BME 401/501. Biomedical Engineering I: Principles. 3 Credits.
The course exposes students to principles used in biomedical engineering. The major focus is on physiology including cell, muscle, and the cardiovascular, respiratory, gastrointestinal and central nervous systems. Furthermore, there will be modules on biomechanics, biomaterials, biochemistry, tissue engineering, and moral and ethical principles in biomedical engineering. Prerequisites: PHYS 111N or higher and MATH 200 or higher.

BME 402/502. Biomedical Engineering II: Applications. 3 Credits.
The course is a continuation of BME 401. This course exposes students to modern biomedical engineering applications aligned with the principles and physiological processes covered in the previous course. Selected topics include: prosthetic devices, tissue engineering applications, neural interfaces, cardiac devices and imaging techniques. Prerequisites: BME 401.

BME 405. Biomechanics. 3 Credits.
This course will discuss methods of quantitative analysis of biological forces and materials that produce human movement. Kinematics, force analysis of joints, the measurement of mechanical properties and the development and understanding of models of the biological materials incorporating structure and composition will be emphasized. Prerequisite: permission of the instructor.

BME 408. Microfluidics. 3 Credits.
This course discusses theory of fluids on the macro-micro-and nanoscales, and devices that use small volumes of fluid for biomedical applications including diagnostics and cellular control. Topics include microscale fluid mechanics, heat and mass transfer, advanced micro/nanotechnology, and methods used in modern fluid dynamics projects. Pre-requisite: Junior standing.

BME 410. Biomedical Instrumentation. 3 Credits.
This course will expose students to fundamentals of medical instrumentation including biosensors, transducers, biomedical signals, signal processing and electrical safety. Instruments for biomedical measurements of cardiovascular, respiratory, and other vital functions will be fabricated and tested in laboratory exercises. Biomedical applications will be discussed. Prerequisite: Junior standing.

BME 454/554. Introduction to Bioelectrics. 3 Credits.
This course covers the electrical properties of cells and tissues as well as the use of electrical and magnetic signals and stimuli in the diagnosis and treatment of disease. Typical topics to be covered include basic cell physiology, endogenous electric fields in the body, electrocardiography, cardiac pacing defibrillation, electrotherapy, electroporation, electrotherapy in wound healing. In addition ultra-short electrical pulses for intracellular manipulation and the application of plasmas to biological systems will be covered. Prerequisites: PHYS 111N or higher and MATH 200 or higher.

BME 462/562. Introduction to Medical Image Analysis. 3 Credits.
Introduction to basic concepts in medical image analysis. Medical image registration, segmentation, feature extraction, and classification are discussed. Basic psychophysics, fundamental ROC analysis and FROC methodologies are covered. Cross-listed with ECE 462/MSIM 462. Prerequisites: a grade of C or better in MATH 212.

BME 464/564. Biomedical Applications of Low Temperature Plasmas. 3 Credits.
This course is cross listed between ECE and Biology. It is designed to be taken by senior undergraduate students and first year graduate students. The course contents are multidisciplinary, combining materials from engineering and the biological sciences. The course covers an introduction to the fundamentals of non-equilibrium plasmas, low temperature plasma sources, and cell biology. This is followed by a detailed discussion of the interaction of low temperature plasma with biological cells, both prokaryotes and eukaryotes. Potential applications in medicine such as wound healing, blood coagulation, sterilization, and the killing of various types of cancer cells will be covered. Prerequisites: Senior standing.

BME 501. Biomedical Engineering I: Principles. 3 Credits.
The course exposes students to principles used in biomedical engineering. The major focus is on physiology including cell, muscle, and the cardiovascular, respiratory, gastrointestinal and central nervous systems. Furthermore, there will be modules on biomechanics, biomaterials, biochemistry, tissue engineering and moral and ethical principles in biomedical engineering.

BME 502. Biomedical Engineering II: Applications. 3 Credits.
The course is a continuation of BME 401 and BME 501. This course exposes students to modern biomedical engineering applications aligned with the principles and physiological processes covered in the previous course. Selected topics include: prosthetic devices, tissue engineering applications, neural interfaces, cardiac devices and imaging techniques. Prerequisites: BME 401 or BME 501.

BME 554. Introduction to Bioelectrics. 3 Credits.
This course covers the electrical properties of cells and tissues as well as the use of electrical and magnetic signals and stimuli in the diagnosis and treatment of disease. Typical topics to be covered include basic cell physiology, endogenous electric fields in the body, electrocardiography, cardiac pacing defibrillation, electrotherapy, electroporation, electrotherapy in wound healing. In addition ultra-short electrical pulses for intracellular manipulation and the application of plasmas to biological systems will be covered.

