Bioengineering

Undergraduate Degrees

- Bachelor of Science in Biomedical Engineering (http://catalog.uta.edu/engineering/bio/undergraduate/)

Graduate Degrees

- Biomedical Engineering, M.S. (http://catalog.uta.edu/engineering/bio/graduate/)
- Biomedical Engineering, B.S. to Ph.D. (http://catalog.uta.edu/engineering/bio/graduate/)
- Biomedical Engineering, Ph.D. (http://catalog.uta.edu/engineering/bio/graduate/)
- Fast Track for Master of Science in Biomedical Engineering and Bachelor of Science in Biomedical Engineering (http://catalog.uta.edu/engineering/bio/undergraduate/#bachelorstext)
- Fast Track for Master of Science in Biomedical Engineering and Bachelor of Science in Biochemistry (http://catalog.uta.edu/engineering/bio/undergraduate/#bachelorstext)
- Fast Track for Master of Science in Biomedical Engineering and Bachelor of Science in Physics (http://catalog.uta.edu/engineering/bio/undergraduate/#bachelorstext)
- Fast Track for Master of Science in Biomedical Engineering and Bachelor of Science in Mathematics (http://catalog.uta.edu/engineering/bio/undergraduate/#bachelorstext)

Graduate Certificate

- Graduate Certificate in Design and Development of Regulated Medical Devices (http://catalog.uta.edu/engineering/bio/graduate/#doctoraltext)

COURSES

BE 1000. UNDERGRADUATE RESEARCH. 0 Hours.
Freshman level undergraduate research. Prerequisite: Departmental good standing and permission of instructor. May be taken a maximum of 3 times.

BE 1105. MEDICAL APPLICATIONS OF ENGINEERING. 1 Hour.
Introduction to basic biology and engineering problems associated with living systems and health care delivery. Examples will be used to illustrate how basic concepts and tools of science & engineering can be brought to bear in understanding, mimicking and utilizing biological processes.

BE 1325. INTRODUCTION TO BIOENGINEERING. 3 Hours.
Topics include introduction to basic engineering principles and quantitative methods, their applications in analyzing and solving problems in biology and medicine. Also includes new trends in the development of bioengineering and biotechnology.

BE 2000. UNDERGRADUATE RESEARCH. 0 Hours.
Sophomore level undergraduate research. Prerequisite: Departmental good standing and permission of instructor. May be taken a maximum of 3 times.

BE 2300. SPECIAL TOPICS IN BIOENGINEERING. 3 Hours.
A study of selected topics in Bioengineering. May be repeated when topics vary.

BE 2310. ENGINEERING APPROACHES TO SOLVING CLINICAL CHALLENGES. 3 Hours.
In this sophomore course, students will apply engineering principles to find solutions to current clinical problems presented to the class. As small groups, students will work as teams to design a process or system to meet the desired needs of the given clinical challenges based on the necessary constraints. As a final project presentation, students will use what they have learned to identify a new clinical challenge and work to define a meaningful set of manufacturing, fiscal, safety, ethical, and health-related constraints associated with the problem. Students will be highly encouraged to identify solutions to these newly derived clinical problems and to integrate this clinical challenge as part of their future senior design project. Prerequisite: C or better in BE 1105, BE 1325, MATH 2425, CHEM 1442, and BE 2315 or consent of BE undergraduate advisor.

BE 2315. INTRODUCTORY COMPUTATIONAL TOOLS FOR BIOENGINEERS. 3 Hours.
Students learn programming concepts (variable, array, command, logics, do-loop, etc.) through the use of SolidWorks, MatLab, and Image J, etc. Students learn to use these computational tools by working on problems and exercises of biological, physiological relevance and clinical applications. Prerequisite: A course grade of C or better in BE 1325, and MATH 1426 or consent of BE undergraduate advisor.

BE 3000. UNDERGRADUATE RESEARCH. 0 Hours.
Junior level undergraduate research. Prerequisite: Departmental good standing and permission of instructor. May be taken a maximum 3 times.

BE 3101. SEMINAR IN BIOENGINEERING. 1 Hour.
University and guest lecturers speak on topics of current research interest in the field of bioengineering. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3180. INTRODUCTION TO MEDICAL DEVICE REGULATORY REQUIREMENTS AND QUALITY STANDARDS. 1 Hour.
Topics include introduction to fundamentals of regulatory requirements for medical devices, broadly defined as mechanical and electronic equipment or tissue-implantable constructs. Familiarization with national and international regulatory agencies, and presentation of the processes of securing regulatory approvals for medical devices. Emphasis will be on the U.S. Food and Drug Administration, but examples from other regulatory agencies will also be presented. The course also introduces students to the U.S. National Institute of Standards and Technology as well as various professional engineering societies that provide quality standards for bioengineering design. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3191. DIRECTED RESEARCH IN BIOENGINEERING. 1 Hour.
Student participates in a research project under the individual instruction of a faculty supervisor. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor and the instructor.

BE 3195. INTERNSHIP IN BIOENGINEERING. 1 Hour.
Students receive training in a bioengineering company or a hospital to gain firsthand industrial or clinical engineering experience. The company or hospital assign projects and a faculty member monitors the student's progress. Prerequisite: Completion of at least 70 undergraduate credit hours in BE and good standing in the undergraduate program. Permission of Undergraduate Academic Advisor.

BE 3295. INTERNSHIP IN BIOENGINEERING. 2 Hours.
Students receive training in a bioengineering company or a hospital to gain first hand industrial or clinical engineering experience. The company or hospital assigns projects and a faculty member monitors the student's progress. Prerequisite: Completion of at least 70 undergraduate credit hours in BE and good standing in the undergraduate program. Permission of Undergraduate Academic Advisor.

