Biomedical Engineering (BME)

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5000. Physiological Systems I

Three credits. Prerequisite: Instructor consent. Recommended preparation: BME 3100.

Eleven major human organ systems are covered in this course, including: integumentary, endocrine, lymphatic, digestive, urinary, reproductive, circulatory, respiratory, nervous, skeletal, and muscular.

5010. Research Methods in Biomedical Engineering

Three credits.

Inquiry into the nature of research with emphasis on the spirit, logic, and components of the scientific methods. Health related research literature is used to aid the student in learning to read, understand, and critically analyze published materials. The preparation of research proposals and reports is emphasized.

5020. Clinical Engineering Fundamentals

Three credits. Prerequisite: Instructor consent.

Provides the fundamental concepts involved in managing medical technology, establishing and operating a clinical engineering department, and the role of the clinical engineering designing facilities used in patient care. Topics covered include managing safety programs, technology assessment, technology acquisition, the design of clinical facilities, personnel management, budgeting and ethical issues of concern to the clinical engineer.

5030. Human Error and Medical Device Accidents

Three credits.

Basic principles needed to analyze medical devices, medical device users, medical device environments and medical device accidents. It particularly focuses on human factors engineering as an important step to minimizing human error. The role of medical device manufacturers, medical device regulators and medical device owners are examined to identify their role in reducing medical device use errors and medical device accidents. The nature and types of human error as well as a taxonomy of medical device accidents are presented. Investigative techniques involving root cause analysis and failure modes and effects analysis are taught and applied to industrial and medical device accidents. Operating room fires, electrosurgical and laser burns, anesthesia injuries, infusion device accidents, catheters and electrode failures and tissue injury in the medical environment are in detail. A semester project will require the student to employ these tools and techniques to analyze a medical device accident.

5040. Medical Instrumentation in the Hospital

Three credits.

This course will examine current major technologies in use by healthcare practitioners. It will review the physiological principles behind each technology, the principles of operation, major features, methods for testing and evaluating each technology and will highlight available versions of the devices on the market today. Technologies to be covered will be selected from anesthesia equipment, surgical and ophthalmic lasers, cardiac assist devices, surgical & endoscopic video systems, radiographic and fluoroscopic devices, CT, MRI, ultrasound imaging equipment, radiation therapy, nuclear medicine, clinical chemistry analyzers, spectrophotometers and hematology analyzers. Course is based on one text, selected manufacturers training documents as well as journal articles from current medical publications. Grading will be based on exams, quizzes, a semester project and class participation. Several classes will take place on site in Hartford area hospitals in order to observe and examine the equipment being discussed.

5050. Engineering Problems in the Hospital

Three credits. Prerequisite: Instructor consent.

Covers engineering solutions to problems that are found in the healthcare environment. Includes wide variety of topics such as electrical power quality of and the reliable operation of high tech medical equipment; electrical safety in the patient care environment; electromagnetic compatibility of various medical devices and electromagnetic interference; radiation shielding and radiation protection; medical gas systems, medical ventilation systems and indoor air quality; fire protection systems required in the hospital; networking medical devices, patient information systems, digital imaging and image storage systems; telemedicine and medical image transmission; and finally, hospital architecture and the design of patient care facilities.

5060. Clinical Engineering Rotations I

Three credits.

Associated with the clinical engineering rotations that interns experience in hospitals, such as surgeries, CT, MRI, ICU, clinical laboratory and physical therapy.

5061. Clinical Engineering Rotations II

Three credits.

Associated with the clinical engineering rotations that interns experience in hospitals, such as surgeries, CT, MRI, ICU, clinical laboratory and physical therapy.

5070. Clinical Systems Engineering

Three credits. Prerequisite: Instructor consent.

Primarily covers medical device connectivity and interoperability. This includes connecting medical devices to the hospital computer network to pass data to the patient medical record or to other medical devices for the purpose of feedback and control. The course will cover basic networking concepts, hospital network architecture, medical systems security and risk management, the role of interconnecting middleware, HL7 and DICOM data standards, moving data on the network, clinical information systems, digital imaging and image storage systems, medical device plug-and-play concepts, and a medical device integration project walk-thru.

