BME - Biomedical Engineering

Biomedical Engineering: BME

Lower-Division Courses

BME 303. Introduction to Computing.

Restricted to biomedical engineering majors. Introduction to computing and programming, focusing on high-level programming languages. Emphasis on programming skills using C++ and Python as well as data acquisition using open-source computer hardware. Emphasis is on biomedical engineering applications for computing. Three lecture hours and two recitation hours a week for one semester. Offered on the letter-grade basis only.

BME 303L. Introduction to Biomedical Engineering Design.

Restricted to biomedical engineering majors. Biomedical engineering design concepts with hands-on learning applications. Three lecture hours and three laboratory hours a week for one semester. Biomedical Engineering 102L and 203L, 303L may not both be counted. Offered on the letter-grade basis only.

BME 306. Fundamentals of Computing.

Restricted to biomedical engineering majors. Introduction to computing including bits and operations on bits, number formats, arithmetic and logic operations, digital logic. Explore the Von Neumann model of processing including memory, arithmetic logic unit, registers, and instruction decoding and execution. Examine structured programming and debugging, machine and assembly language programming, the structure of an assembler, physical input/output through device registers, subroutine call/return; trap instruction, stacks and applications of stacks. Three lecture hours a week for one semester. Additional lab hours to be arranged. Only one of the following may be counted: Biomedical Engineering 306, Electrical and Computer Engineering 306, 306H, Electrical Engineering 306, 306H. Offered on the letter-grade basis only. Prerequisite: Credit with a grade of at least C- or registration for Mathematics 408C or 408K.

BME 311. Network Analysis in Biomedical Engineering.

Restricted to biomedical engineering majors. Basic concepts in circuit analysis and design of systems for biomedical engineering; Ohm's law, Kirchhoff's laws, and nodal and loop analysis; Theyenin's and Norton's theorem; operational amplifiers; high-order circuit and basic AC circuit analysis using Fourier and Laplace transforms. Three lecture hours a week for one semester. Only one of the following may be counted: Biomedical Engineering 311, Electrical and Computer Engineering 411, 411H, Electrical Engineering 411. Offered on the letter-grade basis only. Prerequisite: Physics 303K with a grade of at least C-; and credit with a grade of at least C- or registration for: Mathematics 427J and Physics 303L.

BME 313L. Introduction to Numerical Methods in Biomedical Engineering.

Restricted to biomedical engineering majors. Introduces principles and techniques of numerical analysis of biomedical engineering problems. Examines numerical methods of integration, differentiation, interpolation, curve fitting, data analysis, sampling and estimation, error analysis, analysis of ordinary differential equations, numerical modeling of biomedical engineering systems, symbolic computation, and scientific visualization. Three lecture hours and three laboratory hours a week for one semester. Only one of the following may be counted: Aerospace Engineering 211K, 311, Biomedical Engineering 313L, Computational Engineering 211K, 311K. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 303 or Computational Engineering 301, Biomedical Engineering 303L, and Mathematics 427J.

BME 214L. Computational Fundamentals of Biomedical Engineering Design.

Restricted to biomedical engineering majors. Overview of computational methods used to model biomedical systems, analyze data, and assist in the engineering design process. Subjects and hands-on learning applications include 3D modeling tools and computer aided manufacturing, flow simulation, instrumentation, biomedical imaging modalities, and biomedical informatics. Two lecture hours and three laboratory hours a week for one semester. Biomedical Engineering 314 and 214L may not both be counted. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 303 or Computational Engineering 301, Biomedical Engineering 303L, Physics 303K, and Physics 103M or 105M; and credit with a grade of at least C- or registration for: Biomedical Engineering 311 or Electrical and Computer Engineering 411 (or Electrical Engineering 411), Mathematics 427J, Physics 303L, and Physics 103N or 105N.

Upper-Division Courses

BME 320. International Perspectives on Biomedical Engineering Design.

Activities to consider sociotechnical factors in designing clinically translatable solutions with a focus on international perspectives. Three lecture hours a week for one semester. Biomedical Engineering 320 and 377T (Topic: International Perspectives on Biomedical Engineering Design) may not both be counted.

BME 129S, 229S, 329S, 429S, 529S, 629S, 729S, 829S, 929S. Topics in Biomedical Engineering.

This course is used to record credit the student earns while enrolled at another institution in a program administered by the University's Study Abroad Office. Credit is recorded as assigned by the study abroad adviser in the Department of Biomedical Engineering. University credit is awarded for work in an exchange program; it may be counted as coursework taken in residence. Transfer credit is awarded for work in an affiliated studies program. May be repeated for credit when the topics vary. Offered on the letter-grade basis only.

BME 333T. Engineering Communication.

Restricted to biomedical engineering majors. Advanced communication skills for engineers, with emphasis on biomedical engineering topics. Strategies for written, visual, and interpersonal communication, and for oral presentation. Introduction to library research and to ethical decision making in biomedical engineering. Three lecture hours and one recitation hour a week for one semester. Only one of the following may be counted: Aerospace Engineering 333T, Biomedical Engineering 333T, Chemical Engineering 333T, Civil Engineering 333T, Communication 333T, Electrical and Computer Engineering 333T, Electrical Engineering 333T, Engineering Studies 333T, Mechanical Engineering 333T, Petroleum and Geosystems Engineering 333T. Offered on the letter-grade basis only. Prerequisite: English 303C (or 603A) or Rhetoric and Writing 306 with a grade of at least C-.

BME 335. Engineering Probability and Statistics.

Restricted to biomedical engineering majors. Fundamentals of probability, random processes, and statistics with emphasis on biomedical engineering applications. Includes hypothesis testing, regression, and sample size calculations. The equivalent of four lecture hours a week for one semester. Offered on the letter-grade basis only.

Prerequisite: Biomedical Engineering 303 or Computational Engineering 301, and Mathematics 408D or 408M with a grade of at least C- in each.

BME 336. Cancer Bioengineering.

Restricted to biomedical engineering majors. Comprehensive overview of the biology and pathology of cancer. Emphasis on the fundamental nature of cancer, the roles of genetics and the environment, and the contributions of heterotypic tissues in the tumor microenvironment. Exploration of current challenges in the field and ways that various engineering tools are transforming the future of cancer research. Three lecture hours a week for one semester. Biomedical Engineering 336 and 377T (Topic: Cancer Bioengineering) may not both be counted. Prerequisite: Upper-division standing, Biochemistry 369 and Biology 311C or 315H with a grade of at least C- in each.

BME 337. Nanomedicine.

Restricted to biomedical engineering majors. Explore the fundamental properties, synthesis, and characterization of nanomaterials, including their applications in nanomedicine. Discuss micro- and nano-particles for drug delivery and imaging, microfluidics for in vitro diagnostics and biological systems modeling, and nanomaterials and platforms for biological applications. Examine biomedical applications such as cancer, cardiovascular disease, and infectious diseases. Three lecture hours a week for one semester. Biomedical Engineering 337 and 377T (Topic: Nanomedicine) may not both be counted. Prerequisite: Biomedical Engineering 349 and 352 with a grade of at least C- in each.

BME 338. Thin Film Mechanics.

Restricted to biomedical engineering majors. Examine mechanical testing, design, and failure analysis of thin film structures and devices, with an emphasis on mechanics-related subjects including stress, fracture, delamination, and instability. Explore important technological applications of film materials, including integrated circuits, micro- and nano-electromechanical systems, flexible and stretchable electronics, bioelectronics, and surface coatings. Three lecture hours a week for one semester. Prerequisite: Biomedical Engineering 349 and 352 with a grade of at least C- in each.

BME 339. Biochemical Engineering.

Restricted to biomedical engineering majors. Principles of fermentation and cell culture technologies; introduction to recombinant DNA technology and protein expression; the development of therapeutics, vaccines, and diagnostics using genetic engineering. The equivalent of four lecture hours a week for one semester. Only one of the following may be counted: Biology 335, Biomedical Engineering 339, Chemical Engineering 339, 344, 379 (Topic: Introduction to Biochemical Engr). Prerequisite: Upper-division standing, Biochemistry 369 and Biology 311C or 315H with a grade of at least C- in each.

BME 340. Soft Tissue Biomechanics.

Restricted to biomedical engineering majors. Explore soft tissues and soft tissue mechanics. Examine fundamentals of continuum mechanics (kinematics, stress, balance of linear momentum, hyperelasticity), experimental and nonlinear finite element analysis of soft tissue mechanics, and relevant imaging modalities and facilities available on campus. Three lecture hours a week for one semester. Biomedical Engineering 340 and 377T (Topic: Soft Tissue Biomechanics) may not both be counted. Prerequisite: Biomedical Engineering 352 and 353 with a grade of at least C- in each; and consent of instructor.

BME 342. Biomechanics of Human Movement.

