Biomedical Engineering (BME)

BME 303 Introduction to Computing 3 Hours
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.

BME 303L Introduction to Biomedical Engineering Design 3 Hours
Biomedical engineering design concepts with hands-on learning applications.

BME 306 Fundamentals of Computing 3 Hours
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.

BME 311 Network Analysis in Biomedical Engineering 3 Hours
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.

BME 313L Introduction to Numerical Methods in Biomedical Engineering 3 Hours
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.

BME 214L Computational Fundamentals of Biomedical Engineering Design 2 Hours
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.

BME 117T, 217T, 317T Introductory Topics in Biomedical Engineering 1-3 Hours

BME 320 International Perspectives on Biomedical Engineering Design 3 Hours
Activities to consider sociotechnical factors in designing clinically translatable solutions with a focus on international perspectives.

BME 321D Introduction to Medical Image Processing 3 Hours
Introduction to theories, methods, and applications related to medical image processing through project-based learning. Discuss the principles and approaches for image segmentation, image registration, and deep learning classification, in addition to the global reach of clinical applications based on these methods, such as radiology and radiation oncology.

BME 322 Health Equity in Engineering Design 3 Hours
Discuss healthcare disparities and causal mechanisms that lead to differential patient outcomes of medical devices and therapeutics. Assess how engineers can improve the design process of healthcare technologies to remove bias and improve equity. Explore current research in the field from health disparity specialists.

BME 129S, 229S, 329S, 429S, 529S, 629S, 729S, 829S, 929S Topics in Biomedical Engineering 1-9 Hours
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.

BME 335 Engineering Probability and Statistics 3 Hours
Fundamentals of probability, random processes, and statistics with emphasis on biomedical engineering applications. Includes hypothesis testing, regression, and sample size calculations.

BME 336 Cancer Bioengineering 3 Hours
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.

BME 337 Nanomedicine 3 Hours
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.

BME 338 Thin Film Mechanics 3 Hours
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.

BME 339 Biochemical Engineering 3 Hours
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.

BME 340 Soft Tissue Biomechanics 3 Hours
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.

BME 342 Biomechanics of Human Movement 3 Hours
Modeling and simulation of human movement; neuromuscular control; computer applications; introduction to experimental techniques.

BME 343 Biomedical Engineering Signal and Systems Analysis 3 Hours
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.

BME 344 Biomechanics 3 Hours
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.

BME 344C Introduction to Therapeutics 3 Hours
Introduction to the biological and engineering underpinnings of therapeutics discovery, development and manufacturing. Focus on the quantitative and engineering principles relevant to growing cells and producing molecules for commercial purposes, including basic growth kinetics and stoichiometry, simple bioreactor design and oxygen transfer.

BME 345 Graphics and Visualization Laboratory 3 Hours
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.

BME 245L Experimental Principles of Biomedical Engineering Design 2 Hours
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.

BME 346 Computational Biomolecular Engineering 3 Hours
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.

BME 347 Fundamentals of Biomedical Optics 3 Hours
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.

BME 348 Modeling of Biomedical Engineering Systems 3 Hours
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.

BME 348P Introduction to Computational and Systems Biology 3 Hours
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.

BME 349 Biomedical Instrumentation 3 Hours
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.

BME 350 Computational Methods for Biomedical Engineers 3 Hours
Study of and hands-on experiences with computational methods commonly employed in biomedical engineering research.

BME 352 Engineering Biomaterials 3 Hours
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.

BME 353 Transport Phenomena in Living Systems 3 Hours
Introduction to the principles of heat, mass and momentum transfer and their application to solve problems in living systems.

BME 354 Molecular Sensors and Nanodevices for Biomedical Engineering Applications 3 Hours
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.

BME 355 Molecular Engineering 3 Hours
Working principles of biomolecules such as proteins and nucleic acids. Physical and chemical basis for biomolecular structure, energetics, and function.

BME 356 Polymer and Bioconjugate Chemistry 3 Hours
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.

BME 357 Biomedical Imaging Modalities 3 Hours
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.

BME 358 Medical Decision Making 3 Hours
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.

BME 358M Imaging Clinical Immersion 3 Hours
Identify current unmet clinical needs via close interaction with healthcare professionals and patients. Explore biomedical imaging across the healthcare enterprise.

BME 359 Cellular and Molecular Biomechanics 3 Hours
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.

BME 261L Development and Analysis in Biomedical Engineering Design 2 Hours
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.

BME 362 Introduction to Nonlinear Dynamics in Biological Systems 3 Hours
Introduction to various concepts from nonlinear mathematics and their application to biological systems, ranging from sub-cellular to whole ecosystems levels of investigation.

BME 362C Advanced Engineering Biomaterials 3 Hours
Analyze biomaterials as components of biomedical implants and delivery vehicles. Discuss basic principles of biocompatibility and implant performance as well as material selection and structure-function relationships.