BME 562. Introduction to Medical Image Analysis. 3 Credits.
Introduction to basic concepts in medical image analysis. Medical image registration, segmentation, feature extraction, and classification are discussed. Basic psychophysics, fundamental ROC analysis and FROC methodologies are covered. Cross-listed with ECE 562/MSIM 562.

BME 564. Biomedical Applications of Low Temperature Plasmas. 3 Credits.
This course is cross listed between ECE and Biology. It is designed to be taken by senior undergraduate students and first year graduate students. The course contents are multidisciplinary, combining materials from engineering and the biological sciences. The course covers an introduction to the fundamentals of non-equilibrium plasmas, low temperature plasma sources, and cell biology. This is followed by a detailed discussion of the interaction of low temperature plasma with biological cells, both prokaryotes and eukaryotes. Potential applications in medicine such as wound healing, blood coagulation, sterilization, and the killing of various types of cancer cells will be covered. Prerequisites: Senior standing.

BME 612. Digital Signal Processing I. 3 Credits.
This course will present the fundamentals of digital signal processing. Topics will include frequency domain analysis of discrete-time linear systems, sampling and reconstruction of signals, the Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), and digital filter design and implementations. Practical applications and examples will be discussed. Problem solving using MATLAB is required. Cross-listed with ECE 612. Prerequisite: ECE 381 or equivalent.

BME 630. Advanced Bioelectrics. 3 Credits.
A one-semester course covering advanced topics in bioelectrics. The course will cover advanced applications of pulsed power and plasma in the medical, biological and environmental fields. (Cross-listed with ENGN 630.)
BME 695. Topics in Biomedical Engineering, 3 Credits.
This course will be offered as needed, depending upon the need to introduce special subjects to target specific areas of master's-level specializations in biomedical engineering.

Directed research for the master's thesis. Prerequisite: departmental approval.

BME 720. Modern Biomedical Instrumentation, 3 Credits.
This course covers the design of modern biomedical instruments including select diagnostic, assistive, therapeutic, prosthetic, imaging, and virtual devices and systems. Techniques for mechanical, electrical, and chemical sensor and transducer design; stimulation and measurement; data acquisition; digital signal processing; and data visualization will be examined.

BME 721. Mathematical Modeling in Physiology I, 3 Credits.
The first of a two-course series covering human physiology and pathophysiology, with an emphasis on quantitative modeling, simulation, and analysis of the function of cells, organs, and systems. This course focuses on cellular physiology, including homeostasis, membrane ion channels, excitability, calcium dynamics, and intercellular communication.

BME 722. Mathematical Modeling in Physiology II, 3 Credits.
The second course of a two-course series covering human physiology and pathophysiology with an emphasis on quantitative modeling, simulation, and analysis of the function of cells, organs, and systems. This course focuses on systems physiology, including the heart, respiration, muscle, kidneys, and the endocrine system. Prerequisites: BME 721 or BME 821.

BME 724. Neural Engineering, 3 Credits.
This course presents engineering techniques for the restoration and augmentation of human function via direct interactions between the nervous system and artificial devices, with particular emphasis on brain-computer interfaces. Novel interfaces, hardware and computational issues, and practical and ethical considerations will also be covered.

BME 751. Computational and Statistical Methods in Biomedical Engineering, 3 Credits.
This course covers the theoretical foundation and application of commonly used techniques in biomedical engineering. Topics include linear algebra, partial differential equations, regression analysis, applied probabilities, multivariate distributions, Bayesian statistics, hypothesis tests, multiple comparisons, ANOVA, solution of non-linear equations, numerical methods and optimization. Programming software will be used to perform simulations and analyze biomedical data. Prerequisites: Graduate status.

BME 762. Applied Medical Image Analysis, 3 Credits.
Course explores hands-on exposure to state-of-the-art algorithms in medical image analysis, which builds on open-source software (Insight Segmentation and Registration Toolkit - ITK), as well as the principles of medical image acquisition in the modalities of clinical interest. Medical imaging modalities - X-rays, CT, and MRI/ITK image pipeline; image enhancement, feature detection; segmentation - basic techniques, feature-based classification and clustering, graph cuts, active contour and surface models; surface and volume meshing; registration - transformations, similarity criteria; shape and appearance models are all explored and discussed in this course. Prerequisites: Knowledge of C++ and object-oriented programming.

BME 783. Digital Image Processing, 3 Credits.
Principles and techniques of two-dimensional processing of images. Concepts of scale and spatial frequency. Image filtering in spatial and transform domains. Applications include image enhancement and restoration, image compressing, biomedical imaging for diagnosis of disease, and image segmentation for computer vision. Prerequisites: ECE 782 or ECE 882.