Restricted to biomedical engineering majors. Modeling and simulation of human movement; neuromuscular control; computer applications; introduction to experimental techniques. Three lecture hours a week for one semester. Biomedical Engineering 342 and Mechanical Engineering 354M may not both be counted. Prerequisite: Biomedical Engineering 344 or Engineering Mechanics 319 with a grade of at least C-.

BME 343. Biomedical Engineering Signal and Systems Analysis.

Restricted to biomedical engineering majors. Signals and systems representation; sampling and quantization; time and frequency domains; Laplace and z-transforms, transfer functions, and frequency response; two-port networks; Bode plots; convolution; stability; Fourier series; Fourier transform; AM/FM modulation; filter design; and applications in biomedical engineering. Three lecture hours a week for one semester. Only one of the following may be counted: Biomedical Engineering 343, Electrical and Computer Engineering 313, 313H, Electrical Engineering 313. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 311 or Electrical and Computer Engineering 411 (or Electrical Engineering 411), Biomedical Engineering 313L or Computational Engineering 311K, and Mathematics 427J.

BME 344. Biomechanics.

Restricted to biomedical engineering majors. Examine the principles of engineering mechanics and their applications to basic problems in biomechanics and biomedical engineering. Explore internal forces and deformations in solids, including stress, strain, tension, compression, torsion, bending, internal pressure, and failure analysis under combined mechanical loading. Three lecture hours a week for one semester. Biomedical Engineering 344 and 377T (Topic: Biomechanics) may not both be counted. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 303L, Mathematics 427J, and Physics 303K.

BME 345. Graphics and Visualization Laboratory.

Restricted to biomedical engineering majors. Introduction to techniques for graphical display of biological data. Subjects include transformations, geometric modeling, and two- and three-dimensional display algorithms. Includes computational projects with biomedical applications. Three lecture hours a week for one semester. Prerequisite: Electrical and Computer Engineering 422C (or Electrical Engineering 422C) and Mathematics 340L or 341 with a grade of at least C- in each.

BME 245L. Experimental Principles of Biomedical Engineering Design.

Restricted to biomedical engineering majors. Exploration of biomedical engineering design principles through open-ended, hands-on research applications involving mechanical testing, cell culture, and biomaterials. Analysis and interpretation of experimental data, including written reporting of outcomes in scientific journal format. Two lecture hours and two laboratory hours a week for one semester. Biomedical Engineering 221 and 245L may not both be counted. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biology 206L, Biomedical Engineering 214L, Biomedical Engineering 335 or Mechanical Engineering 335, Biomedical Engineering 344 or Engineering Mechanics 319, and one of the following: Aerospace Engineering 333T, Biomedical Engineering 333T, Chemical Engineering 333T, Civil Engineering 333T, Communication 333T, Electrical and Computer Engineering 333T (or Electrical Engineering 333T), Engineering Studies 333T, Mechanical Engineering 333T, or Petroleum and Geosystems Engineering 333T.

BME 346. Computational Biomolecular Engineering.

Restricted to biomedical engineering majors. Introduction to computational structural biology and molecular modeling, including the fundamentals of biomolecular structure and molecular thermodynamics. The principles and applications of biomolecular modeling used to explore the critical relationship between structure, function, and thermodynamic

driving forces in molecular biology. Three lecture hours a week for one semester. Prerequisite: The following coursework with a grade of at least C-: Biochemistry 369, Biology 311C or 315H, Biomedical Engineering 313L or Computational Engineering 311K, and one of the following: Biomedical Engineering 355, Chemistry 353 or 353M.

BME 347. Fundamentals of Biomedical Optics.

Restricted to biomedical engineering majors. Introduction to the field of biophotonics. Subjects include light scattering theory, tissue optical properties, analytical and numerical techniques for determining light propagation in tissue, light-tissue interactions, and bioheat transfer including solution methods. Three lecture hours a week for one semester. Biomedical Engineering 347 and 377T (Topic: Fundamentals of Biomedical Engineering Optical Imaging) may not both be counted. Prerequisite: Biomedical Engineering 353 with a grade of at least C-.

BME 348. Modeling of Biomedical Engineering Systems.

Restricted to biomedical engineering majors. Lumped and distributed models of physiological system function from molecular through organismal levels. Linear system steady-state and transient behaviors. Interactions among multiple energy domains, including electrical, chemical, diffusional, mechanical, fluid, and thermal. Introduction to feedback control. Three lecture hours and two laboratory hours a week for one semester. Prerequisite: Biomedical Engineering 214L, and Biomedical Engineering 343 or Electrical and Computer Engineering 313 (or Electrical Engineering 313) with a grade of at least C- in each.

BME 348P. Introduction to Computational and Systems Biology.

Restricted to biomedical engineering majors. Introduction to big data technology platforms, data science analytical algorithms and artificial intelligence in computational biology and medicine and network science. Examine DNA sequence alignment and search, high-throughput big data platforms and analysis, network science, multi-omics profiling, statistics, motif finding, molecular structure prediction, genome-wide association studies, artificial intelligence, and personalized precision medicine. Explore computational algorithms including hidden Markov model, clustering, classification methods, and others. Three lecture hours a week for one semester. Only one of the following may be counted: Biomedical Engineering 348P, 377T (Topic: Intro to Comp/Systems Bio), Chemistry 368 (Topic: Intro to Comp/Systems Bio), Computer Science 378 (Topic: Intro to Comp/Systems Bio). Prerequisite: The following coursework with a grade of at least C- in each: Biochemistry 369, Biology 311C or 315H, Biomedical Engineering 335 or Mechanical Engineering 335, and Biomedical Engineering 343 or Electrical and Computer Engineering 313 (or Electrical Engineering 313).

BME 349. Biomedical Instrumentation.

Restricted to biomedical engineering majors. Introduction to biomedical instrumentation, design, and applications. Emphasis on the complete instrumentation development cycle, design for bio-compatibility, safety and efficacy, and design considerations specific to various medical specialties. Three lecture hours a week for one semester. Offered on the letter-grade basis only. Prerequisite: Biomedical Engineering 343 or Electrical and Computer Engineering 313 (or Electrical Engineering 313) with a grade of at least C-.

BME 350. Computational Methods for Biomedical Engineers.

Restricted to biomedical engineering majors. Study of and hands-on experiences with computational methods commonly employed in biomedical engineering research. Three lecture hours a week for one semester. Biomedical Engineering 350 and 377T (Topic: Computational Methods for Biomedical Engineers) may not both be counted. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 313L or Computational Engineering 311K, Biomedical Engineering 214L, and Biomedical Engineering 335 or Mechanical Engineering 335.

BME 352. Engineering Biomaterials.

Restricted to biomedical engineering majors. Overview of properties of metallic, ceramic, polymeric, and composite biomaterials used in biomedical applications. Material synthesis and processing. Analysis of mechanical and chemical properties, including stress-strain. Material interactions with the body and blood. Soft and hard biomaterials applications. Three lecture hours a week for one semester. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biochemistry 369, and Biomedical Engineering 344 or Engineering Mechanics 319.

BME 353. Transport Phenomena in Living Systems.

Restricted to biomedical engineering majors. Introduction to the principles of heat, mass and momentum transfer and their application to solve problems in living systems. Three lecture hours a week for one semester. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 311 or Electrical and Computer Engineering 411 (or Electrical Engineering 411); Biomedical Engineering 214L; Mathematics 427J; Physics 303L; and Physics 103N or 105N.

BME 354. Molecular Sensors and Nanodevices for Biomedical Engineering Applications.

Restricted to biomedical engineering majors. Introduction to major types of molecular sensor systems, device miniaturization, and detection mechanisms, including molecular capture mechanisms; electrical, optical, and mechanical transducers; micro-array analysis of biomolecules; semiconductor and metal nanosensors; microfluidic systems; and microelectromechanical systems (MEMS, BioMEMS) fabrication and applications for biomedical engineering. Three lecture hours a week for one semester. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 313L or Computational Engineering 311K, Biomedical Engineering 335 or Mechanical Engineering 335, and Biomedical Engineering 344 or Engineering Mechanics 319.

BME 355. Molecular Engineering.

Restricted to biomedical engineering majors. Working principles of biomolecules such as proteins and nucleic acids. Physical and chemical basis for biomolecular structure, energetics, and function. Three hours of lecture a week for one semester. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biochemistry 369; Biology 311C or 315H; Mathematics 427J; Physics 303L; and Physics 103N or 105N.

BME 356. Polymer and Bioconjugate Chemistry.

Restricted to biomedical engineering majors. Introduction to synthetic principles of polymeric biomaterials and bioconjugate chemistry with an emphasis on synthetic strategies to achieve specific properties. Explores characterization methods of polymers and bioconjugates as a function of chemical composition, as well as tissue engineering and drug delivery applications as case studies of the biomaterial design process. Three lecture hours a week for one semester. Biomedical Engineering 356 and 377T (Topic: Polymer/Bioconjugate Chem) may not both be counted. Prerequisite: Biomedical Engineering 352 or Chemical Engineering 350 with a grade of at least C-.

