratory  credit: 3 Hours.
Same as MSE 472. See MSE 472.

BIOE 474  Metabolic Engineering  credit: 3 or 4 Hours.
Same as CHBE 474. See CHBE 474.

BIOE 476  Tissue Engineering  credit: 3 Hours.
Tissue engineering therapies for cell-based, material-based, and therapeutic-based solutions. Stem cells, immunology, and clinical applications. 3 undergraduate hours. 3 graduate hours. Prerequisite: BIOE 301.

BIOE 479  Cancer Nanotechnology  credit: 3 Hours.
Applications in Cancer and Mechanobiology will provide an introduction to basic concepts in applications of nanotechnology in mechanobiology and in cancer. This is a highly interdisciplinary field of research where knowledge from various discipline need to be presented and integrated. The course will be a team taught course by faculty from Engineering and LAS. There will be 4 main sections of the course; (i) biological concepts and cancer biology, (ii) introduction to bottom nanotechnology and nanomedicine, (iii) Microfluidics, Lab on Chip, and Top Down Nanotechnology, and (iv) applications in cellular mechanics, i.e. mechanobiology and nanotechnology. The course will be targeted for first year graduate students and senior undergraduate students. 3 undergraduate hours. 3 graduate hours. Approved for letter and S/U grading. Prerequisite: BIOE 206, CHEM 232.

BIOE 480  Magnetic Resonance Imaging  credit: 3 or 4 Hours.
Same as ECE 480. See ECE 480.

BIOE 481  Whole-Body Musculoskel Biomech  credit: 3 or 4 Hours.
Same as ME 481. See ME 481.

BIOE 482  Musculoskel Tissue Mechanics  credit: 3 Hours.
Same as ME 482. See ME 482.

BIOE 497  Individual Study  credit: 1 to 4 Hours.
Special project or reading activity. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated up to 8 hours in a term to a maximum of 12 total hours. Prerequisite: Approved written application to department as specified by department or instructor.

BIOE 498  Special Topics  credit: 1 to 4 Hours.
Subject offerings of new and developing areas of knowledge in bioengineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated in the same or separate terms if topics vary to a maximum of 12 hours, but no more than 8 in any one term.

BIOE 499  Senior Thesis  credit: 1 to 5 Hours.
Limited in general to seniors in the curriculum in bioengineering. Any others must have the consent of the head of the department. Each student taking the course must register in a minimum of 5 hours either in one term or divided over two terms. A maximum registration of 10 hours in two terms is permitted. 1 to 5 undergraduate hours. No graduate credit. May be repeated, if topics vary. Prerequisite: Majors only, senior standing.

Information listed in this catalog is current as of 03/2017