BME 362E Medical Device Innovation 3 Hours
Money, markets, and entrepreneurship with particular focus on medical and health markets.

BME 363 Bioelectronics and Biointerfaces 3 Hours
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.

BME 363E Medical Device Design and Manufacturing 3 Hours
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.

BME 364 Biological Responses to Medical Devices 3 Hours
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.

BME 365 Tissue Microenvironments 3 Hours
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.

BME 365R Quantitative Engineering Physiology I 3 Hours
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.

BME 365S Quantitative Engineering Physiology II 3 Hours
Biological control systems: sensory, renal, respiratory, and immune systems. Focuses on a quantitative, model-oriented approach to physiological systems.

BME 366 Immune Engineering 3 Hours
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.

BME 367 Design of Artificial Organs 3 Hours
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.

BME 367D Point-of-Care Molecular Diagnostics 3 Hours
Introduction to the principles, tools, and technologies required to develop and implement nucleic acid-based molecular diagnostics. Discuss amplification methods, primer design, sample prep, and detection. Focus on global and rural health, accessibility, and real-world applications.

BME 368 Introduction to Mathematical and Physical Biology 3 Hours
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.

BME 369 Biomimetic Design and Engineering 3 Hours
Overview of the core concepts of biomimetic microengineering with particular focus on engineered microphysiological models of human organs, tissues and disease pathophysiology.

BME 369C Matrices, Organoids, and Microphysiological Systems 3 Hours
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.

BME 370 Biomedical Engineering Capstone Design I 3 Hours
Structured methodologies for designing systems or to interface with living systems. Creative design, analysis, selection, development, and fabrication of biomedical components and systems.

BME 371 Biomedical Engineering Capstone Design II 3 Hours
Development of team projects in biomedical engineering with emphasis on prototype development and quantitative analysis, and written and oral reporting of the outcome.

BME 372 Computational Modeling of the Cardiovascular System 3 Hours
Analyze mathematical models and simulations of the cardiovascular system. Examine biomechanical simulations including the biomechanical function of the heart, heart valves, and the vasculature.

BME 372C Delivery of Therapeutic Agents 3 Hours
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.

BME 372P Mathematical Physiology 3 Hours
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.

BME 373 Tissue, Scaffold, and Cell Biomechanics Applications 3 Hours
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.

BME 374 Optical Design 3 Hours
Explore the principles of optical design for imaging and laser delivery systems. Examine the development and testing of designs using optical design software.

BME 374D Biomedical Engineering Microscopy Foundations Laboratory 3 Hours
Explore finite and infinite imagery; conjugate planes, back focal plan manipulation, Abbe theory image formation, point spread functions, camera principles, fluorescence, and advanced fluorescence techniques, and build an optical microscope.

BME 374K Biomedical Instrument Design 3 Hours
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.

BME 374L Applications of Biomedical Instrumentation Lab 3 Hours
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.

BME 375 Stem Cells in Cell and Tissue Engineering 3 Hours
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.

BME 376 Cell Engineering 3 Hours
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.

BME 177, 277, 377 Undergraduate Research Project 1-3 Hours
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.

BME 377M Medical Internship 3 Hours
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.

BME 377R Off-Campus Research 3 Hours
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.

BME 377S Industrial Internship 3 Hours
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.

BME 177T, 277T, 377T Topics in Biomedical Engineering 1-3 Hours

BME 678 Undergraduate Thesis in Biomedical Engineering 6 Hours
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.

BME 379 Tissue Engineering 3 Hours
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.

BME 679H Undergraduate Honors Thesis 6 Hours
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.

BME 180J, 380J Topics in the Fundamentals of Biomedical Engineering 1,3 Hours

BME 180J.1, 380J.1 Mathematical Modeling in Biomedical Engineering 1,3 Hours
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.

BME 180J.2, 380J.2 Quantitative Systems Physiology and Pathophysiology 1,3 Hours
Modeling of physiological systems from the molecular and cellular levels to the systems level; focus on the neuromuscular and cardiovascular systems.

BME 180J.3, 380J.3 Principles of Biomeasurement 1,3 Hours
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.

BME 180J.4, 380J.4 Fields, Forces, and Flows 1,3 Hours
Introduction to mathematical models that integrate different energy domains and length scales, with an emphasis on the coupling between them.

BME 180J.5, 380J.5 Biostatistics, Study Design, and Research Methodology 1,3 Hours
Principles for hypothesis testing; confidence limits; regression analysis; correlation; analysis of variance; experimental design and factorial analysis; discriminate analysis; applications of statistics.

BME 180J.6, 380J.6 Analysis of Biomedical Engineering Systems I 1,3 Hours
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.