BME 357. Biomedical Imaging Modalities.

Restricted to biomedical engineering majors. Introduction to major biomedical imaging modalities, including X-ray radiography, computed tomography (CT), nuclear medicine (SPECT and PET), magnetic resonance imaging (MRI), and ultrasound. Emphasis on principles,

approaches, and applications of each imaging modality. Basic physics and imaging equations of the imaging system; hardware and software; sources of noise and primary artifacts; safety and patient risk. Three lecture hours and two laboratory hours a week for one semester. Prerequisite: Biomedical Engineering 349 and 261L with a grade of at least C- in each.

BME 358. Medical Decision Making.

Restricted to biomedical engineering majors. Understanding of the nature of expertise and related subjects of cognitive psychology and human-made interaction to be able to design more effective systems for supporting medical decision making. Three lecture hours a week for one semester. Biomedical Engineering 358 and 377T (Topic: Medical Decision Making) may not both be counted. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 313L or Computational Engineering 311K, Biomedical Engineering 214L, and Biomedical Engineering 335 or Mechanical Engineering 335.

BME 358M. Imaging Clinical Immersion.

Restricted to biomedical engineering majors. Identify current unmet clinical needs via close interaction with healthcare professionals and patients. Explore biomedical imaging across the healthcare enterprise. Three lecture hours a week for one semester. Biomedical Engineering 358M and 377T (Topic: Imaging Clinical Immersion) may not both be counted. Prerequisite: Consent of instructor.

BME 359. Cellular and Molecular Biomechanics.

Restricted to biomedical engineering majors. Introduction to the concepts needed to understand and work in the emerging field of cellular and molecular biomechanics. Examination of dynamic interplay between chemical, thermal, and physical forces in determining the mechanics of cells/tissues and their molecular components. Three lecture hours a week for one semester. Prerequisite: Biomedical Engineering 344 or Engineering Mechanics 319, and Biomedical Engineering 353 with a grade of at least C- in each.

BME 261L. Development and Analysis in Biomedical Engineering Design.

Restricted to biomedical engineering majors. The design and development of a working biomedical engineering device prototype. Focus on the full engineering design process, including reviews and documentation, and general project management strategies. Also considers the impact of markets, budgets, and the FDA on device requirements and design. Two lecture hours and three laboratory hours a week for one semester. Biomedical Engineering 251 and 261L may not both be counted. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 343 or Electrical and Computer Engineering 313 (or Electrical Engineering 313), and Biomedical Engineering 245L.

BME 362. Introduction to Nonlinear Dynamics in Biological Systems.

Restricted to biomedical engineering majors. Introduction to various concepts from nonlinear mathematics and their application to biological systems, ranging from sub-cellular to whole ecosystems levels of investigation. Three lecture hours a week for one semester. Biomedical Engineering 362 and 377T (Topic: Introduction to Nonlinear Dynamics in Biological Systems) may not both be counted. Prerequisite: Biomedical Engineering 313L or Computational Engineering 311K, and Biomedical Engineering 344 or Engineering Mechanics 319 with a grade of at least C- in each.

BME 362E. Medical Device Innovation.

Money, markets, and entrepreneurship with particular focus on medical and health markets. Two lecture hours a week for one semester. Additional hours to be arranged. Biomedical Engineering 362E and 277T (Topic: Medical Device Innovation: From Lab to Marketplace) may not both be counted.

BME 363. Bioelectronics and Biointerfaces.

Restricted to biomedical engineering majors. Examine critical concepts and strategies in materials development, electronics fabrication and genetic innovations that interface with biological systems. Explore neural interfacing technology, flexible electronics, wearable technology, bio-nanotechnology, and genetic engineering. Focus on the recently developed technology for recording and manipulating neural systems. Three lecture hours a week for one semester. Biomedical Engineering 363 and 377T (Topic: Bioelectronics/Biointerfaces) may not both be counted. Prerequisite: Biomedical Engineering 349 and 352 with a grade of at least C- in each.

BME 363E. Medical Device Design and Manufacturing.

Restricted to biomedical engineering majors. Application of engineering principles in the conception, design and prototyping of medical devices. Development of team projects with emphasis on clinical and market needs analysis, creative and useful concept generation, engineering requirements and specifications, and written and oral reporting of intermediate and final prototype outcomes. Three lecture hours a week for one semester. Only one of the following may be counted: Biomedical Engineering 363E, 377T (Topic: Medical Device Design and Manufacturing), Mechanical Engineering 371D, 379M (Topic: Medical Device Design and Manu). Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 349, 353, and 261L.

BME 364. Biological Responses to Medical Devices.

Restricted to biomedical engineering majors. Explore common biological responses elicited by biomaterials and the impact of these responses on material performance. Emphasis on key challenges in the development and assessment of biomaterials used in medical devices. Includes material surface properties, modification, and characterization; protein/cell interactions with materials; biocompatibility, inflammation and wound healing, cell-mediated biodegradation of materials; thrombosis, infection and calcification of medical devices. Three lecture hours a week for one semester. Biomedical Engineering 364 and 377T (Topic: Biol Responses to Medical Dev) may not both be counted. Prerequisite: Biomedical Engineering 352 with a grade of at least C-.

BME 365. Tissue Microenvironments.

Restricted to biomedical engineering majors. Introduction to, and hands-on applications for, fabrication/bioprinting of tissues on a chip and characterization of mechanical, thermal, transport, and cellular/tissue responses to varying properties of associated microenvironments. Three lecture hours a week for one semester. Biomedical Engineering 365 and 377T (Topic: Tiss Microenv Fab/Tran/Mech) may not both be counted. Prerequisite: Biomedical Engineering 352 and 353 with a grade of at least C- in each.

BME 365R. Quantitative Engineering Physiology I.

Restricted to biomedical engineering majors. A quantitative, model-oriented approach to human physiology, including basic cellular physiology, electrophysiology of nerve and muscle, the motor system, the central nervous system, and the cardiovascular system. The equivalent of four lecture hours a week for one semester. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biology 311C or 315H, Biomedical Engineering 214L, Physics 303L, and Physics 103N or 105N; and credit with a grade of at least C- or registration for: Biochemistry 369 and Biomedical Engineering 343 or Electrical and Computer Engineering 313 (or Electrical Engineering 313).

BME 365S. Quantitative Engineering Physiology II.

Restricted to biomedical engineering majors. Biological control systems: sensory, renal, respiratory, and immune systems. Focuses on a quantitative, model-oriented approach to physiological systems. Three lecture hours a week for one semester. Offered on the letter-grade basis only. Prerequisite: Biomedical Engineering 365R with a grade of at least C-.

BME 366. Immune Engineering.

Restricted to biomedical engineering majors. Introduction to various aspects and applications of immune engineering. Subjects include vaccine design, cancer immunotherapy, genomics, infection, auto-immune diseases and emerging tools and methodologies. Three lecture hours a week for one semester. Biomedical Engineering 366 and 377T (Topic: Immune Engineering) may not both be counted. Prerequisite: Biomedical Engineering 365R and 365S with a grade of at least C- in each.

BME 367. Design of Artificial Organs.

Restricted to biomedical engineering majors. Analysis of the design process for blood-contacting medical devices with an emphasis on ventricular assist devices. Application of computational fluid dynamics and blood rheology to computer-aided design and testing of devices using specific software programs and 3D printing of functioning prototypes. Three lecture hours a week for one semester. Biomedical Engineering 367 and 377T (Topic: Design of Artificial Organs) may not both be counted. Prerequisite: Credit with a grade of at least C- or registration for Biomedical Engineering 353 and 365R.

BME 368. Introduction to Mathematical and Physical Biology.

Restricted to biomedical engineering majors. Introduction to common mathematical and physical techniques used in modeling various aspects of biology at multiple spatial and temporal scales. Analyze critical techniques with words and pictures, and then equations including the computational implementation and simulation of those equations. Three lecture hours a week for one semester. Biomedical Engineering 368 and 377T (Topic: Intro Mathematical & Phys Bio) may not both be counted. Prerequisite: Biomedical Engineering 343 or Electrical and Computer Engineering 313 (or Electrical Engineering 313) with a grade of at least C-.

BME 369. Biomimetic Design and Engineering.

Restricted to biomedical engineering majors. Overview of the core concepts of biomimetic microengineering with particular focus on engineered microphysiological models of human organs, tissues and disease pathophysiology. Three lecture hours a week for one semester. Biomedical Engineering 369 and 377T (Topic: Biomimetic Dsgn/Engineering) may not both be counted. Prerequisite: Upper-division standing, Biochemistry 369 and Biology 311C or 315H with a grade of at least C- in each.

BME 369C. Matrices, Organoids, and Microphysiological Systems.

