Biomedical Engineering (BME)

Major in Biomedical Engineering

Department of Biomedical Engineering, College of Engineering and Applied Sciences

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Undergraduate Program

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Minors of particular interest to students majoring in Biomedical Engineering: Applied Math and Statistics (AMS), Biochemistry (BCH), Nanotechnology (NTS)

Department Information - Biomedical Engineering (BME)

The Department of Biomedical Engineering offers the major in Biomedical Engineering, leading to the Bachelor of Engineering (B.E.) degree. The Department also offers a minor in Bioengineering designed for non-engineering students. (See the entry in the alphabetical listings of Approved Majors, Minors, and Programs for the requirements for the minor in Bioengineering.) In a rigorous, cross-disciplinary training and research environment, the major program provides an engineering education along with a strong background in the biological and physical sciences. It is designed to enhance the development of creativity and collaboration through study of a specialization within the field of biomedical engineering. Teamwork, communication skills, and hands-on laboratory and research experience are emphasized. The curriculum provides students with the underlying engineering principles required to understand how biological organisms are formed and how they respond to their environment. The Biomedical Engineering program is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD, 21202-4012 – telephone: (410)347-7700.

Core courses provide depth within the broad field of biomedical engineering. These are integrated with, and rely upon, course offerings from both the College of Engineering and Applied Sciences and the College of Arts and Sciences. To achieve the breadth of engineering experience expected of Biomedical Engineering graduates, additional elective courses from the College of Engineering and Applied Sciences are required of all Biomedical Engineering students.

The Department also offers a five-year combined B.E./M.S. degree, which can be completed within one additional year of studies beyond the Bachelor's degree.

The combined B.E./M.S. is intended to prepare high-achieving and highly-motivated undergraduate BME students for either doctoral studies or a variety of advanced professional positions. The program is highly selective with admission based on academic performance as well as undergraduate research. Juniors can be admitted into the combined degree program if they satisfy the requirements outlined in the Graduate Bulletin. The requirements for the combined program are the same as the requirements for the B.E. and M.S. degree, except that two graduate 500-level courses replace two 300-level electives, so that six graduate credits are counted toward the undergraduate degree.

Graduates are prepared for entry into professions in biomedical engineering, biotechnology, pharmaceuticals, and medical technology, as well as careers in academia and government. Potential employers include colleges and universities, hospitals, government, research institutes and laboratories, and private industry.

Program Educational Objectives

The undergraduate program in biomedical engineering has the following five specific program educational objectives:

1. Career Preparation: Our graduates will be prepared to excel in bioengineering, bioscience, or medical disciplines in basic and applied research, design, or technology development, representing the fields of academics, government, medicine, law, or industry.

2. Professional Development: Our graduates will emerge as recognized experts in the field of biomedical engineering, and serve in positions of leadership in academics, government, medicine, or industry. Further, our alumni will function successfully as principal members of integrative and interdisciplinary teams.

3. Professional Conduct: Our graduates will hold paramount the health, safety, and welfare of the public, and conduct themselves in a professional and ethical manner at all times. Further, our alumni will communicate effectively to a variety of target audiences through both written and oral media.

4. Societal Contribution: Our graduates will respond and adapt to the scientific and engineering needs of society both nationally and internationally, seek out new opportunities, and contribute to the development of a healthy and globally competitive economy.
5. Life-long Learning: Our graduates will continually build on their undergraduate foundation of science, engineering, and societal understanding, and continue to develop their knowledge, skills, and contributions throughout their professional careers and private lives. This will include active participation in professional societies, attending and making presentations at conferences, and participating in outreach activities within their areas of expertise.

Program Outcomes

To prepare students to meet the above program educational objectives, a set of program outcomes that describes what students should know and be able to do when they graduate, have been adopted. We expect students to gain:

a. the ability to apply knowledge of advanced mathematics, science, biology, physiology, biotechnology, and engineering;
b. the ability to design and conduct experiments from living and non-living systems, as well as to analyze and interpret data;
c. the ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
d. the ability to function on multidisciplinary teams;
e. the ability to identify, formulate, and solve problems at the interface of engineering and biology;
f. the understanding of professional and ethical responsibility;
g. the ability to communicate effectively;
h. the broad education necessary to understand the impact of biomedical engineering solutions in a global, economic, environmental, and societal context;
i. the recognition of the need for, and an ability to engage in, life-long learning;
j. a knowledge of contemporary issues; and
k. the ability to use the techniques, skills, and modern engineering tools necessary for addressing the problems associated with the interaction between living and/or non-living materials and systems.