BME 791. Biomedical Engineering Innovation Seminar, 1-3 Credits.
This course is for students interested in research that originates from a clinical need, is developed in the laboratory and is then implemented clinically. Seminars by healthcare professionals emphasize clinical needs. Students follow the biodesign innovation process toward creation of biotechnologies and devices that address needs.

BME 795. Special Topics in Biomedical Engineering, 1-3 Credits.
Special courses covering selected graduate-level topics in biomedical engineering.

BME 797. Independent Study, 1-3 Credits.
This course allows students to develop specialized expertise by independent study (supervised by a faculty member). Prerequisites: departmental approval.

BME 820. Modern Biomedical Instrumentation, 3 Credits.
This course covers the design of modern biomedical instruments including select diagnostic, assistive, therapeutic, prosthetic, imaging, and virtual devices and systems. Techniques for mechanical, electrical, and chemical sensor and transducer design; stimulation and measurement; data acquisition; digital signal processing; and data visualization will be examined.

BME 821. Mathematical Modeling in Physiology I, 3 Credits.
The first of a two-course series covering human physiology and pathophysiology, with an emphasis on quantitative modeling, simulation, and analysis of the function of cells, organs, and systems. This course focuses on systems physiology, including homeostasis, membrane ion channels, excitability, calcium dynamics, and intercellular communication.

BME 822. Mathematical Modeling in Physiology II, 3 Credits.
The second course of a two-course series covering human physiology and pathophysiology with an emphasis on quantitative modeling, simulation, and analysis of the function of cells, organs, and systems. This course focuses on systems physiology, including the heart, respiration, muscle, kidneys, and the endocrine system. Prerequisites: BME 721 or BME 821.

BME 824. Neural Engineering, 3 Credits.
This course presents engineering techniques for the restoration and augmentation of human function via direct interactions between the nervous system and artificial devices, with particular emphasis on brain-computer interfaces. Novel interfaces, hardware and computational issues, and practical and ethical considerations will also be covered.

BME 851. Computational and Statistical Methods in Biomedical Engineering, 3 Credits.
This course covers the theoretical foundation and application of commonly used techniques in biomedical engineering. Topics include linear algebra, partial differential equations, regression analysis, applied probabilities, multivariate distributions, Bayesian statistics, hypothesis tests, multiple comparisons, ANOVA, solution of non-linear equations, numerical methods and optimization. Programming software will be used to perform simulations and analyze biomedical data. Prerequisites: Graduate status.

BME 862. Applied Medical Image Analysis, 3 Credits.
Course explores hands-on exposure to state-of-the-art algorithms in medical image analysis, which builds on open-source software (Insight Segmentation and Registration Toolkit - ITK), as well as the principles of medical image acquisition in the modalities of clinical interest. Medical imaging modalities - X-rays, CT, and MRI/ITK image pipeline; image enhancement, feature detection; segmentation - basic techniques, feature-based classification and clustering, graph cuts, active contour and surface models; surface and volume meshing; registration - transformations, similarity criteria; shape and appearance models are all explored and discussed in this course. Prerequisites: Knowledge of C++ and object-oriented programming.

BME 883. Digital Image Processing, 3 Credits.
Principles and techniques of two-dimensional processing of images. Concepts of scale and spatial frequency. Image filtering in spatial and transform domains. Applications include image enhancement and restoration, image compressing, biomedical imaging for diagnosis of disease, and image segmentation for computer vision. Prerequisites: ECE 783 and ECE 883.

BME 891. Biomedical Engineering Innovation Seminar, 1-3 Credits.
This course is for students interested in research that originates from a clinical need, is developed in the laboratory and is then implemented clinically. Seminars by healthcare professionals emphasize clinical needs. Students follow the biodesign innovation process toward creation of biotechnologies and devices that address needs.
BME 895. Special Topics in Biomedical Engineering. 1-3 Credits.
Special courses covering selected graduate-level topics in biomedical engineering.

BME 897. Independent Study. 1-3 Credits.
This course allows students to develop specialized expertise by independent study (supervised by a faculty member). Prerequisites: departmental approval.

BME 899. PHD Dissertation Research. 1-9 Credits.
Directed research for the doctoral dissertation.

BME 999. Doctoral Graduate Credit. 1 Credit.
This course is a pass/fail course doctoral students may take to maintain active status after successfully passing the candidacy examination. All doctoral students are required to be registered for at least one graduate credit hour every semester until their graduation.