BE 3301. CELL PHYSIOLOGY FOR BIOENGINEERS. 3 Hours.
This course will cover principles of molecular omics (i.e., genomics, transcriptomics, proteomics and synthetic biology); the field of molecular bioengineering and processes involving inducible transcription and chimeric proteins; the composition of cell membranes, ion transport and the application of optogenetics in cell physiology regulation; the way cells communicate and integrate signals and translate them in intracellular metabolic cascades through the understanding of phosphoproteomics, energy metabolism, metabolomics, cellular motility, and molecular motors; the processes involved in cell proliferation, abnormal cell division dysregulation in cancer, and nanotechnology techniques for tumor treatment. Preferred background: basic understanding of general biology and general chemistry. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3310. BIOMECHANICS AND FLUID FLOW WITH COMPUTATIONAL LABORATORY. 3 Hours.
Following an introduction to the basics of solid, fluid mechanics, student learn the fundamental behavior of various biological materials, flow properties of blood, viscoelastic properties of cells, tissue matrix, as well as their roles in human physiology at normal and disease states. Examples also include the design aspects of medical prosthetic devices. The course will cover biomechanics across a wide range of scales from organism, organ, tissue, cell and to protein levels. Students learn computational modeling to formulate and solve bioengineering problems. Preferred background: basic understanding of general physics, general biology and basic calculus. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3317. LINEAR SYSTEMS IN BIOENGINEERING. 3 Hours.
Time-domain transient analysis, convolution, Laplace Transforms, Fourier Series, Transforms and their applications, transfer functions, signal flow diagrams, Bode plots, stability criteria, sampling, filter designs, and Discrete-time signals and systems. Examples with applications in bioengineering will be emphasized. Preferred background: basic understanding of general physics, general biology and basic calculus. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3320. MEASUREMENT LABORATORY. 3 Hours.
Hands-on experiments with use of transducers used for chemical, mechanical, electrical, and thermal biomedical measurements. Computer-based means of converting analog transducer output into digital form. Analysis of experimentally collected data including error analysis, repeatability, resolution, and functional specifications. Prerequisite: C or better in MATH 2326, BE 2315 and PHYS 1444 (PHYS 1444 may be taken concurrently), or consent of the BE undergraduate advisor.

BE 3325. FLUORESCENCE MICROSCOPY. 3 Hours.
Introduction to the anatomy of fluorescence microscopy and the physical principles of its operation; confocal and multi-photon microscopy; molecular imaging applications based on Forster Resonance Energy Transfer (FRET), Fluorescence Lifetime Imaging (FLIM), Fluorescence Correlation Spectroscopy (FCS), Fluorescence Recovery After Photobleaching (FRAP) and Total Internal Reflection Fluorescence (TIRF) Microscopy. Preferred background: basic understanding of general physics, general chemistry, general biology and basic calculus. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3327. TISSUE OPTICS. 3 Hours.
Introduction to the science and technology behind tissue optical imaging systems and their design requirements for different clinical applications; diffuse optical tomography; fluorescence tomography; bioluminescence tomography; multi-modality imaging. Preferred background: basic understanding of general physics, general chemistry, general biology and basic calculus. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3343. MATLAB AND APPLICATIONS FOR BIOENGINEERS. 3 Hours.
This course consists of two parts: the first part teaches students how to use MATLAB for engineering computation, quantitative analysis, scientific plotting/graphing presentation, and numerical modeling in solving real-world problems. After enabling students to generate arrays, files, functions, and to write MATLAB programs, the course will focus on using MATLAB for bioengineering applications, including 2D and 3D graphing for biological images, data processing for time-varying signals, and 2D Fourier transform for medical image processing. A variety of examples often encountered in the biological, biomedical engineering field will be used as class demonstration, presentation and project assignments. Preferred background: basic programming skills. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3344. BIOINSTRUMENTATION. 3 Hours.
Fundamental principles of bioinstrumentation, including operational amplifiers and instrumentation amplifiers; measurements of biopotentials; signals and noise in biological systems; mechanical transducers; resistive, inductive, capacitive transducers; measurement of temperature, blood pressure and flow; electrical safety. Prerequisite: C or better in EE 2440 or CSE 2440; accepted in BE Professional Program or consent of the BE undergraduate advisor.

BE 3346. MEDICAL IMAGING. 3 Hours.
This course introduces basic medical imaging modalities, including X-ray Computed Tomography (CT), Nuclear Medicine Imaging (PET and SPECT), Magnetic Resonance Imaging (MRI), and image-guided interventions. Through this course, the students will learn fundamental knowledge on how medical images are obtained and how they can be used for diagnosis, therapy, and surgery. Preferred background: basic understanding of general physics, general biology and basic calculus. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3352. DIGITAL PROCESSING OF BIOLOGICAL SIGNALS. 3 Hours.
Fundamental techniques for extraction of useful information from signals acquired from biological systems. Topics include time and frequency domain analysis, cross correlation, spectrum analysis, and convolution. Design of finite impulse response (FIR) and infinite impulse response (IIR) filters for processing biological signals are described. Examples include cardiac, respiratory, and biomechanical movements. Preferred background: basic understanding of general physics and differential equations. Prerequisite: Accepted into the BE Professional Program and BE 3317 (or equivalent course) or consent of the BE undergraduate advisor.

BE 3367. CELL CULTURE AND DRUG DELIVERY LABORATORY. 3 Hours.
This course will cover techniques commonly used in tissue engineering and biomaterial research, including culture media preparation, cell culture/subculture, degradable scaffold, their modification, histological staining, and imaging analyses. The course will also include development of systems for delivery of pharmaceutical agents used for treating different diseases; an understanding of the underlying pharmacokinetics principles is emphasized. Preferred background: basic understanding of general chemistry and general biology. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3380. HUMAN PHYSIOLOGY IN BE. 3 Hours.
An introduction to human physiology emphasizing biomedical engineering related topics. The course focuses on understanding basic function with the relationships on the cellular as well as organ level in both healthy and diseased states. Preferred background: basic understanding of general biology. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 3395. INTERNSHIP IN BIOENGINEERING. 3 Hours.
Students receive training in a bioengineering company or a hospital to gain first hand industrial or clinical engineering experience. The company or hospital assigns projects and a faculty member monitors the student's progress. Prerequisite: Completion of at least 70 undergraduate credit hours in BE and good standing in the undergraduate program. Permission of Undergraduate Academic Advisor.

BE 3415. FUNDAMENTALS OF BIOMOLECULAR ENGINEERING. 4 Hours.
The course will introduce the principles of engineering living systems at the atomic, molecular, and cellular levels. Fundamentals covered in the course will include topics such as chemical bonding and reactions; synthesis, structure and function of carbohydrates, polypeptides, nucleic acids, and lipids; as well as analytical and engineering tools for characterization, design, and production of synthetic biological systems. A laboratory component will provide hands on experience including methods important to synthetic biochemistry, protein engineering, cellular reprogramming, and metabolic engineering. Knowledge of college level general chemistry is required. Prerequisite: C or better in BE 1105, BE 1325, BIOL 1441, CHEM 1442, and MATH 2425, or consent of the BE undergraduate advisor.

BE 4000. UNDERGRADUATE RESEARCH. 0 Hours.
Senior level undergraduate research. Prerequisite: Departmental good standing and permission of instructor. May be taken a maximum of 3 times.

