

# Biomedical Engineering (BME)

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## **BME 101. Introduction to Biomedical Engineering. 3 hours.**

Principles, practice, and the role of biomedical engineers in science, engineering, and commercialization of medical products. Professional ethics, career paths, introduction to graphical design tools and instrumentation. Course Information: Credit is not given for BME 101 if the student has credit in BIOE 101. Previously listed as BIOE 101.

## **BME 102. Biomedical Engineering Freshman Seminar. 1 hour.**

Exposure to biomedical engineering research through attendance of graduate student seminars followed by faculty-mediated discussion. Writing seminar summaries, student shadowing, articulating long-term goals, and planning an academic trajectory. Course Information: Satisfactory/Unsatisfactory grading only. Previously listed as BIOE 102. Restricted to first year Biomedical Engineering students (freshmen or transfer students).

## **BME 194. Special Topics in Biomedical Engineering I. 1-5 hours.**

Special topics to be arranged. Course topics aimed at first-year students. Course Information: May be repeated. Students may register in more than one section per term.

## **BME 205. Biomedical Engineering Thermodynamics. 3 hours.**

Introduction to equilibrium and non-equilibrium thermodynamics, with emphasis on non-equilibrium (living) systems. Applications include thermodynamics of living cells and the lung, molecular energy exchange, and energy exchange in exercise. Course Information: Previously listed as BIOE 205. Credit is not given for BME 205 if the student has credit in BIOE 205 or CHE 201 or ME 205. Prerequisite(s): PHYS 141.

## **BME 240. Modeling Physiological Data and Systems. 3 hours.**

Computational tools and techniques for models and statistics used to describe, interpret and analyze physiological data and systems. Time series, image and population data types. Course Information: Previously listed as BIOE 240. Credit is not given for BME 240 if students have credit for BIOE 240. Prerequisite(s): BIOS 110; and MATH 180; and CS 109.

## **BME 250. Clinical Problems in Biomedical Engineering. 3 hours.**

Examination of three current problems in biomedical engineering. Student teams work with a faculty facilitator toward each solution. Problem identification, strategic planning, brainstorming, information gathering, and reporting. Course Information: Credit is not given for BME 250 if the student has credit in BIOE 250. Previously listed as BIOE 250. Prerequisite(s): Credit or concurrent registration in BIOE 101 and Credit or concurrent registration in BIOE 102; or Credit or concurrent registration in BME 101 and Credit or concurrent registration in BME 102.

## **BME 294. Special Topics in Biomedical Engineering II. 1-5 hours.**

Special topics to be arranged. Course topics aimed at second-year students. Course Information: May be repeated. Students may register in more than one section per term.

## **BME 310. Biological Systems Analysis. 3 hours.**

System dynamics and frequency-domain analysis in bioengineering systems. Topics include population models, predator-prey models, metabolic networks, biological oscillation, dynamics of infectious diseases. Course Information: Previously listed as BIOE 310. Credit is not given for BME 310 if the student has credit in BIOE 310 or ECE 310 or ME 312. Prerequisite(s): MATH 220 and MATH 310; and BIOE 240 or BME 240.

## **BME 325. Biotransport. 3 hours.**

Transport phenomena in biomedical engineering and living systems, specifically processes vital to the design of medical devices for artificial clinical intervention. Topics include circulatory system dynamics and modeling of physiological systems. Course Information: Previously listed as BIOE 325. Credit is not given for BME 325 if students have credit in BIOE 325. Prerequisite(s): MATH 220 and BIOS 110 and BME 205.

## **BME 332. Bioinstrumentation and Measurements I. 3 hours.**

Theory and application of instrumentation used for physiological and medical measurements. Characteristics of physiological variables, signal conditioning devices and transducers. Course Information: Previously listed as BIOE 430. Prerequisite(s): BIOS 110 and ECE 210.

## **BME 333. Bioinstrumentation and Measurement Laboratory I. 2 hours.**

Practical experience in the use of biomedical instrumentation for physiological measurements. Course Information: Previously listed as BIOE 431. Prerequisite(s): Credit or concurrent registration in BME 332 or Credit or concurrent registration in BIOE 430.