Restricted to biomedical engineering majors. Explore current technologies and scientific literature seeking to construct human-relevant, in vitro systems representing tissues, organs, and disease physiologies as platforms for development of new therapies. Focus on how concepts in biomaterials, stem cell biology, microfluidics, additive manufacturing, and biosensing are integrated to create such platforms. Three lecture hours a week for one semester. Biomedical Engineering 369C and 377T (Topic: Matrices/Organs/Microphys Sys) may not both be counted. Prerequisite: Biomedical Engineering 352 and 365S with a grade of at least C- in each.

BME 370. Biomedical Engineering Capstone Design I.

Restricted to biomedical engineering majors. Structured methodologies for designing systems or to interface with living systems. Creative design, analysis, selection, development, and fabrication of biomedical components and systems. Three lecture hours and two laboratory hours a week for one semester. Offered on the letter-grade basis only. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 349, 352, 353, 261L, and 365S.

BME 371. Biomedical Engineering Capstone Design II.

Restricted to biomedical engineering majors. Development of team projects in biomedical engineering with emphasis on prototype development and quantitative analysis, and written and oral reporting of the outcome. Two lecture hours and four laboratory hours a week for one semester. Offered on the letter-grade basis only. Prerequisite: Biomedical Engineering 370 with a grade of at least C-.

BME 372. Computational Modeling of the Cardiovascular System.

Restricted to biomedical engineering majors. Analyze mathematical models and simulations of the cardiovascular system. Examine biomechanical simulations including the biomechanical function of the heart, heart valves, and the vasculature. Three lecture hours a week for one semester. Biomedical Engineering 372 and 377T (Topic: Comput Modlg: Cardiovasc Sys) may not both be counted. Prerequisite: Biomedical Engineering 349 and 365R with a grade of at least C- in each.

BME 372P. Mathematical Physiology.

Restricted to biomedical engineering majors. Explore mathematical modeling in human physiology. Focus on how physiological problems can be formulated and modeled, and how such models give rise to interesting and challenging functional features. Examine several exemplar physiological systems and discuss the mathematical aspects of growth and remodeling in living systems, an area unique to living systems. Three lecture hours a week for one semester. Biomedical Engineering 372P and 377T (Topic: Mathematical Physiology) may not both be counted. Prerequisite: Biomedical Engineering 349 and 365S with a grade of at least C- in each and consent of instructor.

BME 373. Tissue, Scaffold, and Cell Biomechanics Applications.

Restricted to biomedical engineering majors. Fundamentals of biosolid mechanics via the mechanical behavior of scaffolds and living tissues and cells. Emphasis on biomechanical applications to contemporary problems in biomedical research and medical devices. Three hours of lecture a week for one semester. Biomedical Engineering 373 and 377T (Topic: Cell, Tissue and Scaffold Biomechanics for Contemporary Biomedical Engineering Applications) may not both be counted. Prerequisite: The following coursework with a grade of at least C-: Biomedical Engineering 313L or Computational Engineering 311K, Biomedical Engineering 335 or Mechanical Engineering 335, Biomedical Engineering 344 or Engineering Mechanics 319, Biomedical Engineering 353, 365R, and 365S.

BME 374. Optical Design.

Restricted to biomedical engineering majors. Explore the principles of optical design for imaging and laser delivery systems. Examine the development and testing of designs using optical design software. Three lecture hours a week for one semester. Biomedical Engineering 374 and 377T (Topic: Optical Design) may not both be counted. Prerequisite: Biomedical Engineering 343 or Electrical and Computer Engineering 313 (or Electrical Engineering 313) with a grade of at least C-.

BME 374K. Biomedical Instrument Design.

Restricted to biomedical engineering and mechanical engineering majors. Application of electrical engineering principles in the design of electronic instrumentation at the circuit-board level for the measurement of pressure, temperature, flow, and impedance. Also includes the study of light intensity, bioelectric potentials, and stimulation devices such as pacemakers and defibrillators. Focus on design considerations specific to electro-medical environments, safety and efficacy, and public policy issues. Three lecture hours a week for one semester. Prerequisite: Electrical and Computer Engineering 438 (or Electrical Engineering 438) with a grade of at least C-.

BME 374L. Applications of Biomedical Instrumentation Lab.

Restricted to biomedical engineering and mechanical engineering majors. An in-depth examination of selected subjects in biomedical engineering, including optical and thermal properties of laser interaction with tissue; measurement of perfusion in the microvascular system; diagnostic imaging; interaction of living systems with electromagnetic fields; robotic surgical tools; ophthalmic instrumentation; and noninvasive cardiovascular measurements. Students have the opportunity to design analog and digital measurements and acquire and process meaningful biomedical signals. Three lecture hours and six laboratory hours a week for one semester. Prerequisite: One of the following with a grade of at least C-: Biomedical Engineering 349, 374K, Electrical and Computer Engineering 438 (or Electrical Engineering 438), or Electrical and Computer Engineering 374K (or Electrical Engineering 374K).

BME 375. Stem Cells in Cell and Tissue Engineering.

Restricted to biomedical engineering majors. Analysis of recent cell and tissue engineering applications of human embryonic stem cells (hESC) and induced pluripotent stem cells (iPSC). Focus on case studies of each organ in the human body and how it can be engineered using stem cells. Three lecture hours a week for one semester. Biomedical Engineering 375 and 377T (Topic: Stem Cells in Cell and Tissue Engineering) may not both be counted. Prerequisite: Biomedical Engineering 352 and 365S with a grade of at least C- in each.

BME 376. Cell Engineering.

Restricted to biomedical engineering majors. Introduction to principles that govern the structure, organization, and processes at cellular and subcellular levels. Special focus on engineering and quantitative aspects of cellular machinery. Employs engineering approaches to study receptors, macromolecular complexes, and cellular signaling; clinical and pharmaceutical approaches to perturb cellular structure and function for disease prevention and drug design. State-of-the-art experimental and computational techniques to study cellular engineering. Three lecture hours a week for one semester. Prerequisite: Upper-division standing, Biochemistry 369 and Biology 311C or 315H with a grade of at least C- in each.

BME 177, 277, 377. Undergraduate Research Project.

Initiate opportunity individually and select project in conjunction with a faculty member on the Department of Biomedical Engineering's Graduate Studies Committee (GSC) or in another approved University department. A final written report or the equivalent is required. Recommended for students considering graduate study or medical school. Three, six, or nine laboratory hours a week for one semester.

BME 377M. Medical Internship.

Restricted to biomedical engineering majors. Initiate opportunity individually, which may include participation in a variety of medical and clinical activities which apply engineering principles to solve problems in healthcare. A substantial final report or the equivalent is required. Designed for students considering medical school. The equivalent of three lecture hours a week for one semester.

BME 377R. Off-Campus Research.

Restricted to biomedical engineering majors. Initiate opportunity individually and select project in conjunction with a faculty member at an approved institution. A final written report or the equivalent is required. The equivalent of three lecture hours a week for one semester.

BME 377S. Industrial Internship.

Restricted to biomedical engineering majors. Practical work experience in industry or a government agency under the supervision of an engineer, scientist or business professional. A substantial final report or the equivalent is required. The equivalent of three lecture hours a week for one semester.

BME 177T, 277T, 377T. Topics in Biomedical Engineering.

Restricted to biomedical engineering majors. For each semester hour of credit earned, the equivalent of one lecture hour a week for one semester. May be repeated for credit when the topics vary. Prerequisite: Prerequisites vary with the topic.

BME 678. Undergraduate Thesis in Biomedical Engineering.

Restricted to biomedical engineering majors. Research performed during two consecutive semesters under the supervision of a biomedical engineering faculty member or other approved faculty member; topics are selected jointly by the student and faculty member. The student provides a progress report at the end of the first semester and writes a thesis and gives an oral presentation at the end of the second semester. Individual instruction for two semesters. Students pursuing both the Bachelor of Arts, Plan II, and a Bachelor of Science in Biomedical Engineering may use this course to fulfill the thesis requirements for the Bachelor of Arts, Plan II. Prerequisite: For 678A, admission to the major sequence in biomedical engineering and a University grade point average of at least 3.50; for 678B, a University grade point average of at least 3.50 and Biomedical Engineering 678A.

BME 379. Tissue Engineering.

Restricted to biomedical engineering majors. Introduction to biomedical research in tissue engineering. Includes case studies of tissues and organs of the body, physiology and biology of tissue, pathologies of tissue, current clinical treatments, the role of engineers in development of new technologies to diagnose and treat pathologies, quantitative cellular and molecular techniques, and applications of synthetic and natural biomaterials. Three lecture hours a week for one semester. Only one of the following may be counted: Biomedical Engineering 379, Chemical Engineering 339T, 379 (Topic: Cell and Tissue Engineering). Prerequisite: Biomedical Engineering 352 and 365S with a grade of at least C- in each.

BME 679H. Undergraduate Honors Thesis.