More details about program educational objectives and outcomes can be found at http://bme.sunysb.edu/bme/ugrad/index.html#abet

Requirements for the Major in Biomedical Engineering

Acceptance into the Major

Freshman applicants who have specified their interest in the major in Biomedical Engineering may be accepted directly into the major upon admission to the University. Freshman and transfer applicants admitted to the University but not immediately accepted into the Biomedical Engineering major may apply for acceptance to the major at any time during the academic year by contacting the director of the undergraduate program. Students in good academic standing may apply in any semester, but priority for admission to the Biomedical Engineering major is given to those students who have:

1. Completed MAT 132 and PHY 132/PHY 134 or their equivalents;
2. Earned a g.p.a. of 3.20 in all mathematics and physics courses with no more than one grade in the C range; and
3. Received completed course evaluations for all transferred courses that are to be used to meet requirements of the major.

Requirements for the Major

The curriculum begins with a focus on basic mathematics and the natural sciences followed by courses that emphasize engineering science and bridging courses that combine engineering science and design. The sequence of courses culminates with a one-year design experience that integrates the science, engineering, and communication knowledge acquired. The technical electives and additional courses are chosen in consultation with a faculty advisor, taking into consideration the particular interest of the student.

Completion of the major requires approximately 130 credits.

1. Mathematics

a. AMS 151, AMS 161 Calculus I, II
b. AMS 261 or MAT 203 or MAT 205 Calculus III
c. AMS 361 or MAT 303 or MAT 305 Calculus IV
d. AMS 210 Matrix Methods and Models
e. AMS 310 Survey of Probability and Statistics

Note: The following alternate calculus course sequences may be substituted for AMS 151, AMS 161:
MAT 125, MAT 126, MAT 127 or MAT 131, MAT 132 or MAT 141, MAT 142 or MAT 171

2. Natural Sciences
a. BIO 202 Fundamentals of Biology: Molecular and Cellular Biology and BIO 204 Fundamentals of Scientific Inquiry in the Biological Sciences I
b. CHE 131, CHE 132 General Chemistry I, II
c. PHY 131/PHY 133, PHY 132/PHY 134 Classical Physics I, II with labs

Note: The following alternate science sequences may be substituted:
PHY 125, PHY 126, PHY 127, or PHY 141, PHY 142 in lieu of PHY 131/PHY 133, PHY 132/PHY 134
CHE 141, CHE 142, in lieu of CHE 131, CHE 132

3. Computers and Programming
a. BME 120 Programming Fundamentals in Biomedical Engineering

4. Engineering
a. MEC 260 Engineering Statics
b. MEC 262 Engineering Dynamics
c. ESE 271 Electrical Circuit Analysis I

5. Biomedical Engineering
a. BME 100 Introduction to Biomedical Engineering
b. BME 212 Laboratory Methods in Biomedical Engineering
c. BME 301 Bioelectricity
d. BME 304 Genetic Engineering
e. BME 305 Biofluids
f. BME 440 Biomedical Engineering Design
g. BME 441 Senior Design Project in Bioengineering

6. Biomedical Engineering Specializations and Technical Electives
Biomedical engineering students must complete a specialization, composed of at least 30 credits in one of four areas, including at least two 3- to 4-credit design technical elective courses. Three technical elective courses must be 300- or 400-level BME courses (not BME 499). BME 499 may be taken as an additional technical elective for a total of 6 credits. (See below for the four specializations with course options.) The specialization must be declared in writing by the end of the sophomore year and is selected in consultation with the faculty advisor to ensure a cohesive curriculum with depth at the upper level.

7. Upper-Division Writing Requirement: BME 300 Writing in Biomedical Engineering
All degree candidates must demonstrate skill in written English at a level acceptable for engineering majors. All Biomedical Engineering students must complete the writing course BME 300 concurrently with a selected BME 300- or 400-level course. The quality of writing in technical reports submitted for the course is evaluated, and students whose writing does not meet the required standard are referred for remedial help. Satisfactory writing warrants an S grade for BME 300, thereby satisfying the requirement.

Additional Requirements for Pre-Medical or Pre-Dental Students
Seven additional credits are required for the pre-professional students beyond the B.E. in BME degree. These are CHE 133, CHE 134, BIO 203, and BIO 205. It is recommended that CHE 133 is taken during the Freshman Spring, CHE 134 taken during Sophomore Spring, and BIO 203/ BIO 205 taken during Junior Spring.

