

# BIOMEDICAL ENGINEERING

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Chairperson: John M. Cavanaugh

<http://engineering.wayne.edu/bme/>

Biomedical engineering (BME) is one of the fastest growing disciplines in engineering. This field has developed from the knowledge that engineering principles can be applied to better understand how the human body functions as well as the effect that outside forces have on it, whether they be diagnostic or traumatic. A biomedical engineer brings together traditional engineering principles with the life sciences in a completely integrated fashion. The result is an engineer who views the human body as a complex system, its diseases and injuries as breakdowns in that system, and medical interventions as design alternatives for the repair of the system. As the population ages and medical costs increase, biomedical engineers are required both to understand the mechanistic causes of injury and disease and to design and implement interventions to prevent and mitigate the suffering of individuals and to reduce the cost of medical care to society.

Wayne State has a long history with respect to biomedical engineering research. In 1939, faculty from the College of Engineering and School of Medicine began collaborating to investigate the mechanisms of injuries to the human body, and educational programs in the area of biomedical engineering have existed at Wayne State since the 1950s. They have developed from a few courses taken within traditional engineering departments to the graduate degree program in biomedical engineering, introduced in 1998. The Department of Biomedical Engineering, interdisciplinary between the College of Engineering and the School of Medicine, was established in 2002. Drawing upon the strengths of the biomedical engineering graduate program, the Department has established a new undergraduate program that accepted its first students for the Fall 2010 semester.

CAVANAUGH, JOHN: M.D., B.S., Michigan State University; M.S., Wayne State University; Professor and Chair

CHEN, CHAOYANG: M.D., Fujian Medical University; Resident in Orthopaedic Surgery, Beijing Medical University; Associate Research Professor

GELOVANI, JURI: M.D., Ph.D., University of Tartu; Professor

GENIK, RICHARD: Ph.D., M.S., Michigan State University; B.S., Wayne State University; Lecturer

GRIMM, MICHELE J.: Ph.D., M.S.E, University of Pennsylvania; B.S., Johns Hopkins University; Associate Professor

JIN, XIN: Ph.D., Wayne State University; M.S. and B.S. Tsinghua University; Assistant Professor (Research)

KALLAKURI, SRINIVASU: Ph.D., M.S. Wayne State University; M.S. Agra University; B.S. Andhra University; Assistant Professor (Research)

KAVDIA, MAHENDRA: Ph.D., Oklahoma State University; MTech, Indian Institute of Technology; BTech, Indian Institute of Technology; Associate Professor

KING, ALBERT I.: Ph.D., M.S., Wayne State University; B.S., University of Hong Kong; Distinguished Professor

KLUEH, ULRIKE: Ph.D., M.S., University of Connecticut; B.A.Sc., University of Applied Sciences Mittelhessen; Associate Professor

KOU, ZHIFENG: Ph.D., North Dakota State; Associate Professor

LAM, MAI T.: Ph.D., M.S.E., B.S.E., University of Michigan; Assistant Professor

MUNDO, BRIAN: M.S., Wayne State University; B.E., University of Michigan; Lecturer

NASIRIAVANAKI, MOHAMMAD: Ph.D., M.A., University of Kent; M.Sc., University of Semnan; B.Sc., Isfahan University of Technology; Assistant Professor

REN, WEIPING: M.D., Shanghai Second Medical University; M.S. Shanghai; Associate Professor

SUNDARARAGHAVAN, HARINI: Ph.D., Rutgers, State University of New Jersey; B.S.E., University of Michigan; Associate Professor

YANG, KING-HAY: Ph.D., M.S., Wayne State University; B.S., National Taiwan University; Professor

ZHANG, LIYING: M.D., Shandong Medical University; Ph.D., Mahidol University; Associate Professor

- Biomedical Engineering (B.S.) (<http://bulletins.wayne.edu/undergraduate/college-engineering/biomedical-engineering/biomedical-engineering-bs>)

## **BME 1910 Biomedical Engineering Design Lab I Cr. 1**

Application of engineering principles to biomedical engineering problems through laboratory and design exercises. First of a six-semester sequence; work on a biomedical engineering team; basics of biomedical engineering design. Offered Fall.

**Prerequisites:** May be taken concurrently: BE 1500 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$25

## **BME 1920 Biomedical Engineering Design Lab II Cr. 1**

Application of engineering principles to biomedical engineering problems through laboratory and design exercises. Second of a six-semester sequence; basic analysis of biomaterials and design importance of materials. Offered Winter.

