Biomedical Engineering (BME)

Major in Biomedical Engineering
Department of Biomedical Engineering, College of Engineering and Applied Sciences

CHAIRPERSON: Clinton Rubin
UNDERGRADUATE PROGRAM DIRECTOR: Mary Frame McMahon
UNDERGRADUATE PROGRAM ASSISTANT: Wendy Scharf
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WEB ADDRESS: http://www.bme.sunysb.edu/bme

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

Faculty

Danny Bluestein, Associate Professor, Ph.D., Tel Aviv University: Cardiovascular flow mechanics and pathologies; prosthetic devices.

Weiliam Chen, Assistant Professor, Ph.D., University of Michigan: Gene therapy and drug delivery.

Ki Chon, Associate Professor, Ph.D., University of Southern California: Cardiac autonomic nervous system in normal and diseased states; renal autoregulatory dynamics; neuro-respiratory control; medical devices; clinical diagnostic and prognostic applications.

Richard Clark, Professor, M.D., University of Rochester: Tissue engineering; skin cell activation; tissue formation of healing cutaneous wounds.

Anil Dhundale, Assistant Professor, Ph.D., Stony Brook University: Development of diagnostic and research products in biotechnology, pharmaceutical, and medical devices; DNA microarray.

Shmuel Einav, Professor, Ph.D., Stony Brook University: Blood-tissue interaction; vascular prosthetic devices.

Emilia Entcheva, Assistant Professor, Ph.D., University of Memphis: Cardiac cellular electromechanics; cardiac tissue engineering; fluorescence imaging; computer simulations of cellular function.

Michael Hadjiargyrou, Associate Professor, Ph.D., City University of New York: Molecular mechanisms of bone development and regeneration.

Stefan Judex, Assistant Professor, Ph.D., University of Calgary: Adaptation response to mechanical stimuli at the organ, tissue, cellular and molecular levels.

Wei Lin, Research Assistant Professor, Ph.D., Stony Brook University: Noninvasive assessment of bone quality; confocal acoustic scanning technology.

Mary Frame McMahon, Associate Professor, Ph.D., University of Missouri: Microvascular network flow control; nanobiotechnology; tissue engineering of vascular structures.

Liliane Mujca-Parodi, Assistant Professor, Ph.D., Columbia University: Limbic dysregulation in schizophrenia; physiological/cognitive components of human arousal response; complex systems analysis.

Yingtian Pan, Associate Professor, Ph.D., Huazhong University of Science and Technology: Optical imaging of biological tissue at the cellular level; diagnosis and assessment of tissue growth.

Yi-Xian Qin, Associate Professor, Ph.D., Stony Brook University: Fluid flow of porous structures; ultrasonic-based diagnostics.

Clinton Rubin, Professor, Ph.D., University of Bristol: Adaptation of the skeletal system; therapeutic medical devices.

Balaji Sitharaman, Assistant Professor, Ph.D., Rice University: Multifunctional nanobiosystems for simultaneous diagnostics and therapeutics (theragnostics); multidimensional supramolecular biosystems for imaging, drug delivery and tissue regeneration; nanobiointerface devices for tissue regeneration.

Helmut Strey, Assistant Professor, Ph.D., Technical University, Munich: Characterization of nanostructured materials for bioseparation; controlled drug delivery; biosensors; DNA sequencing applications.

Adjunct Faculty

Estimated number: 8

Teaching Assistants

Estimated number: 16

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.

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.

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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.