Grading
All courses taken to satisfy 1 through 6 above must be taken for a letter grade. A grade of C or higher is required in the following courses: AMS 151, AMS 161 or equivalent; BIO 202 or BIO 203; CHE 131, CHE 132 or equivalent; PHY 131/PHY 133, PHY 132/PHY 134 or equivalent; ESE 271; all BME courses.

Specializations
To complete the specialization, students choose from the technical elective course list for one of the three specializations. Other courses may be used towards this requirement with the permission of the undergraduate program director. A total of 30 credits in technical electives are required. Fifteen credits or more must be engineering designations. Nine must be BME (not BME 499), however six additional credits may be BME 499.

a. Biomechanics and Biomaterials

Courses that focus on developing an understanding of mechanical structures and dynamics of biological systems, and material properties of those structures. This specialization is appropriate for students interested in the areas of biofluid mechanics, hard and soft tissue biomechanics, biomaterials, biocompatibility, medical prosthetics, or bioinstrumentation.

Recommended courses:
BME 303 Biomechanics
BME 311 Fundamentals of Macro to Molecular Bioimaging
BME 313 Bioinstrumentation
BME 381 Nanofabrication in Biomedical Applications
BME 404 Essentials of Tissue Engineering
BME 420 Computational Biomechanics
BME 430 Engineering Approaches to Drug and Gene Delivery
BME 461 Biosystems Analysis
BME 481 Biosensors
ESG 302 Thermodynamics of Materials
ESG 332 Materials Science I
ESM 335 Strength of Materials
ESM 353 Biomaterials
ESM 369 Polymers
MEC 363 Mechanics of Solids

Alternative courses:

AMS 315 Data Analysis
AMS 331 Mathematical Modeling
AMS 333 Mathematical Biology
CHE 321 Organic Chemistry I
CHE 322 Organic Chemistry II
CHE 327 Organic Chemistry Laboratory
CSE 326 Digital Image Processing
CSE 332 Introduction to Scientific Visualization
ESE 315 Control System Design
ESG 281 Engineering Intro to Solid State
ESE 316 Engineering Science Design II
ESM 325 Diffraction Techniques and Structure of Solids
ESM 327 Organic Chemistry Laboratory
ESM 334 Materials Engineering
ESM 335 Strength of Materials
ESM 450 Phase Changes and Mechanical Properties of Materials
MEC 310 Introduction to Machine Design
MEC 320 Engineering Design Methodology and Optimization
MEC 402 Mechanical Vibrations
MEC 410 Design of Machine Elements
MEC 411 Control System Analysis and Design
MEC 455 Applied Stress Analysis

b. Bioelectricity and Bioimaging

Courses focusing on the description of biological cells, tissues, and organisms as complex systems. This specialization is appropriate for students interested in the areas of bioinstrumentation, medical imaging, electrical prosthetics, electromagnetic compatibility, tissue engineering, or bioinformatics.

Recommended courses:

BME 311 Fundamentals of Macro to Molecular Bioimaging
BME 313 Bioinstrumentation
BME 461 Biosystems Analysis
BME 481 Biosensors
CSE 377 Introduction to Medical Imaging
ESE 211 Electronics Laboratory A
ESE 218 Digital System Design
ESE 306 Random Signals and Systems
ESE 314 Electronics Laboratory B
ESE 315 Control System Design
ESE 372 Electronics

Alternative courses:

AMS 311 Probability Theory
CHE 321 Organic Chemistry I
CHE 322 Organic Chemistry II
CHE 327 Organic Chemistry Laboratory
ESE 305 Deterministic Signals and Systems
c. Molecular and Cellular Biomedical Engineering

Courses focus on the application of biochemistry, cell biology, and molecular biology (i.e., recombinant DNA methodology) to the broad fields of genetic engineering, biotechnology, bionano-technology, and biosensors. Includes the specific engineering principles that are applied to problems involving structure and function of molecules and cells in areas such as tissue engineering, gene therapy, microarray, drug design and delivery, structural biology computational methods, and bioinformatics.