BE 4191. DIRECTED RESEARCH IN BIOENGINEERING. 1 Hour.
Student participates in a research project under the individual instruction of a faculty supervisor.

BE 4291. DIRECTED RESEARCH IN BIOENGINEERING. 2 Hours.
Student participates in a research project under the individual instruction of a faculty supervisor.

BE 4300. SPECIAL TOPICS IN BIOENGINEERING. 3 Hours.
A study of selected topics in Bioengineering. May be repeated when topics vary. Prerequisite: Consent of instructor and undergraduate advisor.

BE 4312. TISSUE BIOMECHANICS AND BIOENGINEERING. 3 Hours.
This course introduces biomechanics as a means to describe mechanical behavior of biological tissues. A comprehensive course, it covers the fundamental concepts, experimental and theoretical approaches of biomechanics, and their applications in modern bioengineering, including mechano signal transduction, pathophysiology, tissue engineering and regeneration, medical implants, surgical intervention. Structural-mechanical properties of specific tissues, such as heart valves, cardiac tissues, blood vessels, tendon/ligament, skeletal muscles, cartilage, and meniscus will be discussed in great details. This course integrates the concepts of biomechanics, the underlying structural and biological mechanisms, illustrates how experimental, analytical and computational methods have been used to address clinical needs in enhancing the quality of health care delivery. Preferred background: satisfactory completion of BE 3380. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4314. BIOMEDICAL IMPLANTS. 3 Hours.
A comprehensive course covers the essential knowledge in biomedical implants. The goal is to provide students with the knowledge and skills to understand the clinical needs, the engineering principles, methodologies used in implant design, the resulting host-implant interaction, and the constraints, limitations on engineering design optimization, as well as the evaluation and assessment of the implant performance and clinical outcomes. Case studies include mechanical, bio-prosthetic and trans-catheter heart valves, vascular grafts, stents, pacemakers, orthopedic implants, dental implants, etc. The course also covers topics on regulatory issues, patent protection, design validation in animal models and clinical trials, IACUC, IRB, Good Manufacture Practice (GMP), and FDA regulations and approvals. Students are expected to be able to apply the learning to solve problems in the rapidly growing field of biomedical engineering. Preferred background: satisfactory completion of BE 3380. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4318. MEDICAL DEVICE PROTOTYPING. 3 Hours.
This course introduces students to fundamental skills for prototyping medical devices and tissue engineering implants using 3D printing and supporting software. The lectures and exercises provide in depth understanding of the software. Students will learn to build simple 3D parts, move towards designing medical implants and devices for bioengineering applications as well as practice running mechanical simulations on the prototypes. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate adviser.

BE 4324. BIOMEDICAL OPTICS LABORATORY. 3 Hours.
The primary objective of this course is to provide students hands-on experience with fundamental optical techniques and instrumentation used in modern biomedical research and applications. The skills learned will be valuable to anyone who intends to work in an experimental setting that requires working knowledge of optical instrumentation and techniques. The course is divided into ten core lab modules that cover topics ranging from basic optical techniques to advanced imaging and spectroscopy techniques. Preferred background: satisfactory completion of BE 3320. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4325. FUNDAMENTALS OF BIOENGINEERING. 3 Hours.
Topics cover fundamentals of biosensors, bio-signal processing, and bioinstrumentation. An introduction to various imaging modalities such as ultrasound, magnetic resonance, optical tomography, and x-ray radiography is also presented. Other bioengineering topics may be included as time allows or as is appropriate. Preferred background: satisfactory completion of BE 3380. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4326. TISSUE ULTRASOUND-OPTICAL IMAGING. 3 Hours.
This course will introduce the fundamental principles of ultrasound and optical related imaging techniques, such as ultrasonic, tissue optical, and photoacoustic imaging techniques. Some topics related to the new progresses and applications in the related fields will be introduced. Students are expected to know the principles of these imaging techniques, and use mathematical, numerical simulation and experimental methods to understand these technologies and their biomedical applications. Preferred background: satisfactory completion of PHYS 1443, PHYS 1444 and BE 3380. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4329. NEURAL ENGINEERING. 3 Hours.
This course consists of both lecture/discussion and laboratory. Lecture topics include central and peripheral nervous system injury and regeneration, brain/machine interfacing, primary culture of neural cells, neuroinflammatory and neurodegenerative disease. Laboratories include embryonic and neonatal rat derived neuronal culturing, immunostaining and quantitative analysis. Preferred background: satisfactory completion of BE 3367 and BE 3380. Prerequisites: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4330. MEDICAL IMAGE PROCESSING. 3 Hours.
Principles and computational methods in digitally processing medical images are presented. Topics include image reconstruction, two and three dimensional visualization, image registration, quantitative image analysis, image enhancement, and statistical processing methods including Monte Carlo methods. Prerequisites: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4331. BIOPOLYMERS AND BIOCOMPATIBILITY. 3 Hours.
This is a foundation course in polymeric biomaterial design, synthesis, characterization, and processing. The topics include design, surface-engineering, functionalization, characterization, as well as micro- and nano-fabrication of polymeric biomaterials. The biomedical applications of the polymeric biomaterials and their interaction with cell/tissue is discussed. Preferred background: basic understanding of general chemistry and successful completion of BE 3415. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4333. NANO BIOMATERIALS AND LIVING-SYSTEMS INTERACTION. 3 Hours.
Synthesis, fabrication, characterization, and biomedical applications of nanobiomaterials. Topics include synthetic nanobiomaterials, biological nanobiomaterials (DNA nanomaterials, protein and peptide nanomaterials, etc.), biofunctionalization of nanobiomaterials, and use of nanobiomaterials in tissue engineering, drug delivery, gene delivery. Preferred background: basic understanding of general chemistry and successful completion of BE 3415. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4337. TRANSPORT PHENOMENA IN BIOMEDICAL ENGINEERING. 3 Hours.
Principles of momentum, mass and heat transfer; description of blood flow, trans-capillary, interstitial, lymphatic fluid transport and pulmonary gas exchange. Applications in the design of blood oxygenator, dialysis devices, and strategies in drug delivery, hyperthermia treatment. Preferred background: basic understanding of general physics, biology and calculus, and successful completion of BE 3380. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4345. BIOSENSORS. 3 Hours.
The course will cover major classes of bio-sensing technologies currently used in practice and the emerging ones that are currently being evaluated. The basic operating principle behind bio-sensing technologies will be explained and its implementation in medical devices will be discussed. Explanation of biosensor operation will involve understanding the mechanism of bio-signal transduction (bio-parameter to biomechanical, electrical, optical or chemical signal), detection method, and their analysis. Methodology for device calibration and data interpretation of physiological parameters will be discussed. The course material will be derived from book chapters and review papers. Course includes hand-on learning experience in laboratory by deconstructing commercially available biosensors and using experimental bio-sensing instruments. Students will be required to design and implement a point-of-care biosensor. Preferred background: satisfactory completion of EE 2440 or CSE 2440. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4350. SENIOR DESIGN PROJECT I. 3 Hours.
First of two courses in design of biomedical systems and processes. Major design project in biomedical engineering, incorporating engineering standards and realistic design constraints. This course prepares students through a major design experience incorporating engineering principles and realistic constraints that include most of the following considerations: economic, environmental, sustainability, manufacturability, ethical, health and safety, and social consideration. Prerequisite: C or better in BE 3317, BE 3380 and BE 4382; accepted into the BE Professional Program, and consent of the BE undergraduate advisor.

