**Department of Biomedical Engineering**

# **Biomedical Engineering**

**I. Introduction**

Sustech Biomedical Engineering Department absorbed Columbia University's Department of biomedical engineering undergraduate training courses, established the cultivating way of the enhanced version of the Columbia University Biomedical Engineering. The programs in biomedical engineering at Sustech (B.S.,M.S., Ph.D., Eng.Sc.D., and M.D./Ph.D.) prepare students to apply engineering and apply science to problems in biology, medicine, and the understanding of living systems and their behavior, and to develop biomedical systems and devices. Modern engineering encompasses sophisticated approaches to measurement, data acquisition and analysis, simulation, and systems identification. These approaches are useful in the study of individual cells, organs, entire organisms, and populations of organisms. The increasing value of mathematical models in the analysis of living systems is an important sign of the success of contemporary activity. The programs offered in the Department of Biomedical Engineering seek to emphasize the confluence of basic engineering science and applied engineering with the physical and biological sciences, particularly in the areas of biomechanics, cell and tissue engineering, and biosignals and biomedical imaging.

Programs in biomedical engineering are taught by its own faculty, members of other Engineering departments, and faculty from other University divisions who have strong interests and involvement in biomedical engineering. Several of the faculty holds joint appointments in Biomedical Engineering and other University departments. Educational programs at all levels are based on engineering and biological fundamentals. From this basis, the program branches into concentrations along three tracks: biomechanics, cell and tissue engineering, and biosignals and biomedical imaging. The intrinsic breadth of these tracks, and a substantial elective content, prepare bachelor’s and master’s students to commence professional activity in any area of biomedical engineering or to go on to graduate school for further studies in related fields.

**II. Objectives**

The objectives of the undergraduate program in biomedical engineering are as follows:

* Professional employment in areas such as the medical device industry, engineering consulting, and biotechnology;
* Graduate studies in biomedical engineering or related fields;
* Attendance at medical, dental, or other professional schools.

The undergraduate program in biomedical engineering will prepare graduates who will have:

(a) An ability to apply knowledge of mathematics, science, and engineering;

(b) An ability to design and conduct experiments, as well as to analyze and interpret data;

(c) An 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) An ability to function on multidisciplinary teams;

(e) An ability to identify, formulate, and solve engineering problems;

(f) An understanding of professional and ethical responsibility;

(g) An ability to communicate effectively;

(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;

(i) A recognition of the need for, and an ability to engage in life-long learning;

(j) A knowledge of contemporary issues (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice;

(l) An understanding of biology and physiology;

(m) The capability to apply advanced mathematics (including differential equations and statistics), science, and engineering, to solve the problems at the interface of engineering and biology;

(n) The ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and nonliving materials and systems.

The first two years provides a strong grounding in the physical and chemical sciences, engineering fundamentals, mathematics, and modern biology. This background is used to provide a unique physical approach to the study of biological systems. The last two years of the undergraduate program provide substantial exposure to fundamentals in biomedical engineering with emphasis on the integration of principles of biomedical engineering, quantitative analysis of physiology, and experimental quantification and measurements of biomedical systems. The common core biomedical engineering curriculum provides a broad yet solid foundation in biomedical engineering. The flexible choice of technical electives in the Department of Biomedical Engineering, other departments in the Engineering School, as well as in other departments in the arts and sciences allows students to broaden their biomedical engineering education to their individualized interests for a personalized curriculum. These qualities allow the faculty to prepare students for activity in all contemporary areas of biomedical engineering. Graduates of the program are equipped for employment in the large industrial sector devoted to health care, which includes pharmaceuticals, medical devices, artificial organs, prosthetics and sensory aids, diagnostics, medical instrumentation, and medical imaging.

Graduates also accept employment in oversight organizations (FDA, NIH, OSHA, and others), medical centers, and research institutes. They are prepared for graduate study in biomedical engineering and several related areas of engineering and the health sciences. Students can meet entrance requirements for graduate training in the various allied health professions. No more than three additional courses are required to satisfy entrance requirements for most U.S. medical schools.