**Recommended courses:**

- BIO 317 Principles of Cellular Signaling
- BME 313 Bioinstrumentation
- BME 381 Nanofabrication in Biomedical Applications
- BME 404 Essentials of Tissue Engineering
- BME 461 Biosystems Analysis
- BME 481 Biosensors
- CHE 321 Organic Chemistry I
- CHE 322 Organic Chemistry II
- CHE 327 Organic Chemistry Laboratory

**Alternative courses:**

- BIO 302 Human Genetics
- BIO 310 Cell Biology
- BIO 311 Techniques in Molecular and Cellular Biology
- BIO 320 General Genetics
- BIO 325 Animal Development
- BIO 328 Mammalian Physiology
- BIO 361 Biochemistry I
- BIO 362 Biochemistry II
- BIO 365 Biochemistry Laboratory
- BME 303 Biomechanics
- BME 430 Engineering Approaches to Drug and Gene Delivery
- CHE 312 Physical Chemistry
- CHE 346 Biomolecular Structure and Reactivity
- CHE 353 Chemical Thermodynamics
- ESG 332 Materials Science I
- ESM 353 Biomaterials: Manufacture, Properties and Applications
- ESM 369 Polymer Engineering

**BE/MS Degree**

BME undergraduate students may be eligible to enroll in the BE/MS degree starting in their senior year and pursue a Bachelor’s Degree along with a MS in Biomedical Engineering. Important features of this combined degree program are that students must apply to the program through the BME Graduate Program Director during their junior year, and once accepted, they are considered to be a graduate student in all regards.

**Sample Course Sequence for the Major in Biomedical Engineering**

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<thead>
<tr>
<th>Freshman Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
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<td>First Year Seminar 102</td>
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<tr>
<td>D.E.C. A</td>
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<td>BME 120</td>
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<tr>
<td>AMS 151</td>
<td>3</td>
<td>AMS 161</td>
<td>3</td>
</tr>
<tr>
<td>CHE 131</td>
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<td>PHY 131/PHY 133</td>
<td>4</td>
<td>PHY 132/PHY 134</td>
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<td>AMS 261</td>
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### Spring

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<td>BME 301</td>
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<tr>
<td>BME 305</td>
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<tr>
<td>AMS 310</td>
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<tr>
<td>Technical elective</td>
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### Senior Fall

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<tr>
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### Spring

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<td>BME 441</td>
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BME

Biomedical Engineering

BME 100: Introduction to Biomedical Engineering
A rigorous introduction to biomedical engineering that provides the historical and social context of BME though contemporary emerging areas within BME. Specific areas covered in depth include: bioelectricity and biosensors (action potentials to signal processing), bioimaging (invasive and non-invasive), genetic engineering (with ethical discussions), and biostatistics. Hands-on computational modeling introduces the physiological concept of positive and negative feedback loops in the body. Emphasis is placed on ways engineers view the living system by using design based approaches and computation.
Prerequisites: BME major or BNG minor or departmental consent
3 credits

BME 120: Programming Fundamentals in Biomedical Engineering
This course will introduce the theory and fundamentals of computer programming specifically designed for the applications in biomedical engineering. Students will learn the basic computer architecture and the interaction between the computer hardware, operating system and application software. Reading focus will be on the programming control logic and style critical to all programming languages including C and MATLAB. Several core and elective courses in biomedical engineering use MATLAB as a key programming language, and therefore MATLAB will be the primary language used to teach the above mentioned programming principles. This course will also serve as the foundation where the students can pursue further advanced programming skills.
Prerequisite: BME Major
3 credits

BME 201 - H: Biomedical Engineering and Society
How engineers interact with others in the development of solutions to societal problems, with emphasis on engineering problems arising in the biological realm. In-depth evaluations of both successful and unsuccessful technologies illuminate the role of biomedical engineers in supporting the well-being of urban and rural populations throughout the world, through developments in medical engineering, biotechnology, environmental engineering, and ergonomic design. Not for credit in addition to BME 100.
Prerequisite: One D.E.C. category E course
3 credits

BME 212: Biomedical Engineering Research Fundamentals
Introduction to data collection and analysis in the context of biophysical measurements commonly used by bioengineers. Statistical measures, hypothesis testing, linear regression, and analysis of variance are introduced in an application-oriented manner. Data collection methods using various instruments, A/D boards, and PCs as well as LabView, a powerful data collection computer package. Not for credit in addition to the discontinued BME 309.
Prerequisites: BME major; BME 100
Pre- or Corequisite: MEC 260; BIO 202 or 203
3 credits

BME 213: Studies in Nanotechnology
The emerging field of nanotechnology develops solutions to engineering problems by taking advantage of the unique physical and chemical properties of nanoscale materials. This interdisciplinary, co-taught course introduces materials and nano-fabrication methods with applications to electronics, biomedical, mechanical and environmental engineering. Guest speakers and a seminar project involve ethics, toxicology, economic and business implications of nanotechnology. Basic concepts in research and design methodology and characterization techniques will be demonstrated. Course is cross-listed as BME 213, MEC 213, and EST 213 and is required for the Minor in Nanotechnology Studies (NTS).
3 credits