5099. Independent Study

Variable (1-3) credits. Prerequisite: Instructor consent. May be repeated for credit.

Individual exploration of special topics as arranged by the student with an instructor of his or her choice.

5100. Physiological Modeling

Three credits. Prerequisite: Instructor consent. Recommended preparation: BME 3100 and 3400.

Unified study of engineering techniques and basic principles in modeling physiological systems. Focuses on membrane biophysics, biological modeling, and systems control theory. Significant engineering and software design is incorporated in homework assignments using MATLAB and SIMULINK.

5150. Dynamical Modeling of Biochemical Networks

Three credits.

Recent advances in biological measurement technology have opened up a new era in quantitative biology. Part of this revolution is the new field of systems biology, which consists of viewing processes in biological cells as a whole, rather than considering one gene or protein at a time. Systems biology relies heavily on mathematical models of cellular processes, often derived from the microscopic laws of chemical and enzyme kinetics. Focus primarily on continuum (differential equation) models of cellular processes arising from these microscopic laws. Because most of these models wind up being nonlinear, time is devoted to learning techniques to analyze systems of nonlinear ordinary differential equations, and we will explore the fundamental differences between linear and nonlinear systems. Biological applications will include modeling observed error rates in protein translation, using system nonlinearities to design biological toggle switches, and exploring biological motifs that lead to oscillations, switches, and other behaviors.

5210. Biomedical Optics: Tissue Optics, Instruments and Imaging

Three credits. Prerequisite: PHYS 1502Q and ENGR 3101.

Principles and imaging of biomedical optics. Optical absorption, scattering and their biological origins, radiative transfer equation and diffusion theory, diffuse optical tomography, Monte Carlo modeling and photon transport in biological tissue, ballistic light imaging, time domain, frequency domain and continuous light measurement systems, optical coherence tomography, and photoacoustic tomography.

5302. Biochemical Engineering for Biomedical Engineers

Three credits. Not open for credit to students who have passed BME 3300.

Introduction to chemical reaction kinetics; enzyme and fermentation technology; microbiology, biochemistry, and cellular concepts; biomass production; organ analysis; viral dynamics.

5339. Introductory Ergonomics for Biomedical Scientists and Engineers

Three credits. Prerequisite: BME 5600. Recommended preparation: BME 3600 and CE 3110.

This problem-based course begins with a work-related overview of the design strengths and limitations of human anatomy and physiology (molecular, tissue and systems levels) and the contribution of work/worker mismatches to the development of disease. Measurement of the response of these biological tissues and systems to work-related stressors is examined, to define the mechanism and presentation of musculoskeletal disorders. Addresses physiological and anatomical damage due to biomechanical, psychosocial and work organization stressors and explores the range of possible control strategies of interest to the engineer and public health practitioner. To measure presence and levels of risk factors, students will be introduced to the use of laboratory techniques (e.g., EMG, digital motion capture, force cells) as well as field methods used in ergonomic work-site assessment, ranging from simple check-lists (geared towards worker-based interventions), through detailed time/motion studies, self-report effort scales, epidemiological instruments, and psychosocial and organizational measurement tools. A research project is required.

5341. Exposure Assessment in Ergonomics

Three credits. Prerequisite: BME 5339.

The goal of the course is to develop a broad understanding of ergonomic risk factors, knowledge of the measurement modalities available for characterizing workplace risk, and an appreciation of the advantages and disadvantages of each modality. Students will be introduced to the use of laboratory techniques (EMG, videotaping and digitization, digital motion capture, force cells, accelerometry and exercise physiology). They will also be instructed in methods used in ergonomic work-site assessment, ranging from simple checklists (geared towards worker-based interventions), through detailed time/motion studies, self-report effort scales, epidemiological instruments, and psychosocial and organizational measurement tools. The grade will depend on completion of a laboratory-based, field or epidemiological project.

5500. Clinical Instrumentation Systems

Three credits. Recommended preparation: ECE 2001W; BME 3400 and 3500.