**Prerequisite:** BE 1300 (may be taken concurrently) with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$100

## **BME 1925 Biomedical Engineering Design Laboratory: Jump Start I Cr. 2**

Laboratory and design exercises focusing on fundamental design processes for biomedical engineering and the application of materials science to BME. This course replaces the BME 1910 - BME 1920 sequence for students who transfer into the program in the second year. Offered Spring/Summer.

**Restriction(s):** Enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$43

## **BME 2010 Introduction to Physiology for Engineers Cr. 2**

Introduction to human physiological and pathophysiological processes. Offered Winter.

**Prerequisite:** BIO 1510 with a minimum grade of C- and CHM 1240 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students.

**BME 2070 Introduction to Anatomy for Engineers Cr. 2**

A text and models based anatomy course for undergraduate students in biomedical engineering. This course is intended to give the students an introductory experience of the study of human anatomy in relation to engineering principles. Offered Fall.

**Prerequisites:** BIO 1510 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$25

**BME 2910 Biomedical Engineering Design Lab III Cr. 1**

Application of engineering principles to biomedical engineering problems through laboratory and design exercises. Third of a six-semester sequence; analysis of musculoskeletal forces biomechanics. Offered Fall.

**Prerequisite:** (BME 1920 with a minimum grade of C- or BME 1925 with a minimum grade of C-) and ME 2410 (may be taken concurrently) with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$25

**BME 2920 Biomedical Engineering Design Lab IV Cr. 1**

Application of engineering principles to biomedical engineering problems through laboratory and design exercises involving tissue biomechanics. Introduction to finite element modeling. Fourth of a six-semester sequence. Offered Winter.

**Prerequisite:** BE 2100 (may be taken concurrently) with a minimum grade of C- and BME 2010 (may be taken concurrently) with a minimum grade of C- and ME 2420 (may be taken concurrently) with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$25

**BME 3470 Biomedical Signals and Systems Cr. 3**

Mathematical, engineering and computer techniques for describing and analyzing biomedical signals, including ECG, EEG, EMG, blood pressure, and tomographic images. Offered Fall.

**Prerequisites:** May be taken concurrently: BME 3910 with a minimum grade of C- and ECE 3300 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment limited to students in the College of Engineering; enrollment is limited to students in the Department of Biomedical Engineering; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors; enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**Course Material Fees:** \$50

**BME 3910 Biomedical Engineering Design Lab V Cr. 1**

Application of engineering principles to biomedical engineering problems through laboratory and design exercises. Focus on measurement, analysis, modeling, and interaction with biomedical signals from living systems. Fifth of a six-semester sequence. Offered Fall.

**Prerequisite:** BE 1500 with a minimum grade of C- and MAT 2150 with a minimum grade of C- and ENG 3050 with a minimum grade of C- and BME 3470 (may be taken concurrently) with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$25

**BME 3920 Biomedical Engineering Design Lab VI Cr. 2**

Application of engineering principles to biomedical engineering problems through laboratory and design exercises. Introduction to the capstone design process. Integration of the design process with the complete government regulation system for medical device design. Use of advanced CAE tools for analysis. Sixth of a six-semester sequence. Offered Winter.

**Prerequisite:** BME 3910 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$100

**BME 4010 Engineering Physiology Laboratory Cr. 1**

Measurement and analysis of physiological signals on living systems, with focus on neural, cardiovascular, respiratory and muscular systems. Includes a student-designed experiment on a physiological system. Offered Winter.

**Prerequisites:** BME 2010 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$30

**BME 4210 Introduction to Biomechanics Cr. 3**

Broad introduction to the application of mechanical engineering principles to biomedical engineering, including motion analysis, injury and forensic biomechanics, cardiovascular and pulmonary mechanics, and design of implants with mechanical functions. Offered Winter.

**Prerequisite:** CHE 3200 with a minimum grade of C- and ME 2420 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment limited to students in the College of Engineering; enrollment is limited to students in the Department of Biomedical Engineering; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors; enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**BME 4310 Introduction to Biomaterials Cr. 3**

Broad introduction to the field of biomaterials and its application to tissue engineering, implant design, controlled drug delivery, and designer materials for therapeutic use. Offered Winter.