BME 300: Writing in Biomedical Engineering
See Requirements for the Major in Biomedical Engineering, Upper-Division Writing Requirement.
Prerequisites: WRT 102; U3 or U4 standing; BME major
Corequisite: Any upper division BME course; perm. of instructor or Undergraduate Director
S/U grading

BME 301: Bioelectricity
Theoretical concepts and experimental approaches used to characterize electric phenomena that arise in live cells and tissues. Topics include excitable membranes and action potential generation, cable theory, equivalent dipoles and volume conductor fields, bioelectric measurements, electrodes and electric stimulation of cells and tissues.
Prerequisites: BME 212; BIO 202 or 203; ESE 271; and ESG 111 (or ESE 124)
3 credits

BME 303: Biomechanics
Illuminates the principles of mechanics and dynamics that apply to living organisms, from cells to humans to Sequoia trees. The behavior of organisms is examined to observe how they are constrained by the physical properties of biological materials. Locomotion strategies (or the lack thereof) are investigated for the forces and range of motions required and energy expenditures. Includes the relationship between form and function to illustrate how form dominates behavior. Presents the physiological effects of mechanical stresses on organs, pathologies that develop from abnormal stress, and how biological growth and adaptation arise as a natural response to the mechanics of living.
Prerequisite: MEC 260, BME 212
Pre- or Corequisite: BIO 202 or 203
3 credits

BME 304 - H: Genetic Engineering
An introduction to the realm of molecular bioengineering with a focus on genetic engineering. Includes the structure and function of DNA, the flow of genetic information in a cell, genetic mechanisms, the methodology involved in recombinant DNA technology and its application in society in terms of cloning and genetic modification of plants and animals (transgenics), biotechnology (pharmaceuticals, genomics), bioprocessing (production and process engineering focusing on the production of genetically engineered products,), and gene therapy. Production factors such as time, rate, cost, efficiency, safety, and desired product quality are also covered. Considers societal issues involving ethical and moral considerations, consequences of regulation, as well as risks and benefits of genetic engineering.
Prerequisites: BME 100; BIO 202 or 203
3 credits

BME 305: Biofluids
The fundamentals of heat transfer, mass transfer, and fluid mechanics in the context of physiological systems. Techniques for formulating and solving biofluid and mass transfer problems with emphasis on the special features and the different scales encountered in physiological systems, from the organ and the tissue level down to the molecular transport level.
BME 311: Fundamentals of Macro to Molecular Biomaging
This course will cover the fundamentals of modern imaging technologies, including techniques and applications within medicine and biomedical research. The course will also introduce concepts in molecular imaging with the emphasis on the relations between imaging technologies and the design of target specific probes as well as unique challenges in the design of probes of each modality: specificity, delivery, and amplification strategies. The course includes visits to clinical sites.
Prerequisite: BME 212
3 credits

BME 313: Bioinstrumentation
Basic concepts of biomedical instrumentation and medical devices with a focus on the virtual instrumentation in biomedical engineering using the latest computer technology. Topics include basic sensors in biomedical engineering, biological signal measurement, conditioning, digitizing, and analysis. Advanced applications of LabVIEW, a graphics programming tool for virtual instrumentation. Helps students develop skills to build virtual instrumentation for laboratory research and prototyping medical devices.
Prerequisite: BME 212
Pre- or Corequisite: ESE 271
3 credits

BME 353: Biomaterials: Manufacture, Properties, and Applications
The engineering characteristics of materials, including metals, ceramics, polymers, composites, coatings, and adhesives, that are used in the human body. Emphasizes the need of materials that are considered for implants to meet the material requirements specified for the device application (e.g., strength, modulus, fatigue and corrosion resistance, conductivity) and to be compatible with the biological environment (e.g., nontoxic, noncarcinogenic, resistant to blood clotting if in the cardiovascular system). This course is offered as both ESM 353 and BME 353.
Prerequisite: ESG 332
3 credits

BME 371: Biological Microfluidics
This one semester course will outline theory and applications of special fluid handling conditions associated with living systems. Microfluids will be examined with respect to aquaporin channels (single file molecular water movement), intercellular fluid transport mechanisms, microvascular convective fluid movement (2 phase flow), and transvascular fluid movement (3 pore theory) with reference to the similarity of each to flow in fabricated microchannels.
Prerequisite: BME 305
3 credits