## **BME 339. Biostatistics I. 3 hours.**

Statistical treatment of data and model estimation treated in a framework of biological experiments, and attributes of data generated from such experiments. Experimental design is included. Course Information: Credit is not given for BME 339 if the student has credit in BIOE 339. Previously listed as BIOE 339. Extensive computer use required. Prerequisite(s): MATH 210 and CS 109. Recommended background: Prior knowledge of Excel.

## **BME 391. Biomedical Engineering Practicum. 1 hour.**

Provides students with the opportunity to apply the skills and knowledge gained in previous engineering courses within a professional, working environment. Course Information: Satisfactory/Unsatisfactory grading only. May be repeated. A maximum of 3 hours awarded toward degree requirements. Prerequisite(s): Approval of the Department.

## **BME 394. Special Topics in Biomedical Engineering III. 1-5 hours.**

Special topics to be arranged. Course topics aimed at third-year students. Course Information: May be repeated. Students may register in more than one section per term.

## **BME 396. Senior Design I. 3 hours.**

Design considerations for biomedical devices emphasizing traditional engineering design concepts. Course Information: Prerequisite(s): Credit or concurrent registration in BIOE 339. Course Information: Previously listed as BIOE 396. Credit is not given for BME 396 if student has credit in BIOE 396. Prerequisite(s): Credit or concurrent registration in BIOE 332 and Credit or concurrent registration in BIOE 333 and Credit or concurrent registration in BIOE 339.

## **BME 397. Senior Design II. 3 hours.**

Application of principles of engineering and engineering design methodology to the solution of a large scale biomedical engineering design problem. Course Information: Credit is not given for BME 397 if the student has credit in BIOE 397. Previously listed as BIOE 397. Prerequisite(s): BIOE 396 or BME 396.

## **BME 398. Undergraduate Research. 0-5 hours.**

Research under the close supervision of a faculty member. Course Information: May be repeated. Students may register in more than one section per term. Prerequisite(s): Consent of the instructor.

**BME 399. Professional Development for Biomedical Engineers. 0 hours.**

Career options, career planning, and job search skills relevant to bioengineers. Formal and informal networking, on-line resources, resume and portfolio preparation, interview skills. Special issues relevant to international students. Course Information: Satisfactory/Unsatisfactory grading only. Previously listed as BIOE 399. Prerequisite(s): Open only to juniors; or consent of the instructor.

**BME 402. Medical Technology Assessment. 2 or 3 hours.**

Assessment of medical technology in the context of commercialization. Objectives, competition, market share, funding, pricing, manufacturing, growth, and intellectual property; many issues unique to biomedical products. Course Information: Previously listed as BIOE 402. Prerequisite(s): BIOE 250 or BME 250; and junior standing or above.

**BME 403. Quality Assurance for Medical Products. 2 or 3 hours.**

Requirements for current good manufacturing practices and quality assurance in the design and manufacture of medical devices. Course Information: 2 undergraduate hours. 3 graduate hours. Previously listed as BIOE 403. Prerequisite(s): BIOE 250 or BME 250; and junior standing or above.

**BME 407. Pattern Recognition I. 3 or 4 hours.**

The design of automated systems for detection, recognition, classification and diagnosis. Parametric and nonparametric decision-making techniques. Applications in computerized medical and industrial image and waveform analysis. Course Information: Same as ECE 407. 3 undergraduate hours. 4 graduate hours. Prerequisite(s): ECE 341 or BME 339 or IE 342 or STAT 381.

**BME 408. Medical Product Development. 2 or 3 hours.**

Bioentrepreneur course. Major stages of medical product development (investigative, feasibility, development, commercialization, maturation and growth), regulatory issues, product performance, failure mode and effect analysis, hazard analysis. Course Information: 2 undergraduate hours. 3 graduate hours. Previously listed as BIOE 408. Prerequisite(s): BIOE 250 or BME 250; and junior standing or above.

**BME 410. FDA and ISO Requirements for the Development and Manufacturing of Medical Devices. 3 or 4 hours.**

FDA Performance Standard for General Medical Devices for manufacturing and development engineers. Product requirement definition, design control, hazard analysis, failure mode and effect analysis, regulatory submission, product tests, ISO 9001. Course Information: 3 undergraduate hours. 4 graduate hours. Previously listed as BIOE 410. Prerequisite(s): BIOE 250 or BME 250; and junior standing or above.