BE 4355. SENIOR DESIGN PROJECT II. 3 Hours.
Second in two courses in design of biomedical systems. Proposals approved in BE 4350 will be completed. Teams will address, resolve limitations in the design and present final results through an oral presentation. Teams are required to submit a final project report with their design notebooks to the course instructors. Prerequisite: C or better in BE 4350.

BE 4360. FUNDAMENTALS OF ULTRASOUND IN BIOENGINEERING. 3 Hours.
This course instructs the students in the physics of ultrasound transducers, their operation, and their biomedical applications. The material includes modeling of the interaction of acoustic waves with various types of tissue and cells. Mathematical methods for analyzing the reflected and refracted waves as well as constructing images from the waves will be covered. Prerequisite: Accepted into the BE Professional Program and EE 2440 or CSE 2440, BE 3344, or consent of the BE undergraduate advisor.

BE 4364. TISSUE ENGINEERING LECTURE. 3 Hours.
Fundamentals of cell/extracellular matrix interactions in terms of cell spreading, migration, proliferation and function; soft and hard tissue wound healing and nerve regeneration; polymer scaffolding materials and fabrication methods; cell-polymer interactions; in vitro and in vivo tissue culture and organ replacement. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4365. TISSUE ENGINEERING LABORATORY. 3 Hours.
Each student will be given the opportunity to perform the techniques commonly used in tissue engineering and biomaterial research. These techniques are culture media preparation, cell culture/subculture, degradable scaffold preparation, scaffold modification, histological sections and staining, and cell imaging analyses. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4366. PROCESS CONTROL IN BIOTECHNOLOGY. 3 Hours.
Principles and methods and measurement, data acquisition, and analysis. Application of control theory in biological systems and in biotechnology processes; control of pressure, flow, temperature, and pH. Prerequisite: Accepted into the Professional Program and BE 3317 (or equivalent course) or consent of the BE undergraduate advisor.

BE 4368. AN INTRODUCTION TO TISSUE ENGINEERING AND DRUG DELIVERY. 3 Hours.
Topics include fundamentals of cell-ECM interactions, cell spreading, migration, proliferation and function; soft and hard tissue wound healing and nerve regeneration; polymer scaffolding materials and fabrication methods; cell-polymer interactions; in vitro and in vivo tissue culture and organ replacement. Students will be introduced to basic principles of pharmacokinetics and pharmacodynamics. Topics also include design and development of targeted and controlled drug delivery systems, including transdermal, inhalation, drug-eluting stents, stimulated-drug, as well as encapsulated nano and micro-particles for controlled release. Underlying principles of drug delivery, targeting, modification, distribution and diffusive transport will be discussed. Preferred background: satisfactory completion of BE 3380 (or co-requisite). Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4372. DRUG DELIVERY SYSTEMS. 3 Hours.
This class focuses on the development, design, and application of controlled and targeted drug delivery systems including transdermal, inhalation, drug eluting stents, stimulation-drug, as well as microparticles and nanoparticles for controlled drug delivery. Principles of drug delivery, targeting, modification, distribution and diffusion will be discussed. Preferred background: satisfactory completion of BE 3380. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4373. FORMULATION AND CHARACTERIZATION OF DRUG DELIVERY SYSTEMS. 3 Hours.
This class will provide students with hands-on experience in the development of drug delivery systems such as hydrogels, scaffolds, microparticles and/or nanoparticles that can be loaded with and release pharmaceutical agents to treat various diseases. The emphasis is synthesis, characterization and pharmacokinetic studies of these drug delivery systems. Preferred background: satisfactory completion of BE 4372. Prerequisite: Accepted into the BE Engineering Professional Program or consent of the BE undergraduate advisor.

BE 4382. LABORATORY PRINCIPLES. 3 Hours.
Introduction to fundamental biomedical engineering laboratory procedures including human studies and animal surgery; includes clinical laboratory projects, data collection, analysis, and interpretation. Preferred background: satisfactory completion of BE 3320 and BE 3380. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4385. STEM CELL TISSUE ENGINEERING. 3 Hours.
Students will gain experience and expertise in stem cell culture and differentiation, and engineering stem cell-based 2D and 3D tissue constructs. Using phenotypic markers and appropriately integrating with biocompatible scaffolds, the engineered tissue constructs will be differentiated to several tissue types and functionally validated. Lectures will cover stem cells, designing scaffolds and multimodal imaging techniques. The final projects may include acquisition of big data images, data mining and development of pattern recognition algorithms. Prerequisite: Accepted into the BE Professional Program and BE 3380, BE 3301, BE 3367, or consent of the undergraduate advisor.

BE 4388. MEDICAL PRODUCT DESIGN AND DEVELOPMENT. 3 Hours.
This course aims to provide, 1) A comprehensive knowledge of biomedical product design and development life cycle, 2) Basic knowledge on developing business plan, securing funding, designing product and process, conducting preclinical and clinical studies, 3) Basic training and classroom exercises on various biomedical product design and development tools, 4) Basic knowledge of FDA regulation and quality control, 5) Basic training on intellectual property and industrial project management. Prerequisite: Accepted into the BE Professional Program or consent of the BE undergraduate advisor.

BE 4390. UNDERGRADUATE RESEARCH PROJECT. 3 Hours.
Student works on an independent, individual research or development project under supervision of faculty instructor. A final project report is required. Prerequisite: Permission from Instructor.

BE 4391. DIRECTED RESEARCH IN BIOENGINEERING. 3 Hours.
Student participates in a research project under the individual instruction of a faculty supervisor.

BE 5101. SEMINAR IN BIOENGINEERING. 1 Hour.
University and guest lecturers speak on topics of current interest in the field of bioengineering.