BME 381: Nanofabrication in Biomedical Applications
Theory and applications of nanofabrication. Reviews aspects of nanomachines in nature with special attention to the role of self-lubrication, intracellular or interstitial viscosity, and protein-guided adhesion. Discusses current nanofabricated machines to perform the same tasks and considers the problems of lubrication, compliance, and adhesion. Self-assembly mechanisms of nanofabrication with emphasis on cutting-edge discovery to overcome current challenges associated with nanofabricated machines.
Prerequisites: CHE 132; BME 100
Pre- or Corequisite: BIO 202 or 203
3 credits

BME 400: Research and Nanotechnology
This is the capstone course for the minor in Nanotechnology Studies (NTS). Students learn primary aspects of the professional research enterprise through writing a journal-quality manuscript and making professional presentations on their independent research (499) projects in a formal symposium setting. Students will also learn how to construct a grant proposal (a typical NSF graduate fellowship proposal), methods to search for research/fellowship funding, and key factors in being a research mentor.
Prerequisite: BME 213; at least one semester of independent research (499) level
3 credits

BME 403: Computational Biomechanics
Introduces the concepts of skeletal biology; mechanics of bone, ligament, and tendon; and linear and nonlinear properties of biological tissues. Principles of finite differences method (FDM) and finite elements method (FEM) to solve biological problems. Both FDM and FEM are applied to solve equations and problems in solid and porous media. Requires knowledge of Fortran or C programming.
Prerequisites: BME 303; BIO 203
3 credits

BME 440: Biomedical Engineering Design
Introduction to product development from the perspective of solving biomedical, biotechnological, environmental, and ergonomic problems. Teamwork in design, establishing customer needs, writing specifications, and legal and financial issues are covered in the context of design as a decision-based process. A semester-long team design project follows and provides the opportunity to apply concepts covered in class.
Prerequisites: BME major; U4 standing; BME 301 and 305
3 credits

BME 441: Senior Design Project in Biomedical Engineering
Formulation of optimal design problems in biomedical and physiological settings. Introduces optimization techniques for engineering design and modeling for compact and rapid optimization of realistic biomedical engineering problems. Necessary conditions for constrained local optimum with special consideration for the constraints in which the product designed should function in terms of the settings (corporal, ex-corporal, biological, etc.) and the safety considerations involved which are unique to biomedical engineering. Students carry out the detailed design of
projects chosen early in the semester. A final design report is required.  
Prerequisite: BME 440  
3 credits

**BME 461: Biosystems Analysis**

Fundamentals of the linear time series analyses framework for modeling and mining biological data. Applications range from cardiorespiratory; renal blood pressure, flow, and sequence; to gene expression data. Tools of data analysis include Laplace and Z transforms, convolution, correlation, Fourier transform, transfer function, coherence function, various filtering techniques, and time-invariant and time-varying spectral techniques.  
Prerequisites: BME 212 and 301  
3 credits

**BME 475: Undergraduate Teaching Practicum**

Students assist the faculty in teaching by conducting recitation or laboratory sections that supplement a lecture course. The student receives regularly scheduled supervision by the faculty instructor. May be used as an open elective and repeated once.  
Prerequisites: BME major; U4 standing; a minimum g.p.a. of 3.00 in all Stony Brook courses and a grade of B or better in the course in which the student is to assist; or permission of the department  
3 credits

**BME 481: Biosensors**

A comprehensive introduction to the basic features of biosensors. Discusses types of most common biological agents (e.g. chromophores, fluorescence dyes) and the ways in which they can be connected to a variety of transducers to create complete biosensors for biomedical applications. Focus on optical biosensors and systems (e.g. fluorescence spectroscopy, microscopy), and fiberoptically-based biosensing techniques . New technologies such as molecular beacons, Q-dots, bioMEMs, confocal microscopy and multiphoton microscopy, and OCT will be referenced.  
Prerequisites: BIO 202 or 203; ESE 271  
3 credits

**BME 488: Biomedical Engineering Internship**

Participation in off-campus biomedical engineering practice. Students are required to submit a proposal to the undergraduate program director at the time of registration that includes the location, immediate supervisor, nature of the project, and hours per week for the project. One mid-semester report and one end of semester report are required. May be repeated up to a limit of 12 credits.  
Prerequisites: BME 212 and permission of undergraduate program director  
3-6 credits, S/U grading

**BME 499: Research in Biomedical Engineering**

An independent research project with faculty supervision.  
Prerequisites: Permission of instructor  
0-3 credits