**BME 415. Biomechanics. 3 or 4 hours.**

Continuum mechanics of cells, tissues and organs. Statics and force balances; stress, strain and constitutive relations; equilibrium, universal solutions and inflation; finite deformation; nonlinear problems; finite element methods. Course Information: 3 undergraduate hours. 4 graduate hours. Credit is not given for BME 415 if the student has credit in BIOE 415. Previously listed as BIOE 315. Prerequisite(s): BIOE 310 or BME 310.

**BME 421. Biomedical Imaging. 3 or 4 hours.**

Introduction to engineering and scientific principles associated with X-ray, magnetic resonance, ultrasound, computed tomographic and nuclear imaging. Course Information: 3 undergraduate hours. 4 graduate hours. Previously listed as BIOE 421. Credit is not given for BME 421 if the student has credit in BIOE 421. Prerequisite(s): MATH 220 and MATH 310.

**BME 422. Magnetic Resonance Imaging: Theory and Practice. 3 or 4 hours.**

Fundamental principles of magnetic resonance imaging (MRI) from a signal processing perspective. Focus on image acquisition, formation, and analysis. Course Information: 3 undergraduate hours. 4 graduate hours. Previously listed as BIOE 422. Prerequisite(s): BIOE 310 or BME 310 or ECE 310.

**BME 423. Biomedical Imaging Laboratory. 2 hours.**

Acquisition and processing of biomedical imaging data. Relaxation time-based magnetic resonance imaging, motion sensitive magnetic resonance imaging, computed tomography, ultrasound, nuclear medicine imaging and optical imaging. Course Information: Previously listed as BIOE 423. Extensive computer use required. Prerequisite(s): Credit or concurrent registration in BIOE 421 or BME 421.

**BME 452. Biocontrol. 3 or 4 hours.**

Considers the unique characteristics of physiological systems using the framework of linear systems and control theory. Static and dynamic operating characteristics, stability, and the relationship of pathology to control function. Course Information: 3 undergraduate hours. 4 graduate hours. Previously listed as BIOE 452. Prerequisite(s): BIOE 310 or BME 310.

**BME 455. Introduction to Cell and Tissue Engineering. 3 or 4 hours.**

Foundation of cell and tissue engineering covering cell technology, construct technology, and cell-substrate interactions. Emphasis in emerging trends and technologies in tissue engineering. Course Information: 3 undergraduate hours. 4 graduate hours. Previously listed as BIOE 455. Prerequisite(s): BIOE 460 or BME 460; and BIOS 320 or BIOS 343 or BIOS 452.

**BME 456. Cell & Tissue Laboratory. 2 hours.**

Includes polymer scaffold fabrication, microstamping biomolecules, cellular adhesion and proliferation assays, and immo/fluorescent tagging. Course Information: Previously listed as BIOE 456. Prerequisite(s): Credit or concurrent registration in BIOE 455 or Credit or concurrent registration in BME 455; or consent of the instructor.

**BME 460. Materials in Biomedical Engineering. 3 or 4 hours.**

Analysis and design considerations of problems associated with prostheses and other implanted biomedical devices. Course Information: 3 undergraduate hours. 4 graduate hours. Previously listed as BIOE 460. Prerequisite(s): CME 260; and BIOS 220 or BIOS 222 or BIOS 286 or BIOS 340 or PSCH 262 or CHEM 232.

**BME 462. Introduction to Dental Clinical Research and Technology. 3 or 4 hours.**

Dental implants, biomaterials, biomechanics, tissue engineering, oral surgery, orthodontics, endodontics, nanomedicine, simulators and ADEA certifications, digital dentistry, virtual and augmented reality. Course Information: 3 undergraduate hours. 4 graduate hours. Extensive computer use required. Prerequisite(s): CME 260; or consent of the instructor.

**BME 470. Biomedical Optics. 3 or 4 hours.**

Physical principles and instrumentation relevant to the use of light in biomedical research. Several current and developing clinical applications are explored. Course Information: 3 undergraduate hours. 4 graduate hours. Previously listed as BIOE 470. Prerequisite(s): PHYS 142.

**BME 471. Biomedical Optical Imaging. 3 or 4 hours.**

Fundamentals of light-matter interactions, geometric optics, nonlinear optics, ultra-fast lasers, photodetectors, light microscopy, super-resolution imaging, photoacoustic tomography, optical coherence tomography, functional optical imaging. Course Information: 3 undergraduate hours. 4 graduate hours. Credit is not give for BME 471 if the student has credit in BIOE 471. Previously listed as BIOE 471. Prerequisite(s): PHYS 142 and BIOS 110.