Sample Course Sequence for the Major in Biomedical Engineering

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<thead>
<tr>
<th>Freshman Fall Credits</th>
<th>Spring Credits</th>
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<tbody>
<tr>
<td>First Year Seminar 101</td>
<td>First Year Seminar 102</td>
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<tr>
<td>D.E.C. A</td>
<td>BME 120</td>
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<tr>
<td>AMS 151</td>
<td>AMS 161</td>
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<tr>
<td>CHE 131</td>
<td>CHE 132</td>
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<td>PHY 131/133</td>
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<tr>
<td>BME 100</td>
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<td>AMS 261</td>
<td>AMS 361</td>
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<tr>
<td>MEC 260</td>
<td>MEC 262</td>
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<tr>
<td>BME 202</td>
<td>BME 304</td>
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<tr>
<td>BME 204</td>
<td>BME 212</td>
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<td>D.E.C. or BME 212</td>
<td>D.E.C.</td>
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<tr>
<td>ESE 271</td>
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<th>Junior Fall Credits</th>
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<tr>
<td>BME 300</td>
<td>BME 301</td>
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<tr>
<td>AMS 210</td>
<td>AMS 305</td>
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<tr>
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<tr>
<td>D.E.C.</td>
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<th>Senior Fall Credits</th>
<th>Spring Credits</th>
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<tr>
<td>BME 440</td>
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<tr>
<td>Technical elective</td>
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<td>Technical elective</td>
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<tr>
<td>D.E.C.</td>
<td>D.E.C.</td>
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<td>Total 15</td>
<td>Total 15</td>
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Courses Offered in Biomedical Engineering

See the Course Descriptions listing in this Bulletin for complete information.

BME 100 Introduction to Biomedical Engineering
BME 120 Programming Fundamentals in Biomedical Engineering
BME 201-H Biomedical Engineering and Society
BME 212 Biomedical Engineering Research Fundamentals
BME 213 Studies in Nanotechnology
BME 300 Writing in Biomedical Engineering
BME 301 Bioelectricity
BME 303 Biomechanics
BME 304-H Genetic Engineering
BME 305 Biofluids
BME 311 Fundamentals of Macro to Molecular Bioimaging
BME 313 Bioinstrumentation
BME 381 Nanofabrication in Biomedical Applications
BME 400 Research and Nanotechnology
BME 404 Essentials of Tissue Engineering
BME 420 Computational Biomechanics
BME 430 Engineering Approaches to Drug Delivery
BME 440 Biomedical Engineering Design
BME 441 Senior Design Project in Biomedical Engineering
BME 461 Biosystems Analysis
BME 475 Undergraduate Teaching Practicum
BME 481 Biosensors
BME 488 Biomedical Engineering Internship
BME 499 Research in Biomedical Engineering

Acceptance into the Major in Biomedical Engineering

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 132/134 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 in Biomedical Engineering (BME)

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, 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 310 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, 161:

- MAT 125, 126, 127
- MAT 131, 132
- MAT 141, 142
- 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, 132 General Chemistry I, II
   c. PHY 131/133, 132/134 Classical Physics I, II with labs

Note: The following alternate science sequences may be substituted:

- PHY 125, 126, 127, or PHY 141, 142 in lieu of PHY 131/133, 132/134
- CHE 141, 142, in lieu of CHE 131, 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.

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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 Premedical 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 203/205 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, 161 or equivalent; BIO 202 or 203; CHE 131, 132 or equivalent; PHY 131/133, 132/134 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 thirty 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 Macromolecular 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 and Design
- ESM 353 Biomaterials
- ESM 369 Polymers
- MEC 363 Mechanics of Solids
- MEC 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 Macromolecular 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
- CSE 326 Digital Image Processing
- CSE 332 Introduction to Scientific Visualization
- ESE 315 Control System Design
- ESG 281 Engineering Intro to Solid State
- ESG 316 Engineering Science Design II
- ESM 221 Introduction to the Chemistry of Solids
- ESM 309 Thermodynamics of Solids
- ESM 325 Diffraction Techniques and Structure of Solids
- ESM 334 Materials Engineering
- ESM 335 Strength of Materials
- ESM 355 Materials and Processes in Manufacturing Design
- ESM 369 Polymer Engineering
- EST 421 Starting the High-Technology Venture
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, bionanotechnology, 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
- BME/ESM 353 Biomaterials: Manufacture, Properties and Applications
- ESM 369 Polymer Engineering

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Spring 2009: updates since Spring 2007 are in red