Restricted to biomedical engineering majors. Research performed during two consecutive semesters under the supervision of an engineering faculty member; topics are selected jointly by the student and the faculty member with approval by the director of the Engineering Honors Program. The student makes an oral presentation and writes a thesis. Individual instruction for two semesters. Students pursuing both the Bachelor of Arts, Plan II, and a bachelor's degree in engineering may use this course to fulfill the thesis requirement for the Bachelor of Arts, Plan II. Prerequisite: For 679HA, enrollment in the Engineering Honors Program; for 679HB, Biomedical Engineering 679HA and enrollment in the Engineering Honors Program.

Graduate Courses

BME 180J, 380J. Fundamentals of Biomedical Engineering.

One or three lecture hours a week for one semester, or as required by the topic. May be repeated for credit when the topics vary. Prerequisite: Graduate standing.

Topic 1: Mathematical Modeling in Biomedical Engineering. Conservation of mass, momentum, energy, and charge; first and second laws of thermodynamics; first- and second-order differential equations; nonlinear differential equations; partial differential equations as applied to biomedical engineering problems.
Topic 2: Quantitative Systems Physiology and Pathophysiology. Modeling of physiological systems from the molecular and cellular levels to the systems level; focus on the neuromuscular and cardiovascular systems. Prerequisite: An undergraduate physiology course or the equivalent, and consent of instructor.
Topic 3: Principles of Biomeasurement. Principles of signal measurement in the biomedical field; survey of transducers used for chemical, mechanical, electrical, and thermal biomedical measurements; analysis of how signals are converted into digital form; analysis of noise; aliasing; data storage.
Topic 4: Fields, Forces, and Flows. Introduction to mathematical models that integrate different energy domains and length scales, with an emphasis on the coupling between them. Prerequisite: Biomedical Engineering 380J (Topic 1) and 380J (Topic 2).
Topic 5: Biostatistics, Study Design, and Research Methodology. Principles for hypothesis testing; confidence limits; regression analysis; correlation; analysis of variance; experimental design and factorial analysis; discriminate analysis; applications of statistics. Prerequisite: An undergraduate probability theory course or the equivalent, and consent of instructor.
Topic 6: Analysis of Biomedical Engineering Systems I. Quantitative examination of the cardiovascular and respiratory systems from the cell to system levels. Presents the cardiovascular and respiratory systems in three phases: (1) anatomy and physiology; (2) energetics (thermodynamics), cellular processes, and engineering analysis; and (3) engineered devices, instrumentation, and imaging for therapeutics and diagnosis. Additional prerequisite: A course in physiology, proficiency in MATLAB, and consent of the graduate adviser.
Topic 7: Analysis of Biomedical Engineering Systems II. Computational techniques used in biomedical engineering. Students propose and conduct an engineering design study relevant to a selected medical problem. Additional prerequisite: Biomedical Engineering 380J (Topic 6).

BME 080M. Dual MD/PhD Program with UT Medical Branch.

Preclinical medical study at the University of Texas Medical Branch at Galveston. May not be taken concurrently with another course at the University of Texas at Austin. Prerequisite: Graduate standing and admission to the MD/PhD dual degree program in biomedical engineering.

BME 381J. Topics in Cell and Molecular Imaging.

Three lecture hours a week for one semester, or as required by the topic. May be repeated for credit when the topics vary. Prerequisite: Graduate standing in engineering and consent of instructor; additional prerequisites vary with the topic.

Topic 1: Laser-Tissue Interaction: Thermal. Same as Electrical and Computer Engineering 385J (Topic 9). The thermal response of random media in interaction with laser irradiation. Calculation of the rate of heat production caused by direct absorption of the laser light, thermal damage, and ablation. Only one of the following may be counted: Biomedical Engineering 381J (Topic 1), Electrical and Computer Engineering 385J (Topic 9), Electrical Engineering 385J (Topic 9).
Topic 2: Laser-Tissue Interaction: Optical. Same as Electrical and Computer Engineering 385J (Topic 16). The optical behavior of random media such as tissue in interaction with laser irradiation. Approximate transport equation methods to predict the absorption and scattering parameters of laser light inside tissue. Port-wine stain treatment; cancer treatment by photochemotherapy; and cardiovascular applications. Only one of the following may be counted: Biomedical Engineering 381J (Topic 2), Electrical and Computer Engineering 385J (Topic 16), Electrical Engineering 385J (Topic 16).
Topic 3: Imaging Signals and Systems. Same as Electrical and Computer Engineering 385J (Topic 18). Physical principles and signal processing techniques used in thermographic, ultrasonic, and radiographic imaging, including image reconstruction from projections such as CT scanning, MRI, and millimeter wave determination of temperature profiles. Only one of the following may be counted: Biomedical Engineering 381J (Topic 3), Electrical and Computer Engineering 385J (Topic 18), Electrical Engineering 385J (Topic 18).
Topic 4: Optical Spectroscopy. Same as Electrical and Computer Engineering 385J (Topic 23). Measurement and interpretation of spectra: steady-state and time-resolved absorption, fluorescence, phosphorescence, and Raman spectroscopy in the ultraviolet, visible, and infrared portions of the spectrum. Only one of the following may be counted: Biomedical Engineering 381J (Topic 4), Electrical and Computer Engineering 385J (Topic 23), Electrical Engineering 385J (Topic 23).
Topic 5: Therapeutic Heating. Same as Electrical and Computer Engineering 385J (Topic 26). Engineering aspects of electromagnetic fields that have therapeutic applications: diathermy (short wave, microwave, and ultrasound), electrosurgery (thermal damage processes), stimulation of excitable tissue, and electrical safety. Only one of the following may be counted: Biomedical Engineering 381J (Topic 5), Electrical and Computer Engineering 385J (Topic 26), Electrical Engineering 385J (Topic 26).
Topic 6: Noninvasive Optical Tomography. Same as Electrical and Computer Engineering 385J (Topic 28). Basic principles of optical tomographic imaging of biological materials for diagnostic or therapeutic applications. Optical-based tomographic imaging techniques including photothermal, photoacoustic, and coherent methodologies. Only one of the following may be counted: Biomedical Engineering 381J (Topic 6), Electrical and Computer Engineering 385J (Topic 28), Electrical Engineering 385J (Topic 28).
Topic 7: Digital Image and Video Processing. Digital image acquisition, processing, and analysis; algebraic and geometric image transformations; two-dimensional Fourier analysis; image filtering and coding. Additional prerequisite: Credit or registration for Biomedical Engineering 335 or Electrical Engineering 351K.
Topic 8: Functional Imaging Laboratory. Explores in vivo functional imaging, including aspects of imaging hardware and instrumentation, contrast agents, image processing, management of large imaging data sets, and applications of physiological modeling. Three lecture hours a week for one semester. Additional hours to be arranged. Biomedical Engineering 381J (Topic: Functional Imaging Laboratory) and 381J (Topic 8) may not both be counted. Additional prerequisite: Graduate standing in engineering.
Topic 9: Fundamentals of Biomedical Optical Imaging. Fundamentals of the interaction of light with tissue for the purpose of imaging and treatment of disease. Focuses on quantitative modeling of tissue optical properties, light propagation in the tissue, heat transfer of laser irradiated tissue, and thermal damage models. Includes discussion of applications in laser surgery, pulse oximetry, and disease diagnosis using spectroscopy. Biomedical Engineering 381J

(Topic: Fundamentals of Biomedical Optical Imaging) and 381J (Topic 9) may not both be counted.

Topic 10: Optics and Lasers. Fundamentals of geometric and physical optics, interaction of light with matter, spectroscopy, and laser and electro-optics applications. Biomedical Engineering 381J (Topic: Optics and Lasers) and 381J (Topic 10) may not both be counted.

Topic 11: Medical Imaging. Biomedical Engineering 381J (Topic: Medical Imaging) and 381J (Topic 11) may not both be counted.

Topic 12: Optical Design. The principles of optical design for imaging and laser delivery systems are given. Students develop and test designs using a commercial optical design software package. Biomedical Engineering 381J (Topic: Optical Design) and 381J (Topic 12) may not both be counted.

Topic 13: Fluorescence Micro- and Spectroscopy. Fundamentals of fluorescence microscopy, spectroscopy, and techniques; single-molecule detection; advanced microscopy, including multi-photon microscopy, super-resolution imaging, and molecular tracking. Other subjects include metal-enhanced fluorescence, optogenetics, nanomedicine and microfluidics. Biomedical Engineering 381J (Topic: Fluorescence Micro-/Spectroscopy) and 381J (Topic 13) may not both be counted. Additional prerequisite: Understanding of biochemistry and biology; lab experience using microscopic technology and tools.

Topic 14: Digital Video. Same as Electrical and Computer Engineering 381K (Topic 16). Examine video sampling and transform; video (retinal and cortical) filters; motion detection and estimation; statistical models of videos; neuroscience of video perception; natural video statistics; modern video compression standards; video quality prediction; video denoising; active contour models; and video saliency. Only one of the following may be counted: Biomedical Engineering 381J (Topic: Digital Video), 381J (Topic 14), Electrical and Computer Engineering 381K (Topic 16), Electrical Engineering 381K (Topic 16), 381V (Topic: Digital Video).