Analysis and design of transducers and signal processors; measurements of physical, chemical, biological, and physiological variables; special purpose medical instruments, systems design, storage and display, grounding, noise, and electrical safety. These concepts are considered in developing devices used in a clinical or biological environment.

5600. Human Biomechanics

Three credits. Prerequisite: Instructor consent. Recommended preparation: BME 3600W.

Applies principles of engineering mechanics in the examination of human physiological subsystems such as the musculoskeletal system and the cardiovascular system. Topics drawn for biosolid mechanics, biofluids, and biodynamics, the viscoelastic modeling of muscle and bone, non-Newtonian fluid rheology, blood flow dynamics, respiratory mechanics, biomechanics of normal and impaired gait, and sport biomechanics.

5700. Biomaterials and Tissue Engineering

(Also offered as MEDS 5313 and MSE 5700.) Three credits. Prerequisite: Instructor consent. Recommended preparation: BME 3700.

A broad introduction to the field of biomaterials and tissue engineering. Presents basic principles of biological, medical, and material science as applied to implantable medical devices, drug delivery systems and artificial organs.

5800. Bioinformatics

Three credits. Recommended preparation: BME 4800 (or equivalent).

Advanced mathematical models and computational techniques in bioinformatics. Topics covered include genome mapping and sequencing, sequence alignment, database search, gene prediction, genome rearrangements, phylogenetic trees, and computational proteomics.

6086. Special Topics In Biomedical Engineering

Variable (1-6) credits. May be repeated for a total of 12 credits.

Classroom and/or laboratory courses in special topics as announced in advance for each semester.

6094. BME Graduate Seminar

One credit. May be repeated for a total of 10 credits.

Presentations will be given by invited speakers from outside, faculty members, and student presenters on current research topics in biomedical engineering.

6110. Computational Neuroscience

Three credits. Prerequisite: Instructor consent.

Explores the function of single neurons and neural systems by the use of simulations on a computer. Combines lectures and classroom discussions with conducting computer simulations. The simulations include exercises and a term project.

6120. Neuronal Information Processing and Sensory Coding

Three credits. Prerequisite: BME 5100. Not open for credit to students who have passed ECE 6311.

Processing, transmission, and storage of information in the central and peripheral nervous systems. Mechanisms of signal generation, transmission and coding by neurons and dendrites. Analysis of invertebrate and vertebrate visual and auditory systems, including: mechanisms of neurosensory transduction, coding, and signal-to-noise ratio enhancement. Neural spatio-temporal filters for feature extraction and pattern recognition. Information theoretic analysis of signal encoding and transmission in the nervous system. This course assumes a background in linear systems and feedback control systems.

6125. Digital Image Processing

(Also offered as ECE 6125.) Three credits.

Problems and applications in digital image processing, two-dimensional linear systems, shift invariance, 2-D Fourier transform analysis, matrix Theory, random images and fields, 2-D mean square estimation, optical imaging systems, image sampling and quantization, image transforms, DFT, FFT, image enhancement, two-dimensional spatial filtering, image restoration, image recognition, correlation, and statistical filters for image detection, nonlinear image processing, and feature extraction.

6126. Fundamentals of Optical Imaging

(Also offered as ECE 6126.) Three credits.

Learning optical imaging fundamentals. Topics include: review of two-dimensional linear system theory; scalar diffraction theory, wave optics, Fresnel and Fraunhofer diffraction; imaging properties of lenses; image formation; optical resolution in imaging, frequency analysis of optical imaging systems; imaging with coherent and incoherent sources, coherent transfer function; optical transfer function, point spread function, fundamentals of microscopy, two-dimensional spatial filtering; coherent optical information processing; frequency-domain spatial filter synthesis; holography.

6140. Cellular Systems Modeling

Three credits. Prerequisite: BME 5600.

Cellular response to drugs and toxins, as well as normal cell processes such as proliferation, growth and motility often involve receptor-ligand binding and subsequent intracellular processes. Focuses on mathematical formulation of equations for key cellular events including binding of ligands with receptors on the cell surface, trafficking of the receptor-ligand complex within the cell and cell signaling by second messengers. Background material in molecular biology, cell physiology, estimation of parameters needed for the model equations from published literature and solution of the equations using available computer programs are included. Examples from the current literature of cell processes such as response to drugs and proliferation will be simulated with the model equations.