**BME 472. Models of the Nervous System. 3 or 4 hours.**

Mathematical models of neural excitation and nerve conduction, stochastic models and simulation of neuronal activity, models of neuron pools and information processing, models of specific neural networks. Course Information: 3 undergraduate hours. 4 graduate hours. Credit is not given for BME 472 if students have credit in BIOE 472. Previously listed as BIOE 472. Prerequisite(s): BIOE 310 or BME 310; and Credit or concurrent registration in BIOS 484.

**BME 475. Neural Engineering I: Introduction to Hybrid Neural Systems. 3 or 4 hours.**

Modeling and design of functional neural interfaces for in vivo and in vitro applications, electrodes and molecular coatings, neural prostheses and biopotential control of robotics. Course Information: Same as BIOS 475. 3 undergraduate hours. 4 graduate hours. Previously listed as BIOE 475. Prerequisite(s): BIOE 472 or BME 472.

**BME 476. Neural Engineering I Laboratory. 2 hours.**

Hands-on experience with computational and experimental models of engineered neural systems, with emphasis on neuroprostheses and biosensors. Course Information: Previously listed as BIOE 476. Animals used in instruction. Prerequisite(s): Credit or concurrent registration in BIOE 475 and BIOE 430 and BIOE 431; or Credit or concurrent registration in BME 475 and BME 322 and BME 323.

**BME 479. Wearables and Nearables Technology Laboratory. 3 or 4 hours.**

Practical experience in design and development of wearable and nearable devices. Acquisition and processing of sensors data. Design and development of user-friendly user interface. Course Information: Same as CS 479. 3 undergraduate hours; 4 graduate hours. Extensive computer use required. Prerequisite(s): BME 240; or CS 251; or consent of the instructor. Recommended background: ECE 210 and CS 109.

**BME 480. Intro to Bioinformatics. 3 or 4 hours.**

Computational analysis of genomic sequences and other high throughput data. Sequence alignment, dynamic programming, database search, protein motifs, cDNA expression array, and structural bioinformatics. Course Information: 3 undergraduate hours. 4 graduate hours. Credit is not given for BME 480 if the student has credit in BIOE 480. Prerequisite(s): BIOE 240 or BME 240; and BIOS 220 or BIOS 222 or CHEM 232.

**BME 481. Bioinformatics Laboratory. 2 hours.**

Teaches students how to use bioinformatics tools, including sequence alignment methods such as Blast, Fasta, and Pfam, as well as structural bioinformatics tools, such as Rasmol and CastP. Course Information: Extensive computer use required. Previously listed as BIOE 481. Credit is not given for BME 481 if the student has credit in BIOE 481. Prerequisite(s): Credit or concurrent registration in BME 480 or Credit in BIOE 480; and senior standing or above.

**BME 483. Molecular Modeling in Bioinformatics. 3 or 4 hours.**

Basic structural and dynamics tools in protein structure prediction, structure comparison, function prediction, Monte Carlo and molecular dynamics simulations. Course Information: 3 undergraduate hours. 4 graduate hours. Previously listed as BIOE 483. Prerequisite(s): Grade of B or better in BIOE 480 or Grade of B or better in BME 480.

**BME 494. Special Topics in Biomedical Engineering IV. 1-5 hours.**

Special topics to be arranged. Course topics aimed at fourth-year undergraduate and graduate students. Course Information: May be repeated. Students may register in more than one section per term. Previously listed as BIOE 494.

**BME 496. Undergraduate Senior Design Thesis I. 0-8 hours.**

Applying engineering design methodology to a large scale biomedical engineering design problem. Technical reports and presentations, literature survey and undergraduate thesis. Course Information: May be repeated. Credit only given to non-degree students. Extensive computer use required. Previously listed as BIOE 496. Prerequisite(s): Approval of the Department.

**BME 497. Undergraduate Senior Design Thesis II. 0-8 hours.**

Applying engineering design methodology to a large scale biomedical engineering design problem. Technical reports and presentations, literature survey and undergraduate thesis. Course Information: Credit only give to non-degree students. Previously listed as BIOE 497. Extensive computer use required. Prerequisite(s): Approval of the Department.