

# Bioengineering

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**Faculty:** Professors L. Fleishman (Biological Sciences), M. Mafi (Engineering); Assistant Professors J. Currey (Bioengineering), S. Kirkton (Biological Sciences), T. Buma (Electrical and Computer Engineering)

Bioengineering is an interdisciplinary engineering major designed for students interested in exploring the interface between engineering and the life sciences. In bioengineering, students learn to apply engineering principles and analytical approaches to the study of biological systems and seek to understand the benefits and constraints of engineered materials, devices and control systems in life science and biomedical applications.

Students in the bioengineering major share common foundation and core courses in biology, biomechanical engineering, bioengineering and electrical engineering, and choose among upper-level electives in biomechanical and bioelectrical engineering. Courses in biomechanics focus on approaches to understanding the structural properties and dynamics of biological cells, tissues and systems, and of engineered devices with biological and biomedical applications. The bioelectrical engineering courses explore the interfaces among sensory physiology, neuroscience and electrical engineering and students focus on techniques to acquire, analyze and interpret neurological, biomedical and other biological signals and images. During senior year, students engage in a bioengineering capstone design and may elect to conduct research under the guidance of a faculty member.

Educational objectives and program outcomes are listed on the program website:  
[union.edu/academic\\_depts/bioengineering](http://union.edu/academic_depts/bioengineering).

**Requirements for the Major:** The Bioengineering major requires courses in 1) math, science and general engineering, 2) foundation and core courses in bioengineering, 3) bioengineering electives, and 4) a capstone design course.

## **Required courses in math, science and general engineering.**

Calculus through MTH-117; MTH-130 (Differential Equations); CSC-10x (Introduction to Computer Science); ESC 100 (Exploring Engineering); PHY-120 (Matter in Motion) and PHY-121 (Principles of Electromagnetics); CHM-101 (Introductory Chemistry I) or CHM-110 (Accelerated Introductory Chemistry).

## **Required foundation and core courses in bioengineering.**

BNG-101 (Graphics and Image Processing for Biomedical Systems); BNG-201 (Biomechanics I); BNG-202 (Biomechanics II); two additional courses in biomechanics (BNG-33x or BNG-34x); BIO-101 (Physiology of Cells and Organisms); BIO-225 (Molecular Biology of the Cell); two additional >300-level biology courses, one with lab, pre-med students may substitute BIO 102 for the non-lab course requirement; ECE-225 (Electric Circuits); ECE-240 (Circuits and Systems); ECE-241 (Discrete Systems); BNG-386 (Introduction to Biomedical Instrumentation).

## **Bioengineering electives.**

Five courses from BNG, ECE, CSC 243 or other engineering courses subject to approval (but not BNG 240 or BNG 375), one must have a lab and at least three must be >300 level.

**Capstone design.**

BNG-495 (Bioengineering Capstone Design)

**Requirements for Honors.** The criteria for graduating with honors in Bioengineering are: (1) cumulative index of at least 3.3; (2) index in major courses of at least 3.3 with at least an A- in at least three major courses; (3) final six terms of courses at Union. The major courses are listed under “Courses for the Major” and also include BIO-101, BIO-225, BIO-3XX, ECE-225, ECE-240, ECE-241

**Requirements for the Minor:** A minimum of six courses taken outside the major department organized around the following:

**Core Course Requirements:** BIO-101, BNG-240, ESC-100, MTH-112 (or MTH-113 or equivalent), PHY-110 (or PHY-120)

**Upper-Level Course Requirements**

*Engineering and Computer Science Majors:* Three courses from the following: 200 level or above biology or bioengineering courses and/or PHY-200 or PHY-210. Third and fourth year students entering the Minor may opt to take an additional 200 level or above course instead of BNG-240.

*Biological Sciences Majors:* Three courses from the following: 200 level or above engineering (BNG, MER, ECE, CSC) courses and/or PHY-200 or PHY-210. Third and fourth year students entering the Minor may opt to take an additional 200 level or above course instead of ESC-100.

*Other Majors:* Three 200 level or above courses in biology, engineering and/or PHY-200 or PHY-210 with approval by the Program Directors.