6143. Pattern Recognition and Neural Networks

(Also offered as ECE 6143.) Three credits.

Review of probability and stochastic processes. Statistical pattern recognition. Nonlinear signal processing and feature extraction. Correlation filters. Metrics for pattern recognition. Baysian classifiers. Minimum probability of error processors. Supervised and unsupervised learning. Perception learning methods. Multilayer neural networks. Applications to security and encryption.

6160. Computational Genomics

Three credits. Prerequisite: CSE 5800 or BME 5800.

Advanced computational methods for genomic data analysis. Topics covered include motif finding, gene expression analysis, regulatory network inference, comparative genomics, genomic sequence variation and linkage analysis.

6180. Computational Foundations of Systems Biology

Three credits. Not open for credit to students who have passed BME 4985.

Focuses on studying dynamic and intelligent features (e.g., adaptation and robustness) of biological systems such as gene networks. Emphasizes the tools and methods of computational systems biology come from other computation-oriented fields such as computational physics, digital signal processing, control engineering, and digital logic. Programming using MATLAB, LabVIEW, and C# in the context of modeling, analyzing, estimating, and controlling real biological systems. Through a variety of assignments and projects, students will obtain a deeper understanding of physical and engineering principles applied to biological systems. Students will also read and present journal articles on topics covered in class, which will expose them to interdisciplinary research and views.

6400. Biomedical Imaging

Three credits. Prerequisite: Instructor consent. Recommended preparation: BME 3400 or ECE 3111.

Fundamentals of detection, processing and display associated with imaging in medicine and biology. Topics include conventional and Fourier optics, optical and acoustic holography, thermography, isotope scans, and radiology. Laboratory demonstrations will include holography and optical image processing. Assumes a background in linear systems.

6420. Medical Imaging Systems

Three credits. Prerequisite: BME 5500 or 6500.

This course covers imaging principles and systems of x-ray, ultrasound, optical tomography, magnetic resonance imaging, positron emission tomography.

6450. Optical Microscopy and Bio-imaging

(Also offered as MEDS 6450.) Three credits.

Presents the current state of the art of optical imaging techniques and their applications in biomedical research. The course materials cover both traditional microscopies (DIC, fluorescence etc.) that have been an integrated part of biologists' tool-box, as well as more advance topics, such as single-molecule imaging and laser tweezers. Four lab sessions are incorporated in the classes to help students to gain some hand-on experiences. Strong emphasis will be given on current research and experimental design.

6500. Biomedical Instrumentation I

Three credits. Prerequisite: BME 5500 or instructor consent.

Origins of bioelectric signals; analysis and design of electrodes and low noise preamplifiers used in their measurement. Statistical techniques applied to the detection and processing of biological signals in noise, including the treatment of nerve impulse sequences as stochastic point processes. Methods of identifying the dynamic proper ties of biosystems. Assumes a background in linear systems and electronics.

6510. Biomedical Instrumentation Laboratory

Three credits. Prerequisite: Instructor consent.

Experimental investigation of electrodes, transducers, electronic circuits and instrumentation systems used in biomedical research and clinical medicine.

6520. Biosensors

Three credits. Prerequisite: BME 5500 or instructor consent.

Principles and design of acoustic imaging transducers, and force, pressure and hearing sensors. Covers also optical biosensors including oxygen monitoring sensors, glucose sensors and optical sensors used in imaging.

6620. Biosolid Mechanics

Three credits. Prerequisite: BME 5600. Recommended preparation: BME 3600 and CE 3110.

Mechanical behavior of biological solids. Applications of the theories of elasticity, viscoelasticity, and poroelasticity to bones, ligaments and tendons, skeletal muscle, and articular cartilage. Axial, bending, shearing and torsional loadings. Bone morphology and growth. Biphasic theory. Failure theories. Research paper. Topics may be modified slightly to accommodate student interests.