BME 180J.7, 380J.7 Analysis of Biomedical Engineering Systems II 1,3 Hours
Computational techniques used in biomedical engineering. Students propose and conduct an engineering design study relevant to a selected medical problem.

BME 180J.8, 380J.8 Mathematical Methods for Biomedical Engineering 1,3 Hours
Analyze common mathematical techniques useful for biomedical engineering. Utilize vector calculus, linear algebra, Fourier and Laplace Transforms, and ordinary and partial differential equations. Explore common MATLAB (or Python) functions and manipulations for computationally implementing these mathematical techniques in biomedical engineering applications.

BME 080M Dual MD/PhD Program with UT Medical Branch 0 Hours
Preclinical medical study at the University of Texas Medical Branch at Galveston.

BME 381J Topics in Cell and Molecular Imaging 3 Hours

BME 381J.1 Laser-Tissue Interaction: Thermal 3 Hours
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.

BME 381J.10 Optics and Lasers 3 Hours
Fundamentals of geometric and physical optics, interaction of light with matter, spectroscopy, and laser and electro-optics applications.

BME 381J.11 Medical Imaging 3 Hours

BME 381J.12 Optical Design 3 Hours
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.

BME 381J.13 Fluorescence Micro- and Spectroscopy 3 Hours
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.

BME 381J.14 Digital Video 3 Hours
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.

BME 381J.15 Imaging Clinical Immersion 3 Hours
Identify current unmet clinical needs via close interaction with healthcare professionals and patients. Explore biomedical imaging across the healthcare enterprise.

BME 381J.2 Laser-Tissue Interaction: Optical 3 Hours
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.

BME 381J.3 Imaging Signals and Systems 3 Hours
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.

BME 381J.4 Optical Spectroscopy 3 Hours
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.

BME 381J.5 Therapeutic Heating 3 Hours
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.

BME 381J.6 Noninvasive Optical Tomography 3 Hours
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.

BME 381J.7 Digital Image and Video Processing 3 Hours
Digital image acquisition, processing, and analysis; algebraic and geometric image transformations; two-dimensional Fourier analysis; image filtering and coding.

BME 381J.8 Functional Imaging Laboratory 3 Hours
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.

BME 381J.9 Fundamentals of Biomedical Optical Imaging 3 Hours
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.

BME 681M Normal Body Structure and Function 6 Hours
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.

BME 382J Topics in Cellular and Biomolecular Engineering 3 Hours

BME 382J.1 Cell and Tissue Engineering 3 Hours
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.

BME 382J.10 Immune Engineering 3 Hours
Introduction to the concept of immune engineering. Discussion of vaccine design, cancer immunotherapy, genomics, infection, auto-immune diseases and emerging tools and methodologies.

BME 382J.11 Polymer and Bioconjugate Chemistry 3 Hours
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.

BME 382J.12 Biological Responses to Medical Devices 3 Hours
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.

BME 382J.13 Delivery of Therapeutic Agents 3 Hours
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.

BME 382J.14 Nanomedicine 3 Hours
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.

BME 382J.15 Matrices, Organoids, and Microphysiological Systems 3 Hours
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.

BME 382J.2 Introduction to Biochemical Engineering 3 Hours
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.

BME 382J.3 Molecular Sensors and Nanodevices for Biomedical Engineering Applications 3 Hours
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.

BME 382J.4 Advanced Engineering Biomaterials 3 Hours
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.

BME 382J.5 Structured Surfaces, Fabrication, Characterization, and Application 3 Hours
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.

BME 382J.6 Biopolymers and Drug/Gene Delivery 3 Hours
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.

BME 382J.7 Cellular and Molecular Biomechanics 3 Hours
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.

BME 382J.8 Molecular Biophysics: Measurements and Methods 3 Hours
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.

BME 382J.9 Biomimetic Design and Engineering 3 Hours
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.

BME 382M, 682M Biodesign: Needs Identification 3,6 Hours
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.

BME 383J Topics in Computational Biomedical Engineering and Bioinformatics 3 Hours

BME 383J.1 Network Thermodynamics in Biophysics 3 Hours
Modeling and simulation methods for nonlinear biological processes, including coupling across multienergy domains; practical implementation by bond graph techniques.

BME 383J.10 Computational Biomolecular Engineering 3 Hours
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.

BME 383J.11 Dynamical Modeling of Biological Signaling and Regulatory Systems 3 Hours
Introduction to various approaches currently used for modeling and simulating cellular signal transduction, metabolic, and gene regulatory networks.

BME 383J.12 Computational Modeling in Bioengineering and Medicine 3 Hours
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.

BME 383J.13 Introduction to Mathematical and Physical Biology 3 Hours
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.

BME 383J.14 Mathematical Physiology 3 Hours
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.