**Course Selection Guidelines**

*Placement.* Students will receive credit for AP or IB courses following the guidelines of the appropriate supporting department.

*Course Sequence.* Students should consult with their academic advisor and the following yearly requirements when scheduling courses. Some 300 level courses are not offered every year, and some of these courses will be taken outside of the year indicated.

*Senior Projects.* Students interested in working with a faculty member on a two-term Senior Project should meet with potential faculty advisors during their junior year to identify a project; students should notify a Program Director when this process is complete. The first course (BNG-497) will count as a Free Elective and BNG-498 will count as a BNG Elective.

**First Year:**

BIO-101, CHM-101, CSC-10X, ESC-100, FPR-100, MTH-113<sup>(i)</sup>, MTH-115<sup>(i)</sup>, PHY-120<sup>(i)</sup>, PHY-121<sup>(i)</sup>, Elective<sup>(ii)</sup>

## Second Year

BIO-225, BNG-101, BNG-201, BNG-202, ECE-225, ECE-240, ECE-241, MTH-130, SRS-200, Elective<sup>(ii)</sup>

## Third Year<sup>(iii)</sup>

BIO-3XX<sup>(iv)</sup>, BNG-386, BNG-33X<sup>(v)</sup>, MTH-117, BNG-Elective<sup>(vi)</sup>, BNG-Elective<sup>(vi)</sup>, Elective<sup>(ii)</sup>, Elective<sup>(ii)</sup>, Elective<sup>(ii)</sup>

## Fourth Year

BIO-3XX<sup>(iv)</sup>, BNG-33X<sup>(v)</sup>, BNG-495, BNG-Elective<sup>(vi)</sup>, BNG-Elective<sup>(vi)</sup>, BNG-Elective<sup>(vi)</sup>, Elective<sup>(ii)</sup>, Elective<sup>(ii)</sup>, Elective<sup>(ii)</sup>, Elective<sup>(ii)</sup>, Elective<sup>(ii)</sup>

<sup>(i)</sup>Alternative mathematics and physics sequences are possible depending on the preparation of the student.

<sup>(ii)</sup>The Elective courses must be satisfied as follows: five General Education courses and five Free Electives. Students planning to attend medical school should take CHM-231/232 (organic chemistry) as electives and BIO-102 as a >300 level Biology course (see note <sup>iv</sup> below).

<sup>(iii)</sup>The Linguistic and Cultural Competency component of the General Education curriculum is recommended to be satisfied in the third year through a Term Abroad during Fall Term.

<sup>(iv)</sup>Biological Science courses must be >300 level and one requires lab. Pre-med students may use BIO-102 to satisfy the non-lab course requirement.

<sup>(v)</sup>Bioengineering courses BNG 330-339 represent courses in the Biomechanics area.

<sup>(vi)</sup>The BNG Elective courses include any five courses from BNG, ECE, CSC 243 or other engineering courses subject to approval; one must have a lab and at least three must be >300 level.

## Courses for Major

**BNG-101. Graphics and Image Processing for Biomedical Systems** (Fall; Catravas, Cotter). Students will learn how to create objects, assemblies, and engineering drawings using SolidWorks, a solid modeling software. Students will also be introduced to the fundamentals of image acquisition and processing in biomedical systems and the use of block diagrams to construct more complex processing systems. There is a weekly laboratory.

**BNG-201. Biomechanics I** (Fall, Mafi). A basic biomechanics course concerned with two- and three-dimensional force systems, equilibrium and distributed forces. These topics will be studied in the context of the musculoskeletal system. This course also introduces strength and elastic deflection of biological tissues due to loads applied axially, in torsion, in bending, and in shear. Shear and bending moment diagrams, friction, and area moments of inertia will be introduced. There is a weekly laboratory.

**BNG-202. Biomechanics II** (Winter, Currey). Kinematics and kinetics of particles and rigid bodies in planar motion with applications to human motion analysis. The course includes Newtonian and energy approaches to problem solutions. There is a weekly laboratory.