BE 5191. DIRECTED RESEARCH IN BIOENGINEERING. 1 Hour.
Student participates in a research project under the individual instruction of a faculty supervisor.

BE 5193. MS COMPREHENSIVE EXAMINATION. 1 Hour.
Individual instruction, directed study, consultation, and comprehensive examination over coursework leading to the Thesis-Substitute Master of Science degree in bioengineering. Graded P/F/R. Required of all Thesis-Substitute MS students.

BE 5201. SEMINAR IN BIOENGINEERING. 2 Hours.
University and guest lecturers speak on topics of current research interest in the field of bioengineering. Students are expected to write a report for each topic to summarize the presentation and to offer critiques. Prerequisite: Graduate admission to the BE MS program.

BE 5281. BEST PRACTICES IN TEACHING AND LEARNING. 2 Hours.
Introduction to approaches and activities that can facilitate learning. Students gain insight into specific challenges of teaching, basics of designing a course, role of assessments and evaluations, good presentation skills and comparisons of various engagement levels. Students teach mock lessons and are given feedback.

BE 5291. DIRECTED RESEARCH IN BIOENGINEERING. 2 Hours.
Student participates in a research project under the individual instruction of a faculty supervisor.

BE 5293. MASTERS COMPREHENSIVE EXAMINATION. 2 Hours.
Individual instruction, directed study, consultation, and comprehensive examination over coursework leading to the Master of Science degree in bioengineering. Required of all MS students.

BE 5300. SELECTED TOPICS IN BIOENGINEERING. 3 Hours.
Material may vary from semester to semester. May be repeated for credit if different topics are covered for each registration. Prerequisite: permission of the instructor.

BE 5301. CELL PHYSIOLOGY FOR BIOENGINEERS. 3 Hours.
This course will cover principles of molecular omics (i.e., genomics, transcriptomics, proteomics and synthetic biology). The field of Molecular bioengineering and processes involving inducible transcription and chimeric proteins. The composition of cell membranes, ion transport and the application of optogenetics in cell physiology regulation. The way cells communicate and integrate signals and translated them in intracellular metabolic cascades through the understanding of phosphoproteomics, energy metabolism, metabolomics, cellular motility, and molecular motors. The processes involved in cell proliferation, abnormal cell division dysregulation in cancer, and nanotechnology techniques for tumor treatment. Prerequisite: Graduate Level or Instructor Permission.

BE 5309. HUMAN PHYSIOLOGY IN BIOENGINEERING. 3 Hours.
An introduction to human physiology emphasizing biomedical engineering related topics. The course focuses on understanding basic function with the relationships on the cellular as well as organ level both in healthy and diseased states.

BE 5310. BIOMECHANICS AND FLUID FLOW WITH COMPUTATIONAL LAB. 3 Hours.
Follow an introduction to the basics of solid, fluid mechanics, student learn the fundamental behavior of various biological materials, flow properties of blood, viscoelastic properties of cells, tissue matrix, as well as their roles in human physiology at normal and disease states. Examples also include the design aspects of medical prosthetic devices. The course will cover biomechanics across a wide range of scales from organism, organ, tissue, cell and to protein levels. Students learn computational modeling to formulate and solve bioengineering problems. Prerequisite: Undergraduate solid and fluid mechanics courses or consent of the instructor.

BE 5312. TISSUE BIOMECHANICS AND BIOENGINEERING. 3 Hours.
This course introduces biomechanics as a means to describe mechanical behavior of biological tissues. A comprehensive course, it covers the fundamental concepts, experimental and theoretical approaches of biomechanics, and their applications in modern bioengineering, including mechano signal transduction, pathophysiology, tissue engineering and regeneration, medical implants, surgical intervention. Structural-mechanical properties of specific tissues, such as heart valves, cardiac tissues, blood vessels, tendon/ligament, skeletal muscles, cartilage, and meniscus will be discussed in great details. This course integrates the concepts of biomechanics, the underlying structural and biological mechanisms, illustrates how experimental, analytical and computational methods have been used to address clinical needs in enhancing the quality of health care delivery.

BE 5314. BIOMEDICAL IMPLANTS. 3 Hours.
A comprehensive course covers the essential knowledge in biomedical implants. The goal is to provide students with the knowledge and skills to understand the clinical needs, the engineering principles, methodologies used in implant design, the resulting host-implant interaction, and the constraints, limitations on engineering design optimization, as well as the evaluation and assessment of the implant performance and clinical outcomes. Case studies include mechanical, bio-prosthetic and trans-catheter heart valves, vascular grafts, stents, pacemakers, orthopedic implants, dental implants, etc. The course also covers topics on regulatory issues, patent protection, design validation in animal models and clinical trials, IACUC, IRB, Good Manufacture Practice (GMP), and FDA regulations and approvals. Students are expected to be able to apply the learning to solve problems in the rapidly growing field of biomedical engineering.

BE 5315. FUNDAMENTALS OF BIOMOLECULAR ENGINEERING. 3 Hours.
The course will introduce the principles of engineering living systems at the atomic, molecular, and cellular levels. Fundamentals covered in the course will include topics such as chemical bonding and reactions; synthesis, structure and function of carbohydrates, polypeptides, nucleic acids, and lipids; as well as analytical and engineering tools for characterization, design, and production of synthetic biological systems.

BE 5316. FUNDAMENTAL MATH AND PHYSICS FOR BIOENGINEERING. 3 Hours.
This course introduces the basic physics concepts such as introduction to electromagnetism, Maxwell's equations, computation of Fresnel coefficients, interference and diffraction of light, waveguides and optical fibers, photon counting statistics, and Beer-Lambert law. It also covers basic mathematical concepts such as curvilinear coordinates, vector calculus, Stokes theorem and solving differential equations with initial conditions and the diffusion equation.

BE 5318. MEDICAL DEVICE PROTOTYPING. 3 Hours.
This course introduces students to fundamental skills for the prototyping medical devices and tissue engineering implants using 3D printing and supporting software. The lectures and exercises provide in depth understanding of the software. Students will learn to build simple 3D parts, move towards designing medical implants and devices for bioengineering applications, as well as practice running mechanical simulations on the prototypes.

BE 5323. INTRODUCTION TO BIOPHOTONICS. 3 Hours.
Introduction to properties of light, light-cell/tissue interactions, optical techniques, and optical instrumentation, in the context of biophotonic medical applications. Topics that will be covered include fundamental properties of optical wave fields, basic properties and characterization of laser sources and detectors used in modern biomedicine, interferometry, linear and nonlinear light-tissue interactions exploited for biomedical imaging and sensing applications, and spectroscopy.