BME 383J.2 Musculoskeletal Biomechanics 3 Hours
Synthesis of properties of the musculotendon and skeletal systems to construct detailed computer models that quantify human performance and muscular coordination.

BME 383J.3 Introduction to Computational Oncology 3 Hours
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.

BME 383J.4 Biomechanics of Human Movement 3 Hours

BME 383J.5 Introduction to Nonlinear Dynamics in Biological Systems 3 Hours
Basic concepts of nonlinear mathematics and their application to biological systems.

BME 383J.7 Data Mining 3 Hours
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.

BME 383J.8 Systems Biology 3 Hours
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.

BME 383J.9 Computational Methods for Biomedical Engineers 3 Hours
Study of and hands-on experiences with computational methods commonly employed in biomedical engineering research.

BME 383M, 683M Biodesign: Entrepreneurship 3,6 Hours
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.

BME 384J Topics in Instrumentation 3 Hours

BME 384J.1 Biomedical Instrumentation I 3 Hours
Application of electrical engineering techniques to analysis and instrumentation in biological sciences: pressure, flow, temperature measurement; bioelectrical signals; pacemakers; ultrasonics; electrical safety; electrotherapeutics.

BME 384J.2 Biomedical Instrumentation II: Real-Time Computer-Based Systems 3 Hours
Design, testing, patient safety, electrical noise, biomedical measurement transducers, therapeutics, instrumentation electronics, microcomputer interfaces, and embedded systems. Participate in an individual laboratory.

BME 384J.3 Biosignal Analysis 3 Hours
Theory and classification of biological signals such as EEG, EKG, and EMG. Data acquisition and analysis procedures for biological signals, including computer applications.

BME 384J.4 Bioelectric Phenomena 3 Hours
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.

BME 384J.5 Projects in Biomedical Engineering 3 Hours
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.

BME 384J.6 Neurophysiology/Prosthesis Design 3 Hours
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.

BME 384J.7 Introduction to Neural Engineering 3 Hours
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.

BME 384J.8 Rehabilitation Engineering 3 Hours
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.

BME 384J.9 Bioelectronics and Biointerfaces 3 Hours
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.

BME 384T Topics in Biomechanics 3 Hours

BME 384T.1 Bioheat Transfer 3 Hours
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.

BME 384T.2 Cellular, Tissue, and Scaffold Biomechanics 3 Hours
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.

BME 384T.3 Soft Tissue Biomechanics 3 Hours
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.

BME 384T.4 Thin Film Mechanics 3 Hours
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.

BME 384T.5 Tissue Microenvironments 3 Hours
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.

BME 385J Topics in Biomedical Engineering 3 Hours

BME 385J.39 Medical Decision Making 3 Hours
Selected subjects from cognitive psychology and human-machine interaction for engineering students to design more effective systems for supporting medical decision making.

BME 385J.40 Cancer Bioengineering 3 Hours
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.

BME 385J.41 Medical Device Design and Manufacturing 3 Hours
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.

BME 385J.42 Inquiry Based Instructional Design 3 Hours
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.

BME 385J.6 Analysis of Biological Systems 3 Hours

BME 685M Mechanisms of Disease 6 Hours
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.

BME 386J Biomedical Engineering Microscopy Foundations Laboratory 3 Hours
Explore finite and infinite imagery; conjugate planes, back focal plan manipulation, Abbe theory image formation, point spread functions, camera principles, fluorescence, and advanced fluorescence techniques. Build an optical microscope.

BME 396 Research Internship 3 Hours
Students participate in research in an industry, clinic, or academic laboratory setting selected with the approval of the faculty adviser.

BME 197, 297, 397, 597, 697 Research Problems 1,2,3,5,6 Hours
Problems selected by the student with approval of the faculty adviser.

BME 197D Deep Reading in Science and Engineering 1 Hour
Analyze primary research articles with the goal of improving understanding of experimental design/methods, writing scientific articles and critiquing current research.

BME 197E Professional Responsibilities in Imaging 1 Hour

BME 197M Mentoring Undergraduates in Research 1 Hour
Designed to support and develop students' skills in mentoring undergraduates engaged in science, technology, engineering and mathematics (STEM) research.

BME 197N Integrated Biomedical Engineering Seminar 1 Hour
Designed to support students' professional development as well as their broad understanding of the biomedical engineering research enterprise.

BME 197P, 297P, 397P Graduate Professional Development Seminar 1-3 Hours
Explores professional development goals of biomedical engineers. Subjects include an individual development plan, careers in academia, entrepreneurship, careers in industry, and more.

BME 197S Graduate Seminar in Biomedical Engineering 1 Hour

BME 698 Thesis 6 Hours

BME 398R Master's Report 3 Hours
Preparation of a report to fulfill the requirement for the master's degree under the report option.

BME 399W, 699W, 999W Dissertation 3,6,9 Hours