Topic 15: Imaging Clinical Immersion. Identify current unmet clinical needs via close interaction with healthcare professionals and patients. Explore biomedical imaging across the healthcare enterprise. Biomedical Engineering 381J (Topic 15) and 385J (Topic: Imaging Clinical Immersion) may not both be counted.

BME 681M. Normal Body Structure and Function.

Restricted to students in the Master of Science in Engineering and Doctor of Medicine dual-degree program. Exploration of the structure and function of the human body at all levels of organization, from molecular and cellular to the integrated function of multiple organ systems attempting to maintain homeostasis. Emphasis on wellness and normal structure/function, in addition to the mechanistic disruptions that cause illness as well as the scientific rationale for methods to diagnose and treat selected diseases. Six lecture hours a week for one semester.

BME 382J. Topics in Cellular and Biomolecular Engineering.

Three lecture hours a week for one semester, or as required by the topic. May be repeated for credit when the topics vary. Prerequisite: Graduate standing in engineering and consent of instructor.

Topic 1: Cell and Tissue Engineering. Use of case studies to explore pathologies of tissue, current clinical treatment, and the role of engineers in developing new technologies to diagnose and treat these pathologies. Emphasis on the use of quantitative cellular and molecular techniques. Applications of synthetic and natural biomaterials. Additional prerequisite: Quantitative physiology or pathophysiology course.

Topic 2: Introduction to Biochemical Engineering. Microorganisms in chemical and biochemical synthesis; genetic manipulation of cells by classical and recombinant DNA techniques; enzyme technology; design of bioreactors and microbial fermentations; and separations of biological products.

Topic 3: Molecular Sensors and Nanodevices for Biomedical Engineering Applications. Introduction to a variety of methods used to detect biological molecules with optical and electrical transduction mechanisms. Covers the classical approaches to biosensors for the detection of specific molecules in biological systems.

Topic 4: Advanced Engineering Biomaterials. Overview of biomaterials, including prosthetics, ceramics, metal implants, and polymers, with specific emphasis on properties and applications. The immunology of material-tissue interactions and the issues of biocompatibility.

Topic 5: Structured Surfaces, Fabrication, Characterization, and Application. Introduction to fabrication and characterization techniques used to create and analyze microstructured and nanostructured surfaces for biomedical and biotechnology applications. Focuses on the use of self-assembly processes for the fabrication of biological functionality in surface structures.

Topic 6: Biopolymers and Drug/Gene Delivery. Biomedical polymers and their applications in drug delivery and gene therapy. Emphasis on parenteral, mucosal, and topical delivery of biomolecules, and the role of polymers in genetic therapy and DNA vaccination.

Topic 7: Cellular and Molecular Biomechanics. Introduction to the concepts needed to understand and work in the emerging field of cellular and molecular biomechanics. Examination of dynamic interplay between chemical, thermal, and physical forces in determining the mechanics of cells/tissues and their molecular components. Three lectures hours a week for one semester, with additional hours to be arranged. Biomedical Engineering 382J (Topic: Cellular and Molecular Biomechanics) and 382J (Topic 7) may not both be counted. Additional prerequisite: Graduate standing; and coursework in calculus, physics, solid mechanics, and basic chemical/biological principles.

Topic 8: Molecular Biophysics: Measurements and Methods. In-depth study and development of intuition for thermodynamics and mechanics and application of understanding to molecular-scale problems in cell biology and biomedical engineering. Focus on increasing students' familiarity with modern methods of biophysical measurement, their strengths and limitations, and how they are being applied to address current research problems. Biomedical Engineering 382J (Topic: Molecular Biophysics: Measurements and Methods) and 382J (Topic 8) may not both be counted. Additional prerequisite: Undergraduate biology, calculus, chemistry, and physics is recommended.

Topic 9: Biomimetic Design and Engineering. Introduction to biomimetic reverse engineering, including the weaknesses of animal models to predict human physiology, microphysiological systems, the potential of human organs on chips to accelerate drug development processes, pharmaceutical preclinical testing requirements, human microbiome, disease models to study pathophysiology, and related subjects. Biomedical Engineering 382J (Topic: Biomimetic Design and Engineering) and 382J (Topic 9) may not both be counted.

Topic 10: Immune Engineering. Introduction to the concept of immune engineering. Discussion of vaccine design, cancer immunotherapy, genomics, infection, auto-immune diseases and emerging tools and methodologies. Biomedical Engineering 382J (Topic: Immune Engineering) and 382J (Topic 10) may not both be counted. Additional prerequisite: Understanding of biology.

Topic 11: Polymer and Bioconjugate Chemistry. Examine principles of polymeric biomaterials and bioconjugate chemistry with an emphasis on synthetic strategies to achieve specific properties. Includes characterization methods of polymers and bioconjugates as a function of chemical composition, as well as tissue engineering and drug delivery applications as case studies of the biomaterial design process. Three lecture hours a week for one semester. Biomedical Engineering 382J (Topic: Polymer/Bioconjugate Chem) and 382J (Topic 11) may not both be counted.

Topic 12: Biological Responses to Medical Devices. Examine key challenges in the development and assessment of biomaterials used in medical devices, including common biological responses elicited by biomaterials and the impact of these responses on material performance. Includes material surface properties, modification, and characterization; protein/cell interactions with materials; biocompatibility, inflammation and wound healing, cell-mediated biodegradation of materials; thrombosis, infection and calcification of medical devices. Biomedical Engineering 382J (Topic: Biol Responses to Medical Dev) and 382J (Topic 12) may not both be counted.
Topic 13: Delivery of Therapeutic Agents. Explore molecular, biological, chemical, and mathematical fundamentals of the use of macromolecular carriers for the release of small and high molecular weight therapeutic agents in vitro and in vivo. Examine design and advanced techniques of protein, peptide, antibodies, and gene therapy. Discuss targeted delivery, mucoadhesive therapy, and theranostics, as well as advanced biomedical devices for treatment of diseases. Biomedical Engineering 382J (Topic: Delivery of Therapeutic Agents) and 382J (Topic 13) may not both be counted.
Topic 14: Nanomedicine. Explore the fundamental properties, synthesis and characterization of nanomaterials, including their applications in nanomedicine. Discuss micro- and nano-particles for drug delivery and imaging, microfluidics for in vitro diagnostics and biological systems modeling, and nanomaterials and platforms for biological applications. Examine biomedical applications such as cancer, cardiovascular disease, and infectious diseases. Biomedical Engineering 382J (Topic: Nanomedicine) and 382J (Topic 14) may not both be counted.
Topic 15: Matrices, Organoids, and Microphysiological Systems. Explore current technologies and scientific literature seeking to construct human-relevant, in vitro systems representing tissues, organs, and disease physiologies as platforms for development of new therapies. Focus on how concepts in biomaterials, stem cell biology, microfluidics, additive manufacturing, and biosensing are integrated to create such platforms. Biomedical Engineering 382J (Topic: Matrices/Organs/Microphys Sys) and 382J (Topic 15) may not both be counted.

BME 682M. Biodesign: Needs Identification.

Restricted to students in the Clinical Innovation and Design Program. Identify concrete clinical needs via clinical immersion experience with healthcare professionals and patients. Apply engineering design methodologies to identify clinical needs based upon the most meaningful problems observed. Three lecture hours and three laboratory hours a week for one semester. Biomedical Engineering 682M and 385J (Topic: Biodsgn: Needs Identification) may not both be counted. Prerequisite: Consent of instructor.

BME 383J. Topics in Computational Biomedical Engineering and Bioinformatics.

Three lecture hours a week for one semester, or as required by the topic. May be repeated for credit when the topics vary. Prerequisite: Graduate standing in engineering and consent of instructor; additional prerequisites may vary with the topic.