**BNG-240. Introduction to Bioengineering** (Winter, Mafi). In this course, students will explore the application of engineering principles and analyses to the study of biological systems and seek to understand the potential benefits and constraints of engineered materials and devices in medical and environmental applications. The course will cover principles of solid mechanics, fluid mechanics and biosignals. Topics include the mechanics of support and locomotion, biofluids, and neuro-muscular signal acquisition and processing. Course prerequisites: MTH-110 or equivalent and one course in BIO, CHM or PHY that counts towards the major.

**BNG-331. Cell-Tissue-Material Interaction** (Not offered in 2011-12; Same as BIO-231). Study interactions between living cells, tissues and implant biomaterials, with a focus on molecular and cellular level phenomena in the initiation and generation of tissue and systemic responses. Prerequisite: BIO-101.

**BNG-344. Biomechanics of Human Motion** (Not offered in 2011-12; Same as MER-344). Study of the dynamics of human motion through a series of modules comprised of lecture and laboratory activities. The modules will include: musculoskeletal modeling with inertial effects, determination of mass moments of inertia of body segments, principle mass moments of inertia, instrumentation used in kinematics and kinetics analyses, numerical differentiation and integration and terrestrial locomotion. Prerequisite: MER-212.

**BNG-345. Orthopedic Biomechanics** (Not offered in 2011-12; Same as MER-345). Structure, function, mechanical properties, constitutive models, and methods of analysis of bone and other biologic hard tissues; introduction to the analysis of skeletal joints, prosthetics, and implants. Prerequisite: MER-214.

**BNG-346. Soft Tissue Mechanics** (Not offered in 2011-12; Same as MER-346). Introduction to the mechanical behavior of biological soft tissues including ligament, tendon, skeletal muscle, articular cartilage, intervertebral disc, and skin. Topics include the hierarchical structure, function, properties, and constitutive modeling of each tissue. Prerequisite: MER-214.

**BNG-375. Animal Locomotion** (Spring; Same as BIO-375, Kirkton). This course examines the evolutionary diversity of animal locomotion by investigating how physical properties of both the organisms and their environment affect the biochemistry, anatomy and physiology of movement. This course also uses engineering principles to explain animal locomotor mechanisms of animals. One lab per week. Prerequisites: BIO-101 and PHY-110 (or PHY-120).

**BNG-386. Introduction to Biomedical Instrumentation** (Winter; Same as ECE-386, Buma). Introduction to the theory and application of instruments in medicine. Measurements of the major systems in the body are covered. A weekly laboratory provides an opportunity to perform measurements and use biomedical instruments. Prerequisite: ECE 225.

**BNG-397 Biometric Signal Processing** (Not offered in 2011-12; Same as ECE-377). This course details how signal processing is applied to create biometric systems, which are technologies that measure and analyze human body characteristics. These systems are widely used today in security and forensic applications. The course will reinforce many of the fundamental concepts that students have learned in their introductory DSP course and will cover both 1D (voice) and 2D (face and fingerprint) biometrics. Students will be introduced to image processing, pattern recognition, and the statistics used to measure the performance of biometric systems. The important societal and ethical issues involved in the design and deployment of biometric systems will be addressed. A weekly laboratory will complement the lecture material.

**BNG-487. Biomedical Signal and Image Processing** (Not offered in 2011-12). Introduction to the applications of signal processing methods in the measurement of biomedical signals. Processing of one dimensional signals (e.g., ECG) and two dimensional image signals (e.g., fMRI) are covered. Prerequisites: ECE-241, CSC-109 or equivalent.

**BNG-495. Bioengineering Capstone Design** (Winter, Currey). A capstone design experience in which students work in teams comprised of at least one member from each track in Bioengineering. Each team will use design methodologies and techniques to produce a complete and detailed design for a designated bioengineering client. The course will be instructed by a team comprised of faculty from each track and from Biological Sciences. Co-Requisite: BNG-311, MER-311 or ECE-241.

**BNG-497. Bioengineering Senior Project 1.** Capstone research or design project, performed either independently or as a team, under the supervision of one or more faculty participating in the Bioengineering program. Co-Requisite: BNG-311, MER-311 or ECE-241.

**BNG-498. Bioengineering Senior Project 2.** Capstone research or design project, performed either independently or as a team, under the supervision of one or more faculty participating in the Bioengineering program. Prerequisite: BNG-497.