**Prerequisite:** CHE 3200 with a minimum grade of C- and ME 2420 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment limited to students in the College of Engineering; enrollment is limited to students in the Department of Biomedical Engineering; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors; enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**BME 4410 Introduction to Biomedical Instrumentation Cr. 3**

Broad introduction to the use and design of instrumentation for biomedical applications, in both clinical and research use; includes filtering techniques, safety issues, and special concerns for implanted and external systems. Offered Winter.

**Prerequisites:** BME 3470 with a minimum grade of C- and ECE 3300 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment limited to students in the College of Engineering; enrollment is limited to students in the Department of Biomedical Engineering; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors; enrollment limited to students in the following programs: BS in Biomedical Engineering, BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering.

**Course Material Fees:** \$25

**BME 4910 Biomedical Engineering Capstone Design I Cr. 3**

**Satisfies General Education Requirement:** Writing Intensive Competency First in a two-semester sequence during which student teams develop a design to address a biomedical engineering challenge; includes discussions with clinical faculty, analysis of current solutions, and finalization of conceptual design. Offered Fall.

**Prerequisite:** BME 3920 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment limited to students with a class of Senior; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$50

**BME 4920 Biomedical Engineering Capstone Design II Cr. 3**

Second of a two-semester sequence. Students develop and test a prototype of their biomedical engineering design; culminates in a public design expo to exhibit student designs. Offered Winter.

**Prerequisite:** BME 4910 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Undergraduate level students; enrollment limited to students with a class of Senior; enrollment is limited to students with a major in Biomedical Engineering or Biomedical Engg Honors.

**Course Material Fees:** \$50

**BME 5010 Quantitative Physiology Cr. 4**

Basic principles of human physiology presented from the engineering perspective. Bodily functions, their regulation and control discussed in quantitative terms and illustrated by mathematical models where feasible. Offered Fall, Winter.

**Equivalent:** CHE 5100, ECE 5100, IE 5100, ME 5100

**BME 5020 Computer and Mathematical Applications in Biomedical Engineering Cr. 4**

Application of numerical methods in biomedical engineering. Programming algorithms and development of data analysis interfaces using Matlab and Excel. Development and refinement of mathematical models, binary data storage and round-off error, algorithm truncation error, and application of Taylor series for function approximation, error estimation, and algorithm development. Numerical methods for solving: roots of equations, systems of linear equations, system optimization, regression and interpolation, integration, differentiation, and ordinary and partial differential equations. Attention is focused on application of techniques within biomedical engineering. Offered Fall, Winter.

**BME 5040 Fundamentals of Engineering Analysis Cr. 2**

Intended to train biomedical engineering students, who have no engineering background, with fundamental principles of engineering and basics of an engineering programming language. It includes Matlab programming language and basics of engineering statics, dynamics, strength of materials, and electrical circuits. Offered Fall.

**BME 5070 Engineering Anatomy Cr. 4**

A cadaver based anatomy course for undergraduate students and MS-level students in biomedical engineering. This hands-on course is intended to give the students directed experience of the study of human anatomy in relation to engineering principles. The histological study of tissues in relation to mechanical function of the organism is included in this study. Offered Fall.

**Prerequisites:** BME 2070 with a minimum grade of C-

**Restriction(s):** Enrollment is limited to Graduate or Undergraduate level students; enrollment limited to students in a BS in Biomedical Engg degree.

**Course Material Fees:** \$225

**BME 5130 Vehicle Safety Engineering Cr. 4**

Role of vehicle in road safety, occupation and pedestrian injury mechanisms, measures of vehicle safety performance, driver behavior and vehicle interface. Use of new technology to improve vehicle safety. Offered Irregularly.

**BME 5210 Musculoskeletal Biomechanics Cr. 4**

Structure and properties of the major tissue components of the musculoskeletal system and evaluation of how tissues combine to provide support and motion to the body. Offered Fall.

**Prerequisite:** BME 5010 with a minimum grade of C or BMS 6550 with a minimum grade of C

**Equivalent:** ME 5160

**BME 5220 Cellular and Tissue Biomechanics Cr. 3**

Introduces biomechanics on the cellular to the tissue level. We will be studying mediators of cell mechanics such as the cytoskeleton, extracellular matrix and receptor-ligand interactions. Topics include cell adhesion, cell motility, and hemodynamics. Understanding of these topics will lead to discussion of translation of these forces up to the tissue level and subsequent tissue function. Offered Fall.