BE 5324. BIOMEDICAL OPTICS LABORATORY. 3 Hours.
The primary objective of the Biomedical Optics Laboratory course is to provide students hands-on experience with fundamental optical techniques and instrumentation used in modern biomedical research and applications. The skills learned will be valuable to anyone who intends to work in an experimental setting that requires working knowledge of optical instrumentation and techniques. The course is divided into ten core lab modules that cover topics ranging from basic optical techniques to advanced imaging and spectroscopy techniques.

BE 5325. FLUORESCENCE MICROSCOPY. 3 Hours.
Introduction to the anatomy of a fluorescence microscope and the physical principles of its operation. Confocal and multi-photon microscopy. Molecular imaging applications based on Forster Resonance Energy Transfer (FRET), Fluorescence Lifetime Imaging (FLIM), Fluorescence Correlation Spectroscopy (FCS), Fluorescence Recovery After Photobleaching (FRAP) and Total Internal Reflection Fluorescence (TIRF) Microscopy.

BE 5326. TISSUE ULTRASOUND OPTICAL IMAGING. 3 Hours.
This course will introduce the fundamental principles of ultrasound and optical related imaging techniques, such as ultrasound, tissue optical, photo-acoustic and ultrasound-modulated optical imaging techniques. Lectures, laboratories, simulations, and paper presentations and discussion will be adopted in this course. Some topics related to the new progresses and applications in the related fields will be introduced. Prerequisite: Graduate level or instructor permission.

BE 5327. TISSUE OPTICS. 3 Hours.
Introduction to the science and technology behind tissue optical imaging systems and their design requirements for different clinical applications. Diffuse optical tomography, fluorescence tomography, bioluminescence tomography, multi-modality imaging.

BE 5329. NEURAL ENGINEERING. 3 Hours.
This course consists of both lecture/discussion and laboratory. Lecture topics include central and peripheral nervous system injury and regeneration, brain/machine interfacing, primary culture of neural cells, neuroinflammatory and neurodegenerative disease. Laboratories include embryonic and neonatal rat derived neuronal culturing, immunostaining and quantitative analysis.

BE 5331. POLYMERS AND BIOCOMPATIBILITY. 3 Hours.
This is a foundation course in polymeric biomaterial design, synthesis, characterization, and processing. The topics include design, surface-engineering, functionalization, characterization, as well as micro- and nano-fabrication of polymeric biomaterials. The biomedical applications of the polymeric biomaterials and their interaction with cell/tissue is discussed.

BE 5333. NANO BIOMATERIALS AND LIVING-SYSTEMS INTERACTION. 3 Hours.
Synthesis, fabrication, characterization, and biomedical applications of nanobiomaterials. Topics include synthetic nanobiomaterials, biological nanobiomaterials (DNA nanomaterials, protein and peptide nanomaterials, etc.), biofunctionalization of nanobiomaterials, use of nanobiomaterials in tissue engineering, drug delivery, gene delivery.

BE 5335. BIOLOGICAL MATERIALS, MECHANICS, & PROCESSES. 3 Hours.
Typical functional behavior of various biological materials, flow properties of blood, bioviscoelastic fluids and solids, mass transfer in cardiovascular and pulmonary systems.

BE 5337. TRANSPORT PHENOMENA IN BIOMEDICAL ENGINEERING. 3 Hours.
Principles of momentum, mass and heat transfer; description of blood flow, trans-capillary, interstitial, lymphatic fluid transport and pulmonary gas exchange. Applications in the design of blood oxygenator, dialysis devices, and strategies in drug delivery, hyperthermia treatment. Prerequisite: undergraduate courses in CE 2312 Statics/Dynamics, MAE 2314 Fluid Mechanics I or CE 3305 and MAE 3310 Thermodynamics I or CHEM 3321.

BE 5340. FINITE ELEMENT APPLICATIONS IN BIOENGINEERING. 3 Hours.
The course describes the fundamental principles of the finite element method and various numerical modeling techniques. Topics include variational and Galerkin formulations, linear and Hermitian elements, accuracy and convergence. Applications in biological systems and to the design of prosthetic devices are emphasized. Topic areas include linear elasticity, fluid dynamics, heat transfer, and mass transport processes.

BE 5343. IMAGE PROCESSING WITH MATLAB: APPLICATIONS IN MEDICINE AND BIOLOGY. 3 Hours.
This course focuses on introduction to image processing for applications in medicine and biology. After a review of how to use MATLAB arrays, files, functions, and to write MATLAB programs for quantitative computation and graphing, students will learn the fundamental tools in image processing, image analysis, and two-dimensional Fourier transform, using MATLAB functions available in the textbook. Topics also include image segmentation. Real-world research-based examples will be presented, and discussed in the course. With hands-on exercises, students will learn the basic skills, knowledge on MATLAB usage and the problem-solving techniques required for medical image processing.

BE 5344. BIOINSTRUMENTATION I. 3 Hours.
Fundamental principles of bioinstrumentation, including operational amplifiers and instrumentation amplifiers; measurements of biopotentials; signals and noise in biological systems; mechanical transducers; resistive, inductive, capacitive transducers; measurement of temperature, blood pressure and flow; electrical safety.

BE 5345. BIOSENSOR. 3 Hours.
The course will cover major classes of bio-sensing technologies currently used in practice and the emerging ones that are currently being evaluated. The basic operating principle behind bio-sensing technologies will be explained and its implementation in medical devices will be discussed. Explanation of biosensor operation will involve understanding the mechanism of bio-signal transduction (bio-parameter to biomechanical, electrical, optical or chemical signal), detection method, and their analysis. Methodology for device calibration and data interpretation of physiological parameters will be discussed. The course material will be derived from book chapters and review papers. Course includes hand-on learning experience in laboratory by deconstructing commercially available biosensors and using experimental bio-sensing instruments. Students will be required to design and implement a point-of-care biosensor. Prerequisite: Undergraduate instrumentation courses or consent of the instructor.

BE 5346. MEDICAL IMAGING. 3 Hours.
This course introduces basic medical imaging modalities, including X-ray Computed Tomography (CT), Nuclear Medicine Imaging (PET and SPECT), Magnetic Resonance Imaging (MRI), and image-guided interventions. Through this course, the students will learn fundamental knowledge on how medical images are obtained and how they can be used for diagnosis, therapy, and surgery.