**III. Period of Study and Degree Requirement**

**Time length**: 4 years

**Degree conferred:** Bachelor of Engineering

**The minimum credit requirement for graduation:** 154.5 credits

**IV. Discipline**

Biomedical Engineering

**V. Main Courses**

**Major Foundational Courses：** The Fundamentals of Electric Circuits、Fundamentals of Materials Science and Technology、Theoretical Mechanics、Probability and Mathematical Statistics、Cell Biology、Animal Physiology

**Major Core Courses：**Quantitative Physiology I、Quantitative Physiology II、Biomedical Engineering I、Biomedical Engineering II、Biomedical Engineering Lab I、Biomedical Engineering Lab II

**VI. Practice-Based Courses**

Research Projects， Internship， Biomedical Engineering Design I， Biomedical Engineering Design II

**VII. Course Structure and Credit Requirements**

GE Required Courses: 66.5 credits;

GE Elective Courses: 10 credits;

Major Foundational Courses: 21 credits;

Major Core Courses: 18 credits;

Major Elective Courses: 27 credits;

Undergraduate Thesis/Projects, Research Projects, Internship: 12 credits;

The minimum credit requirement for graduation: 154.5 credits.

Note: Biomedical Engineering Design I and II replace the undergraduate thesis for students of biomedical engineering. The courses of Columbia University are used as reference.

**VIII. Course Arrangement**

**Table 1: Major Required Course (Foundational and Core Courses)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Name** | | **Credits** | **Lab Credits** | **Hours/week** | **Terms** | **Advised term to take the course** | | **Instruction language** | **Prerequisite** | **Dept.** |
| EE104 | The Fundamentals of Electric Circuits | | 2 |  | 2 | Spr. | 1/Spr. | |  | MA101B, MA103A | EEE |
| MSE201 | Fundamentals of Materials Science and Technology | | 4 | 1 | 5 | Fall | | 2/Fall |  | PHY105B, CH101A | MSE |
| MAE203 | Theoretical Mechanics I | | 3 |  | 3 | Fall | 2/ Fall | |  | Calculus I & II, College Physics I & II | MAE |
| MA212 | Probability and Mathematical Statistics | | 3 |  | 3 | Spr./Fall | 2/Spr. | |  | MA102a or MA102B | MATH |
| BIO206-15 | Cell Biology | | 4 |  | 4 | Fall | 2/ Fall | |  | BIO201 | BIO |
| BIO311-14 | Animal Physiology | | 3 |  | 3 | Fall | 3/ Fall | |  |  | BIO |
| BIO104 | General Biology Laboratory | | 2 | 2 | 4 | Spr. | 2/Spr. | |  | BIO102A or BIO102B | BIO |
| **Total** | | | **21** | **3** | **24** |  |  | |  |  |  |
| BMEB311 | Quantitative Physiology I | | 3 |  | 3 | Fall | 3/ Fall | |  |  | BME |
| BMEB312 | Quantitative Physiology II | | 3 |  | 3 | Spr. | 3/Spr. | |  | BMEB311 | BME |
| BMEB313 | Biomedical Engineering I | | 3 |  | 3 | Fall | 3/ Fall | |  |  | BME |
| BMEB314 | Biomedical Engineering II | | 3 |  | 3 | Spr. | 3/Spr. | |  | BMEB313 | BME |
| BMEB321 | Biomedical Engineering Lab I | | 3 | 3 | 6 | Fall | 3/ Fall | |  |  | BME |
| BMEB322 | Biomedical Engineering Lab II | | 3 | 3 | 6 | Spr. | 3/Spr. | |  | BMEB321 | BME |
| **Total** | | | **18** | **6** | **24** |  |  | |  |  |  |
| BMEB121 | | Research Projects | 2 | 2 | 4 |  |  | |  |  | BME |
| BMEB323 | | Internship | 2 | 2 | 4 | Smr. | 3/ Smr. | |  |  | BME |
| BMEB422 | | Biomedical Engineering Design I | 4 |  | 4 | Fall | 4/ Fall | |  |  | BME |
| BMEB423 | | Biomedical Engineering Design II | 4 |  | 4 | Spr. | 4/Spr. | |  | BMEB422 | BME |