**Prerequisites:** MAT 2010 with a minimum grade of C- and MAT 2020 with a minimum grade of C-

**BME 5310 Device and Drug Approval and the FDA Cr. 3**

Government regulations and industrial procedures that lead to device/drug approval. Offered Spring/Summer.

**Prerequisite:** BME 5010 with a minimum grade of C

**BME 5350 Regenerative Biology and Medicine for Biomedical Engineers Cr. 4**

Introduces students specializing in biomedical engineering and premedical students to the conceptual and methodological principles of modern regenerative biology and medicine. Includes a review of research methods and achievements in this field and the translational applications of regenerative biology to tissue engineering and the development of regenerative therapies. Offered Winter, Spring/Summer.

**Prerequisites:** BME 2070 with a minimum grade of C-

**BME 5360 Histology and Embryology Cr. 4**

Examines the normal structure and development of human tissues and organisms and the applications of this knowledge to biomedical engineering. Working with microscopes, students will study the molecular and cellular characteristics of different tissues and the lab procedures used for the analysis of tissue specimens. Particular attention is focused on technical principles of tissue engineering of human organs in experimental and clinical settings. Offered Fall, Spring/Summer.

**Prerequisites:** BME 2070 with a minimum grade of C-

**BME 5370 Introduction to Biomaterials Cr. 4**

Introduction to study of both biological materials (bone, muscle, etc.) and materials for medical applications. Topics include tissue properties and effects of pathology, biocompatibility, and design considerations. Offered Winter.

**Prerequisite:** BE 1300 with a minimum grade of C- or BME 5010 with a minimum grade of C or BMS 6550 with a minimum grade of C

**Equivalent:** ME 5180

**BME 5380 Biocompatibility Cr. 4**

Wound healing and the tissue response to foreign materials. The organization, activation, and mechanisms of the immune system. Bioactive materials and the molecular basis for surface recognition and masking. Offered Irregularly.

**Prerequisite:** BME 5010 with a minimum grade of C or BMS 6550 with a minimum grade of C

**Equivalent:** MSE 5385

**BME 5450 Microscopic Analysis: Methods & Instrumentation Cr. 4**

Provides the students specializing in biomedical engineering with a basis for understanding the modern methods of microscopic analysis and the design of different types of instrumentation used for microscopic analysis and imaging. Offered Winter.

**Prerequisites:** BME 2070 with a minimum grade of C-

**BME 5510 Introduction to Clinical Engineering and Technology Cr. 2**

Fundamental topics, including evolution of clinical engineering, medical technology, risk management, patient safety, medical equipment planning. Offered Winter.

**Prerequisite:** BME 5010 with a minimum grade of C

**BME 5990 Directed Study Cr. 1-4**

Independent projects on subjects in the field of biomedical engineering. Offered Every Term.

**Repeatable for 998.99 Credits**

**BME 5995 Special Topics in Biomedical Engineering I Cr. 1-4**

Topics as announced in Schedule of Classes. Offered Irregularly.

**BME 6130 Accident Reconstruction Cr. 3**

Passenger car and light truck behavior in collisions; recognition of roadway markings and vehicle damage used to analyze vehicle accidents and to use that evidence to reconstruct driver, vehicle and occupant dynamics at the time of the collision. Offered Spring/Summer.

**BME 6470 Smart Sensor Technology I: Design Cr. 4**

Introduction to various types of sensors and the design of basic analog VLSI circuit building blocks. Offered Fall.

**Equivalent:** ECE 6570, PHY 6570

**BME 6480 Biomedical Instrumentation Cr. 4**

Engineering principles of physiological measurements. Signal conditioning equipment, amplifiers, recorders and transducers. Recent advances. Offered Winter.

**Prerequisites:** BME 5020 with a minimum grade of C and ECE 3300 with a minimum grade of C or BME 5010 with a minimum grade of C or BMS 6550 with a minimum grade of C

**Equivalent:** ECE 6180, IE 6180, ME 6180

**BME 6500 Enabling Technology Cr. 3,4**

Principles of application of enabling technology: across life stages, for differing ethnic and cultural backgrounds, for individuals with varying functional abilities. Offered Irregularly.

**Equivalent:** ECE 6100

**BME 6991 Internship in Industry Cr. 1-4**

Industrial internship in biomedical engineering. Offered Every Term.

**Repeatable for 99 Credits**