Topic 1: Network Thermodynamics in Biophysics. Modeling and simulation methods for nonlinear biological processes, including coupling across multienergy domains; practical implementation by bond graph techniques. Additional prerequisite: Mechanical Engineering 344 or consent of instructor.
Topic 2: Musculoskeletal Biomechanics. Synthesis of properties of the musculotendon and skeletal systems to construct detailed computer models that quantify human performance and muscular coordination. Additional prerequisite: Mathematics 341 and Kinesiology 395 (Topic 36: Biomechanics of Human Movement).
Topic 3: Introduction to Computational Oncology. Computational techniques commonly used in modeling various aspects of cancer at multiple spatial and temporal scales. Exploration of how computational modeling offers unique and complementary information to traditional methods of cancer research. Emphasis on the integration of theory and experiment while identifying the current barriers preventing computational modeling from having a broader impact on both cancer biology and clinical oncology. Only one of the following may be counted: Biomedical Engineering 383J (Topic: Introduction to Computational Oncology), Biomedical Engineering 383J (Topic 3), Computational Science, Engineering, and Mathematics 397 (Topic: Introduction to Computational Oncology).
Topic 4: Biomechanics of Human Movement. Same as Kinesiology 395 (Topic 36: Biomechanics of Human Movement). Additional prerequisite: Kinesiology 326K, two semesters of calculus, one semester of college physics (mechanics), and consent of instructor.
Topic 5: Introduction to Nonlinear Dynamics in Biological Systems. Same as Kinesiology 395 (Topic 63: Introduction to Nonlinear Dynamics in Biological Systems). Basic concepts of nonlinear mathematics and their application to biological systems. Additional prerequisite: Two semesters of college-level calculus and consent of instructor.
Topic 7: Data Mining. Analyzing large data sets for interesting and useful information; online analytical processing, finding association rules, clustering, classification, and function approximation; scalability of algorithms and real-life applications.
Topic 8: Systems Biology. The biological function of genetic and biochemical networks from a quantitative perspective. Students use mathematical tools to model network modules, such as biological switches, oscillators, and amplifiers. Discusses recent papers on a variety of biological problems that can be addressed with a systems biology approach. Additional prerequisite: Biology 311C and Mathematics 427K; an introductory course in biochemistry, and knowledge of MATLAB, are recommended.
Topic 9: Computational Methods for Biomedical Engineers. Study of and hands-on experiences with computational methods commonly employed in biomedical engineering research. Three lecture hours a week for one semester. Biomedical Engineering 383J (Topic: Computational Methods for Biomedical Engineers I) and 383J (Topic 9) may not both be counted. Additional prerequisite: Graduate standing in engineering.
Topic 10: Computational Biomolecular Engineering. Provides an introduction to the principles and applications of biomolecular modeling and simulation, including the theoretical background of molecular thermodynamics and molecular mechanics, major simulation/computational techniques and commonly used software tools. Biomedical Engineering 383J (Topic: Computational Biomolecular Engineering) and 383J (Topic 10) may not both be counted. Additional prerequisite: Undergraduate biochemistry coursework, and thermodynamics or physical chemistry coursework; or consent of instructor.
Topic 11: Dynamical Modeling of Biological Signaling and Regulatory Systems. Introduction to various approaches currently used for modeling and simulating cellular signal transduction, metabolic, and gene regulatory networks. Biomedical Engineering 383J (Topic: Dynamical Modeling of Biological Signaling and Regulatory Systems) and 383J (Topic 11) may not both be counted. Additional prerequisite: Understanding of biochemistry and biology; familiarity with a programming environment.
Topic 12: Computational Modeling in Bioengineering and Medicine. Comprehensive introduction to methods used in simulation of biological systems and processes. Emphasis on selected applications from single channels, cells, and tissues up to whole organs. Only one of the following may be counted: Biomedical Engineering 383J (Topic 12), 385J (Topic: Comptl Mdlng Bioengr and Med), Computational

Science, Engineering, and Mathematics 397 (Topic: Comptl Mdlng in Bioengr & Med).

Topic 13: Introduction to Mathematical and Physical Biology. Introduction to common mathematical and physical techniques used in modeling various aspects of biology at multiple spatial and temporal scales. Explore the integration of theory and experiment while identifying the current barriers preventing computational modeling from having a broader impact in biology. Only one of the following may be counted: Biomedical Engineering 383J (Topic: Intro Mathematical & Phys Bio), 383J (Topic 13), Computational Science, Engineering, and Mathematics 397 (Topic: Intro Mathematical & Phys Biol).

Topic 14: Mathematical Physiology. Same as Computational Science, Engineering, and Mathematics 397 (Topic 9). Explore mathematical modeling in physiology, how physiological problems can be formulated and modeled, and how such models give rise to interesting and challenging functional features. Examine several exemplar physiological systems. Discuss the mathematical aspects of growth and remodeling in living systems, an area unique to living systems. Only one of the following may be counted: Biomedical Engineering 383J (Topic: Mathematical Physiology), 383J (Topic 14), Computational Science, Engineering, and Mathematics 397 (Topic: Mathematical Physiology), 397 (Topic 9).

BME 683M. Biodesign: Entrepreneurship.

Restricted to students in the Clinical Innovation and Design Program. Develop a team project in biomedical engineering with emphasis on detailed design and prototyping. Prepare a business plan designed to bring product to market or use in clinical practice. Three lecture hours and three laboratory hours a week for one semester. Biomedical Engineering 683M and 385J (Topic: Biodesign: Entrepreneurship) may not both be counted. Prerequisite: Consent of instructor and Biomedical Engineering 682M with a grade of at least C-.

BME 384J. Topics in Instrumentation.

Three lecture hours a week for one semester, or as required by the topic. May be repeated for credit when the topics vary. Prerequisite: Graduate standing in engineering and consent of instructor; additional prerequisites vary with the topic.

Topic 1: Biomedical Instrumentation I. Same as Electrical and Computer Engineering 385J (Topic 31). Application of electrical engineering techniques to analysis and instrumentation in biological sciences: pressure, flow, temperature measurement; bioelectrical signals; pacemakers; ultrasonics; electrical safety; electrotherapeutics. Only one of the following may be counted: Biomedical Engineering 384J (Topic 1), Electrical and Computer Engineering 385J (Topic 31), Electrical Engineering 385J (Topic 31).

Topic 2: Biomedical Instrumentation II: Real-Time Computer-Based Systems. Same as Electrical and Computer Engineering 385J (Topic 17). Design, testing, patient safety, electrical noise, biomedical measurement transducers, therapeutics, instrumentation electronics, microcomputer interfaces, and embedded systems. Participate in an individual laboratory. Only one of the following may be counted: Biomedical Engineering 384J (Topic 2), Electrical and Computer Engineering 385J (Topic 17), Electrical Engineering 385J (Topic 17).

Topic 3: Biosignal Analysis. Same as Electrical and Computer Engineering 385J (Topic 15). Theory and classification of biological signals such as EEG, EKG, and EMG. Data acquisition and analysis procedures for biological signals, including computer applications. Only one of the following may be counted: Biomedical Engineering 384J (Topic 3), Electrical and Computer Engineering 385J (Topic 15), Electrical Engineering 385J (Topic 15).

Topic 4: Bioelectric Phenomena. Same as Electrical and Computer Engineering 385J (Topic 3). Examines the physiological bases of bioelectricity and the techniques required to record bioelectric phenomena both intracellularly and extracellularly; the representation of bioelectric activity by equivalent dipoles and the volume conductor fields produced. Only one of the following may be counted: Biomedical Engineering 384J (Topic 4), Electrical and Computer Engineering 385J (Topic 3), Electrical Engineering 385J (Topic 3).

Topic 5: Projects in Biomedical Engineering. Same as Electrical and Computer Engineering 385J (Topic 32). An in-depth examination of selected topics, such as optical and thermal properties of laser interaction with tissue; measurement of perfusion in the microvascular system; diagnostic imaging; interaction of living systems with electromagnetic fields; robotic surgical tools; ophthalmic instrumentation; noninvasive cardiovascular measurements. Only one of the following may be counted: Biomedical Engineering 384J (Topic 5), Electrical and Computer Engineering 385J (Topic 32), Electrical Engineering 385J (Topic 32). Additional prerequisite: Biomedical Engineering 384J (Topic 1) or Electrical and Computer Engineering 385J (Topic 31) (or Electrical Engineering 385J (Topic 31)).

Topic 6: Neurophysiology/Prosthesis Design. Same as Electrical and Computer Engineering 385J (Topic 33). The structure and function of the human brain. Discussion of selected neurological diseases in conjunction with normal neurophysiology. Study of neuroprosthesis treatments and design philosophy, functional neural stimulation, and functional muscular stimulation. Only one of the following may be counted: Biomedical Engineering 385J (Topic 6), Electrical and Computer Engineering 385J (Topic 33), Electrical Engineering 385J (Topic 33).

Topic 7: Introduction to Neural Engineering. Survey of important concepts, applications, and challenges in neural engineering. Subjects include basic neurophysiology and electrophysiological signals, major neural interface modalities and various optical microscopy techniques, and design aspects of neural engineering devices. Emphasis on recent trends and frontiers in neural engineering. Only one of the following may be counted: Biomedical Engineering 381J (Topic: Electrophysiology: Methods and Frontiers), Biomedical Engineering 381J (Topic: Introduction to Neural Engineering), Biomedical Engineering 384J (Topic 7).

Topic 8: Rehabilitation Engineering. Same as Mechanical Engineering 385J (Topic 24). Explores use of robotic devices in physical therapy for neuromuscular injury. Clinicians lecture each week on a specific malady, followed by critical review of the literature of that malady from the perspective of rehabilitation engineering. Shadows therapists and develops a prototype of a device for therapy, assistance or diagnosis of patients, or conducts an experiment to test a hypothesis in the field using a device. Three lecture hours a week for one semester. Only one of the following may be counted: Biomedical Engineering 381J (Topic: Rehabilitation Engineering), 384J (Topic 8), Mechanical Engineering 385J (Topic 24), 397 (Topic: Rehabilitation Engineering).