**Table 2. Major Elective Courses**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Name** | **Credits** | **Lab Credits** | **Hours/week** | **Terms** | **Advised term to take the course** | **Instruction language** | **Prerequisite** | **Dept.** |
| BMEB131 | Introduction to Biomedical Engineering | 2 |  | 2 | Spr. | 1/Spr. |  |  | BME |
| BMEB317 | Principles of Medical Imaging Systems | 3 |  | 3 | Fall | 3/ Fall |  | EE104, EE205 | BME |
| BMEB325 | Medical Imaging Systems Laboratory | 2 |  | 2 | Fall | 3/ Fall |  | BMEB317, EE205 | BME |
| BMEB221 | Biomedical instrumentation | 4 | 2 | 6 | Spr. | 2/ Spr. |  |  | BME |
| BMEB318 | Biomechanics | 3 | 1 | 4 | Fall | 3/ Fall |  |  | BME |
| BIO411-16 | Dynamical Systems Simulation in Biology | 3 |  | 3 | Fall | 4/ Fall |  | BIO206-15, BIO201, MA102B, MA103B | BIO |
| BIO332 | Stem Cell and Regenerative Medicine | 2 |  | 2 | Spr. | 3/Spr. |  | BIO102A | BIO |
| BIO203 | Microbiology | 3 |  | 3 | Fall | 2/ Fall |  |  | BIO |
| BIO201 | Biochemistry（Macromolecules） | 3 |  | 3 | Fall | 2/ Fall |  | BIO102A,CH101A | BIO |
| BIO405 | Immunology | 3 |  | 3 | Fall | 4/ Fall |  | BIO206-15 | BIO |
| BIO202 | Biochemistry（Metabolism） | 3 |  | 3 | Spr. | 2/Spr. |  | BIO201 | BIO |
| BIO222 | Biochemistry and Molecular Biology Laboratory | 2 | 2 | 4 | Spr. | 2/Spr. |  | BIO201, BIO320 | BIO |
| BIO306 | Bioinformatics | 4 | 2 | 6 | Spr. | 3/Spr. |  | BIO309 | BIO |
| BIO304 | Systems Biology | 3 |  | 3 | Spr. | 3/Spr. |  | BIO102A , MA212, BMEB311 | BIO |
| BIO313-15 | Animal Physiology Laboratory | 2 | 2 | 4 | Fall | 3/ Fall |  | BIO311-14 | BIO |
| BIO320 | Molecular Biology | 3 |  | 3 | Spr. | 2/Spr. |  | BIO102A | BIO |
| BIO310 | Neurobiology | 3 |  | 3 | Spr. | 3/Spr. |  | BIO201 | BIO |
| BMEB316 | Medical image processing | 3 | 1 | 4 | Fall | 3/ Fall |  |  | BIO |
| EE326 | Digital image processing | 3 | 1 | 4 | Spr. | 3/Spr. |  | EE205 | EEE |
| BMEB315 | Biomedical Optics | 2 |  | 2 | Spr. | 3/Spr. | CH/EN |  | BME |
| BMEB324 | Biomedical Optics Laboratory | 2 | 2 | 4 | Spr. | 3/Spr. | CH/EN | BMEB315 | BIO |
| MSE316 | Biomaterials | 4 | 2 | 6 | Spr. | 3/Spr. | EN | MSE201 | MSE |
| MA305 | Numerical Analysis | 3 |  | 3 | Fall | 3/ Fall | CH | MA203a or MA213 | MATH |
| EE306 | Introduction to MEMS | 3 | 1 | 4 | Spr. | 3/Spr. | CH/EN | PHY105B | EEE |
| EE407 | Energy Harvesting Technologies | 3 |  | 3 | Fall | 4/ Fall |  |  | EEE |
| EE419 | Biosensors | 3 | 1 | 4 | Fall | 4/ Fall |  |  | EEE |
| EE208 | Engineering electromagnetics | 3 | 1 | 4 | Spr. | 2/Spr. | CH/EN | MA101B,MA103A,EE104 | EEE |
| EE202-17 | Digital Circuit | 3 | 0 | 3 | Spr. | 2/Spr. | CH | PHY105B,EE201-17 | EEE |
| EE202-17L | Digital Circuit Laboratory | 1 | 1 | 2 | Spr. | 2/Spr. | CH | EE202-17 | EEE |
| EE205 | Signals and Systems | 3 | 1 | 4 | Fall | 2/Fall | CH/EN |  | EEE |
| EE323 | Digital Signal Processing | 3 | 1 | 4 | Fall | 3/Fall | EN | EE205 | EEE |
| EE303 | Fundamental of Optoelectronic Technology | 3 | 1 | 4 | Fall | 3/Fall |  | PHY105B | EEE |
| CS301 | Embedded System | 3 | 1 | 4 | Fall | 3/Fall |  | CS207 | CS |
| CS203 | Data structures and algorithm analysis | 3 | 1 | 4 | Fall | 2/Fall |  | CS102A | CS |
| CS202 | Computer organization Principle | 3 | 1 | 4 | Spr. | 2/Spr. |  | CS207 | CS |
| EE201 | Analog circuit | 3 | 1 | 4 | Fall | 2/Fall |  | PHY105B,EE104 | EEE |
| BIO322 | Cell Biology Laboratory | 2 | 2 | 4 | Fall | Spr |  | BIO206-15 | BIO |
| EE429 | Image and Video Processing | 3 | 1 | 4 | Fall | 4/Fall |  | EE205,  MA103A,MA212 | EEE |
| EE431 | BioMEMS and Lab-on-a-Chip | 3 |  | 3 | Fall | 4/Fall |  |  | EEE |
| **Total** | | **114** | **31** | **142** |  |  |  |  |  |
| A minimum of 27 credits MUST be taken to fulfill Major Requirements. | | | | | | | | | |