BE 5347. PRINCIPLES OF FUNCTIONAL MAGNETIC RESONANCE IMAGING. 3 Hours.
This course introduces basic principles of Magnetic Resonance Imaging (MRI) and functional MRI (fMRI) for brain functional imaging. After taking this course, the students will gain basic knowledge on how functional brain images are obtained from MRI and fMRI as well as how they can be used for diagnosis, therapy, and surgery. The emphasis in this course is on fMRI . This course will include lecture and some laboratory exercises involving actual fMRI measurement data.

BE 5350. MODELING AND CONTROL OF BIOLOGICAL SYSTEMS. 3 Hours.
Introduction to fundamental methods of modeling, analysis and control of biological systems. Linear system modeling, state space modeling, stability analysis, basic identification techniques. Examples from cardiopulmonary, visual, and motor control systems. Prerequisite: an undergraduate course in linear systems, control theory, or consent of the instructor.

BE 5352. DIGITAL PROCESSING OF BIOLOGICAL SIGNALS. 3 Hours.
Fundamental techniques for extraction of useful information from signals acquired from biological systems. Topics include time and frequency domain analysis, cross correlation, spectrum analysis, and convolution. Design of FIR and IIR filters for processing biological signals are described. Examples include cardiac, respiratory, and biomechanical movements. Prerequisite: an undergraduate engineering course in signals and systems analysis or consent of the instructor.

BE 5360. DESIGN AND APPLICATION OF ARTIFICIAL ORGANS. 3 Hours.
Fundamental principles of fluid mechanics, mass transfer and chemical reaction in engineered biological systems. Simple solutions are developed for the design of artificial ventricular assist devices, total artificial hearts, lungs and kidneys.

BE 5361. BIOMATERIALS AND BLOOD COMPATIBILITY. 3 Hours.
This course is an introduction to polymer structure and fabrication methods. Blood and tissue interactions with materials, and methods to improve the biocompatibility of materials are discussed.

BE 5364. TISSUE ENGINEERING LECTURE. 3 Hours.
Fundamentals of cell/extracellular matrix interactions in terms of cell spreading, migration, proliferation and function. Soft and hard tissue wound healing and nerve regeneration. Polymer scaffolding materials and fabrication methods. Cell-polymer interactions. In vitro and in vivo tissue culture and organ replacement.

BE 5365. TISSUE ENGINEERING LAB. 3 Hours.
Each student will be given the opportunity to perform the techniques commonly used in tissue engineering and biomaterial research. These techniques are culture media preparation, cell culture/subculture, degradable scaffold preparation, scaffold modification, histological sections and staining, and cell imaging analyses.

BE 5366. PROCESS CONTROL IN BIOTECHNOLOGY. 3 Hours.
Principles and methods of measurement, data acquisition and analysis. Application of control theory in biological systems and in biotechnology processes; control of pressure, flow, temperature, and pH. Prerequisite: an undergraduate course in control theory or consent of the instructor.

BE 5370. BIOMATERIAL - LIVING SYSTEMS INTERACTION. 3 Hours.
This course describes current developments in molecular structure and organization at synthetic material interfaces with tissues and the subsequent influences on cells and cell membranes. It is designed to lay the groundwork for an improved understanding of events at the biomaterial-living system interface.

BE 5372. DRUG DELIVERY. 3 Hours.
This class focuses on the development, design and application of controlled and targeted drug delivery systems including transdermal, inhalation, drug eluting stents, stimulated-drug as well as microparticles and nanoparticles for controlled drug delivery. Principles of drug delivery, targeting, modification, distribution and diffusion will be discussed.

BE 5373. FORMULATION AND CHARACTERIZATION OF DRUG DELIVERY SYSTEMS. 3 Hours.
This class will provide the students with hands-on experience for developing drug delivery systems such as microparticles and nanoparticles that deliver pharmaceutical agents to treat various diseases. The emphasis is on understanding the principles of pharmacokinetics and drug delivery systems to improve the clinical efficacy and reduce side effects.

BE 5382. LABORATORY PRINCIPLES. 3 Hours.
Introduction to fundamental biomedical engineering laboratory procedures including human studies and animal surgery; includes clinical laboratory projects; data collection, analysis, and interpretation. Prerequisite: permission of the instructor.

BE 5385. STEM CELL TISSUE ENGINEERING. 3 Hours.
Students will gain experience and expertise in stem cell culture and differentiation, and engineering stem cell-based 2D and 3D tissue constructs. Using phenotypic markers and appropriately integrating with biocompatible scaffolds, the engineered tissue constructs will be differentiated to several tissue types and functionally validated. Lectures will cover stem cells, designing scaffolds and multimodal imaging techniques. The final projects may include acquisition of big data images, data mining and development of pattern recognition algorithms.

BE 5386. MEDICAL PRODUCT DESIGN CONTROL AND RISK MANAGEMENT. 3 Hours.
This course presents a thorough description of the design control for medical device development, starting with documenting the product requirements and concluding with design verification and validation that the design output meets the design meets product specifications and user needs. The role and scope of standard operating procedures (SOP) and representative content of an SOP are described. The students are introduced to elements of design history file and documentation.

BE 5387. MEDICAL DEVICE PROTOTYPE DEVELOPMENT. 3 Hours.
Students in this course are grouped in small teams to practice the design and development of a medical device that strictly adheres to the needed controls for regulatory affair approval of the product. The teams will be provided with a typical medical device manufacturer's standard operating procedure (SOP) and will be asked to apply that to their design. The teams demonstrate their understanding and implementation of design input, history file documentation, verification, and validation.

BE 5388. MEDICAL PRODUCT DESIGN AND DEVELOPMENT. 3 Hours.
This course aims to provide 1) A comprehensive knowledge of biomedical product design and development life cycle, 2) Basic knowledge on developing business plan, securing funding, designing product and process, conducting preclinical and clinical studies, 3) Basic training and classroom exercises on various biomedical product design and development tools, 4) Basic knowledge of FDA regulation and quality control, 5) Basic training on intellectual property and industrial project management.

BE 5390. RESEARCH PROJECT. 3 Hours.
Taken by students enrolled in the non-thesis option for the MS degree. Individual instruction in research and/or instrumentation development and evaluation conducted under supervision of the instructor. A final report required. Prerequisite: Permission of the instructor.

BE 5391. DIRECTED RESEARCH IN BIOENGINEERING. 3 Hours.
Student participates in a research project under the individual instruction of a faculty supervisor.

BE 5395. INTERNSHIP IN BIOENGINEERING. 3 Hours.
Students receive training in a Bioengineering company or a hospital to gain firsthand industrial or clinical engineering experience. The company or hospital assigns projects, and a faculty member monitors the student's progress. Prerequisite: Completion of at least 9 graduate credit hours in BE with good standing in the graduate program. International students need to complete at least 2 full semesters and comply with OIE/CPT rules to enroll. Prerequisite: Completion of at least 9 graduate credit hours in BE with good standing in the graduate program. Permission of Graduate Academic Advisor.