Topic 9: Bioelectronics and Biointerfaces. Examine critical concepts and strategies in materials development, electronics fabrication and genetic innovations that interface with biological systems. Explore neural interfacing technology, flexible electronics, wearable technology, bio-nanotechnology, and genetic engineering. Focus on the recently developed technology for recording and manipulating neural systems. Biomedical Engineering 384J (Topic: Bioelectronics/Biointerfaces) and 384J (Topic 9) may not both be counted.

BME 384T. Topics in Biomechanics.

Restricted to students in the Cockrell School of Engineering. Three lecture hours a week for one semester, or as required by the topic. May be repeated for credit when the topics vary. Prerequisite: Graduate standing and consent of instructor; additional prerequisites vary with the topic.

Topic 1: Bioheat Transfer. Explore the application of the principles of heat transfer to the solution of a series of advanced, open-ended problems in medicine and biology. Identify and pursue solution strategies for a range of cutting-edge problems in bioheat transfer. Biomedical Engineering 384T (Topic 1) and 385J (Topic 12) may not both be counted. Additional prerequisite: Prior course in heat transfer or transport phenomena.

Topic 2: Cellular, Tissue, and Scaffold Biomechanics. Explore an analysis of biosolid mechanics via the mechanical behavior of scaffolds and living tissues and cells. Examine biomechanical application areas, including cell mechanics, engineered materials, hard and soft tissues, and organs. Only one of the following may be counted: Biomedical Engineering 384T (Topic 2), 385J (Topic: Tissue/Scaffold Biomechanics), 385J (Topic 7).

Topic 3: Soft Tissue Biomechanics. Explore the fundamentals and critical applications of soft tissue mechanics. Examine continuum mechanics (kinematics, stress, balance of linear momentum, hyperelasticity), experimental and nonlinear finite element analyses of soft tissue mechanics, and relevant imaging modalities and related facilities available on campus. Only one of the following may be counted: Biomedical Engineering 384T (Topic 3), 385J (Topic: Soft Tissue Biomechanics), Engineering Mechanics 397 (Topic: Soft Tissue Biomechanics), Mechanical Engineering 385J (Topic: Soft Tissue Biomechanics).

Topic 4: Thin Film Mechanics. Explore a comprehensive introduction to, and important applications of, thin film structures and devices. Discuss stress, fracture, delamination, instability, and other mechanics-related subjects involving thin films. Examine technological applications including integrated circuits, micro- and nano-electromechanical systems, flexible and stretchable electronics, bioelectronics, and surface coatings. Only one of the following may be counted: Biomedical Engineering 384T (Topic 4), 385J (Topic: Thin Film Mechanics), Engineering Mechanics 397 (Topic: Thin Film Mechanics).

Topic 5: Tissue Microenvironments. Explore varying native and bio-fabricated tissue microenvironments and hands-on opportunities for fabrication and bioprinting of tissues on a chip. Examine characterization of mechanical, thermal, transport, and cellular tissue response to microenvironments; imaging and computational approaches that enable prediction of cell and tissue behavior within physiological and pathological native or bio-fabricated tissues; and clinical perspectives which drive design of physiologically representative tissues on a chip and their use for diagnostic screening and therapeutic planning. Only one of the following may be counted: Biomedical Engineering 384T (Topic 5), 385J (Topic: Tiss Microenv: Fab/Tran/Mech), Mechanical Engineering 397 (Topic: Tiss Microenv: Fab/Tran/Mech), 397M (Topic: Tiss Microenv: Fab/Tran/Mech).

BME 385J. Topics in Biomedical Engineering.

Three lecture hours a week for one semester, or as required by the topic. Biomedical Engineering 385J and 387J may not both be counted unless the topics vary. May be repeated for credit when the topics vary. Prerequisite: Graduate standing in engineering and consent of instructor.

Topic 6: Analysis of Biological Systems. Biomedical Engineering 383J (Topic: Analysis of Biological Systems I) and 385J (Topic 6) may not both be counted.

Topic 39: Medical Decision Making. Selected subjects from cognitive psychology and human-machine interaction for engineering students to design more effective systems for supporting medical decision making. Biomedical Engineering 385J (Topic: Medical Decision Making) and 385J (Topic 39) may not both be counted.

Topic 40: Cancer Bioengineering. Analysis of the biology and pathology of cancer, including the fundamental nature of cancer, cellular oncogenes, growth factor signaling, tumor suppressor genes, apoptosis, multi-step tumorigenesis, angiogenesis, metastasis, and tumor immunology and immunotherapy. Also explores ways in which the tools of engineering are transforming the future of cancer research. Biomedical Engineering 385J (Topic: Cancer Bioengineering) and 385J (Topic 40) may not both be counted.

Topic 41: Medical Device Design and Manufacturing. Apply engineering principles in the conception, design and prototyping of medical devices. Develop team projects with emphasis on clinical and market needs analysis, creative and useful concept generation, engineering requirements and specifications, and written and oral reporting of intermediate and final prototype outcomes. Three lecture hours a week for one semester. Biomedical Engineering 385J (Topic: Medical Device Design and Manu) and 385J (Topic 41) may not both be counted.

Topic 42: Inquiry Based Instructional Design. Examine principles of inquiry-based learning methods and their applications to an engineering pedagogical context. Use multiple, open-ended engineering problems as case studies and develop an independent course integrating inquiry-based learning content. Only one of the following may be counted: Biomedical Engineering 385J (Topic: Dsgn IBL: Bioheat Transfer), 385J (Topic: Inquiry Based Instruc Dsgn), 385J (Topic 42).

BME 685M. Mechanisms of Disease.

Restricted to students in the Master of Science in Engineering and Doctor of Medicine dual-degree program. Overview of the disease-specific concepts required to participate in patient care by integrating clinical medicine, microbiology, pathology, and pharmacology into organ system modules, and the pathophysiology of diseases, the differential diagnosis of cardinal symptoms, and treatment modalities. Includes other concepts such as radiology and diagnostics. Six lecture hours a week for one semester.

BME 396. Research Internship.

Students participate in research in an industry, clinic, or academic laboratory setting selected with the approval of the faculty adviser. At least twenty hours of fieldwork a week for one semester. May be counted only once toward either the master's or the doctoral degree. Offered on the credit/no credit basis only. Prerequisite: Graduate standing.

BME 197, 297, 397, 597, 697. Research Problems.

Problems selected by the student with approval of the faculty adviser. For each semester hour of credit earned, three laboratory hours a week for one semester. Offered on the credit/no credit basis only. Prerequisite: Graduate standing in biomedical engineering.

BME 197D. Deep Reading in Science and Engineering.

Analyze primary research articles with the goal of improving understanding of experimental design/methods, writing scientific articles and critiquing current research. The equivalent of one lecture hour a week for one semester. May be repeated for credit. Offered on the credit/no credit basis only. Prerequisite: Graduate standing and consent of instructor.

BME 197E. Professional Responsibilities in Imaging.

One lecture hour a week for one semester. Offered on the credit/no credit basis only. Prerequisite: Graduate standing.

BME 197M. Mentoring Undergraduates in Research.

Designed to support and develop students' skills in mentoring undergraduates engaged in science, technology, engineering and mathematics (STEM) research. The equivalent of one lecture hour a week for one semester. Biomedical Engineering 180J (Topic: Research

Mentoring) and 197M may not both be counted. Offered on the credit/no credit basis only. Prerequisite: Graduate standing.

BME 197N. Integrated Biomedical Engineering Seminar.

Designed to support students' professional development as well as their broad understanding of the biomedical engineering research enterprise. One lecture hour a week for one semester. Prerequisite: Graduate standing.

BME 197P, 297P, 397P. Graduate Professional Development Seminar.

Explores professional development goals of biomedical engineers. Subjects include an individual development plan, careers in academia, entrepreneurship, careers in industry, and more. For each semester hour of credit earned, one lecture hour a week for one semester. Offered on the credit/no credit basis only.

BME 197S. Graduate Seminar in Biomedical Engineering.

The equivalent of one lecture hour a week for one semester. May be repeated for credit. Offered on the credit/no credit basis only. Prerequisite: Graduate standing.

BME 698. Thesis.

The equivalent of three lecture hours a week for two semesters. Offered on the credit/no credit basis only. Prerequisite: For 698A, graduate standing in biomedical engineering and consent of the graduate adviser; for 698B, Biomedical Engineering 698A.

BME 398R. Master's Report.

Preparation of a report to fulfill the requirement for the master's degree under the report option. The equivalent of three lecture hours a week for one semester. Offered on the credit/no credit basis only. Prerequisite: Graduate standing in biomedical engineering and consent of the graduate adviser.

BME 399W, 699W, 999W. Dissertation.

May be repeated for credit. Offered on the credit/no credit basis only. Prerequisite: Admission to candidacy for the doctoral degree.

Professional Courses