**Table 3: Overview of Practice-Based Courses**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Name** | **Credits** | **Lab Credits** | **Hours/week** | **Terms** | **Advised term to take the course** | **Instruction language** | **Prerequisite** | **Dept.** |
| BIO313-15 | Animal Physiology Laboratory | 2 | 2 | 4 | Fall | 3/Fall |  | BIO311-14 | BIO |
| BIO306 | Bioinformatics | 4 | 2 | 6 | Spr. | 3/Spr. |  | BIO309 | BIO |
| BIO204 | Biochemistry Laboratory | 2 | 2 | 4 | Spr. | 2/Spr. | CH/EN |  | BIO |
| BIO322 | Cell Biology Laboratory | 2 | 2 | 4 | Fall | Spr |  | BIO206-15 | BIO |
| BMEB316 | Medical Image Processing | 3 | 1 | 4 | Fall | 3/Fall | CH/EN |  | BME |
| EE207 | Data Structure and Algorithm Analysis | 3 | 1 | 4 | Fall | 2/Fall |  | CS102A | EEE |
| BMEB325 | Medical Imaging Systems Laboratory | 2 |  | 2 | Fall | 3/Fall | CH | BMEB317,EE205 | BME |
| BMEB221 | Biomedical instrumentation | 4 | 2 | 6 | Spr. | 2/Spr. | CH |  | BME |
| BMEB318 | Biomechanics | 3 | 1 | 4 | Fall | 3/Fall |  |  | BME |
| BMEB324 | Biomedical Optics Laboratory | 2 | 2 | 4 | Spr. | 3/Spr. | CH/EN | BMEB315 | BME |
| EE202-15 | Digital Circuit | 4 | 1 | 5 | Spr. | 2/Spr. | CH | PHY105B,EE201-17 | EEE |
| EE326 | Digital image processing | 3 | 1 | 4 | Spr. | 3/Spr. |  | EE205 | EEE |
| EE208 | Engineering electromagnetics | 3 | 1 | 4 | Spr. | 2/Spr. | CH/EN | MA101B,MA103A,  EE104 | EEE |
| EE303 | Fundamental of Optoelectronic Technology | 3 | 1 | 4 | Fall | 3/Fall | CH/EN | PHY105B | EEE |
| EE323 | Digital Signal Processing | 3 | 1 | 4 | Fall | 3/Fall | EN | EE205 | EEE |
| EE319 | Embedded System | 3 | 1 | 4 | Fall | 3/Fall |  | CS207 | CS |
| EE205 | Signals and Systems | 3 | 1 | 4 | Fall | 2/Fall | CH/EN |  | EEE |
| EE306 | Introduction to MEMS | 3 | 1 | 4 | Spr. | 3/Spr. | CH/EN | PHY105B | EEE |
| MSE201 | Fundamentals of Materials Science and Technology | 4 | 1 | 5 | Fall | 2/Fall | EN | PHY105B,CH101-A | MSE |
| MSE316 | Biomaterials | 4 | 2 | 6 | Spr. | 3/Spr. | EN | MSE201 | MSE |
| CS202 | Computer organization Principle | 3 | 1 | 4 | Spr. | 2/Spr. |  | CS207 | CS |
| BMEB121 | Projects of Science and Technology Innovation | 2 | 2 | 4 |  |  |  |  | BME |
| BMEB321 | \*Professional practice | 2 | 2 | 4 | Smr. | 3/ Smr. |  |  | BME |
| BMEB422 | Biomedical Engineering Design I | 4 |  | 4 | Fall | 4/Fall | EN |  | BME |
| BMEB423 | Biomedical Engineering Design II | 4 |  | 4 | Spr. | 4/Spr. | EN | BMEB422 | BME |
| **Total** | | **75** | **34** | **109** |  |  |  |  |  |

**Table 4. Overview of Credit Hours and Credits**

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Category** | **Total Course Hours** | **Total Credits** | **The Minimum Credit Requirement** |
| **General Education (GE) Required Courses** | 1168 | 66.5 | 66.5 |
| **General Education (GE) Elective Courses** | 3144 | 182.5 | 10 |
| **Major Foundational Courses** | 304 | 21 | 21 |
| **Major Core Courses** | 384 | 18 | 18 |
| **Major Elective Courses** | 1984 | 114 | 27 |
| **Undergraduate Thesis/Projects, Research Projects, Internship** | 448 | 12 | 12 |
| **Total** | 7432 | 414 | 154.5 |