BE 5398. THESIS. 3 Hours.
Prerequisite: graduate standing in biomedical engineering.

BE 5691. DIRECTED RESEARCH IN BIOENGINEERING. 6 Hours.
Student participates in a research project under the individual instruction of a faculty supervisor.

BE 5698. THESIS. 6 Hours.
Graded P/F/R. Prerequisite: Graduate standing in Biomedical Engineering.

BE 6101. PhD SEMINAR IN BIOENGINEERING. 1 Hour.
University and guest lecturers speak on topics of current research interests in the field of bioengineering. Prerequisite: Graduate admission to BE PhD program.

BE 6102. PhD SEMINAR IN BIOENGINEERING. 1 Hour.
University and guest lecturers speak on topics of current research interests in the field of bioengineering. Prerequisite: Graduate admission to BE PhD program.

BE 6103. PhD SEMINAR IN BIOENGINEERING. 1 Hour.
This course serves as a forum to present recent scientific and technological topics in Bioengineering and as a a practical guide to organize and deliver proper and effective scientific oral presentations. Prerequisite: PhD student status.

BE 6194. DOCTORAL DIAGNOSTIC EXAMINATION. 1 Hour.
Individual instruction, directed study, consultation, and diagnostic examination. Required of all doctoral students in the semester when they take any portion of the diagnostic examination.

BE 6195. DOCTORAL COMPREHENSIVE EXAMINATION. 1 Hour.
Individual instruction, directed study, consultation, and comprehensive examination on a detailed prospectus of proposed dissertation research as well as an oral examination. Required of all doctoral students in the semester when they take the comprehensive examination. Prerequisite: BE 6194.

BE 6197. RESEARCH IN BIOENGINEERING. 1 Hour.
Individually approved research projects leading to a doctoral dissertation in the area of biomedical engineering.

BE 6297. RESEARCH IN BIOENGINEERING. 2 Hours.
Individually approved research projects leading to a doctoral dissertation in the area of biomedical engineering.

BE 6395. INTERNSHIP IN BIOENGINEERING. 3 Hours.
Students receive training in a bioengineering company or a hospital to gain firsthand industrial or clinical engineering experience. The company or hospital assigns projects, and a faculty member monitors the student's progress. Prerequisite: Completion of at least 9 graduate credit hours in BE with good standing in the graduate program. International students need to complete at least 2 full semesters and comply with OIE/CPT rules to enroll. Prerequisite: Completion of at least 9 graduate credit hours in BE and good standing in the graduate program.

BE 6397. RESEARCH IN BIOENGINEERING. 3 Hours.
Individually approved research projects leading to a doctoral dissertation in the area of bioengineering.

BE 6399. DISSERTATION. 3 Hours.
Preparation and submission of a doctoral dissertation in an area of bioengineering. Graded R/F only. Prerequisite: Admission to candidacy for the Ph.D. in Biomedical Engineering.

BE 6499. DISSERTATION. 4 Hours.
Preparation and submission of a doctoral dissertation in an area of bioengineering. This course is only to be taken by students preparing a dissertation for submission that is supervised primarily by a University of Texas Southwestern Medical School faculty member and must be taken concurrently with a 5-hour dissertation course at that institution. To satisfy requirement that a P be awarded in a 9-hour dissertation course in their final semester of enrollment, a student must be concurrently enrolled in this course and the 5-hour dissertation course at the University of Texas Southwestern Medical School and receive a P in both courses at the end of that semester. If a P is not awarded in both classes, the two classes must be repeated until P grades are concurrently awarded.

BE 6695. INTERNSHIP IN BIOENGINEERING. 6 Hours.
Students receive training in a bioengineering company or a hospital to gain firsthand industrial or clinical engineering experience. The company or hospital assigns projects, and a faculty member monitors the student's progress. Prerequisite: Completion of at least 9 graduate credit hours in BE with good standing in the graduate program. International students need to complete at least 2 full semesters and comply with OIE/CPT rules to enroll. Prerequisite: Completion of at least 9 graduate credit hours in BE and good standing in the graduate program.

BE 6697. RESEARCH IN BIOENGINEERING. 6 Hours.
Individually approved research projects leading to a doctoral dissertation in the area of bioengineering.

BE 6699. DISSERTATION. 6 Hours.
Preparation and submission of a doctoral dissertation in an area of bioengineering. Graded R/F only. Prerequisite: Admission to candidacy for the Ph.D. in Biomedical Engineering.

BE 6995. INTERNSHIP IN BIOENGINEERING. 9 Hours.
Students receive training in a bioengineering company or a hospital to gain firsthand industrial or clinical engineering experience. The company or hospital assigns projects, and a faculty member monitors the student's progress. Prerequisite: Completion of at least 9 graduate credit hours in BE with good standing in the graduate program. International students need to complete at least 2 full semesters and comply with OIE/CPT rules to enroll. Prerequisite: Completion of at least 9 graduate credit hours in BE and good standing in the graduate program.

BE 6997. RESEARCH IN BIOENGINEERING. 9 Hours.
Individually approved research projects leading to a doctoral dissertation in the area of bioengineering.

BE 6999. DISSERTATION. 9 Hours.
Preparation and submission of a doctoral dissertation in an area of bioengineering. Graded P/R/F. Prerequisite: admission to candidacy for the Ph.D. in Biomedical Engineering.

BE 7399. DOCTORAL DEGREE COMPLETION. 3 Hours.
This course may be taken during the semester in which a student expects to complete all requirements for the doctoral degree and graduate. Enrolling in this course meets minimum enrollment requirements for graduation, for holding fellowships awarded by The Office of Graduate Studies and for full-time GTA or GRA positions. Students should verify that enrollment in this course meets other applicable enrollment requirements. To remain eligible in their final semester of study for grants, loans or other forms of financial aid administered by the Financial Aid Office must enroll in a minimum of 5 hours as required by the Office of Financial Aid. Other funding sources may also require more than 3-hours of enrollment. Additional hours may also be required to meet to requirements set by immigration law or by the policies of the student's degree program. Students should contact the Financial Aid Office, other sources of funding, Office of International Education and/or their graduate advisor to verify enrollment requirements before registering for this course. This course may only be taken once and may not be repeated. Students who do not complete all graduation requirements while enrolled in this course must enroll in a minimum of 6 dissertation hours (6699 or 6999) in their graduation term. Graded P/F/R.