BIOMEDICAL ENGINEERING

BME 5000f. PRINCIPLES OF BIOMEDICAL ENGINEERING I.
(3 cr; A-F) Sieck
This course and BME 5050 are problem-based courses which provide experience, apply biomedical engineering principles to address physiological problems.

BME 5050w. PRINCIPLES OF BIOMEDICAL ENGINEERING II.
(3 cr; A-F) Daniel, Mantilla
This course, together with BME 5000, introduces basic principles in biomedical engineering.

BME 5100f. RADIOLOGICAL HEALTH. (2 cr; S-N; offered odd years; consent of instructor required prior to registration) Vetter
Introduction to concepts of radiological health, philosophy and principles of radiation protection, interpretation of standards and regulations, and planning of facilities and activities.

BME 5150f. INTRODUCTORY RADIATION BIOLOGY. (2 cr; A-F; offered even years {2010}) Karn itz
Emphasis is on understanding the actions of radiation on living systems including physico-chemical interactions, effects at the molecular, cellular, tissue, and organismal levels, carcinogenesis, genetic effects, and embryo-fetus effects; mechanisms providing basis of radiation therapy are stressed.

BME 5160f. INTRODUCTION TO RADIATION PHYSICS. (3 cr; A-F; offered every other year {2009}, prereq calculus, atomic or modern physics) McGee, Antolak
This is an introductory graduate course designed for those interested in the radiation sciences. It will rigorously cover ionizing radiation, interactions, cavity theory, dosimetry fundamentals, and measurements.

BME 5200su. ADVANCED ENGINEERING MATHEMATICS. (4 cr; A-F) Manduca, Bajzer
This BME advanced mathematics course will include a short recapitulation (1.5 week) of prerequisites such as Trig, Calc and vector algebra, although the college calculus is a prerequisite. The bulk consists of advanced engineering math topics: linear algebra, vector analysis, complex variables and functions, Fourier series and transforms, dimensional analysis, Laplace transforms, ordinary differential equations, calculus of variations, and partial differential equations.

BME 5225i. TUTORIAL IN NEURAL NETWORKS. (3 cr; A-F; offered only once per

year with consent of instructor required prior to registration; prerequisites background of computer science, engineering) Manduca
This course will provide a theoretical and practical understanding of the most important artificial neural network models. The focus will be on practical applications of the technology.

BME 5250w. ANATOMY FOR BIOMEDICAL ENGINEERS. (2 cr; S-N; offered odd years {2009}; required course for all BME students) Pawlina
Students dissect selected regions of the human body and learn correct names and locations of associated anatomical structures. Each student then gives a detailed presentation to the class of the region studied.

BME 5300f. CELL AND NEUROPHYSIOLOGY. (3 cr; A-F) Mantilla, Sieck
This course will provide an understanding of basic concepts in cell and neurophysiology. The course will start with an introduction to cell physiology, electrophysiology and cell signaling. The focus will then move more specifically into sensory and motor systems.

BME 5450f. LABORATORY METHODS IN BIOMEDICAL IMAGE PROCESSING. (3 cr; A-F) Robb
Provides an introduction to important concepts in applied biomedical imaging, including digital processing of images, image signal characteristics, histogram analysis, domain processing, digital filters, image compression, reconstruction from projections, discussions of image composition, interactive 3D display, image processing and segmentation, registration and quantitative analysis. Practical applications in basic science and medicine are discussed. Students will use ANALYZE biomedical imaging software developed at Mayo to investigate these topics.

BME 5453w,su. FUNDAMENTAL CONCEPTS IN BIOMECHANICS.
(3 cr; A-F) Kaufman
This course is an introduction to biomechanics and addresses the fundamental topics of force, movement, statics, geometric properties, kinematics and kinetics.

BME 5460f. FINITE ELEMENT METHODS. (3 cr; A-F; offered odd years) Aquino
This course introduces the fundamental concepts of the finite element methods and its major applications in biomechanics research.

BME 5505s. PHYSIOLOGICAL CONTROL SYSTEMS I – MODELING AND SIMULATION. (3 cr; A-F) Roy
This course covers dynamic system modeling, control, and simulation of some physiological systems. It uses MathWorks, Inc.'s Simulink package for simulation of the different open-and closed-loop physiological systems under study. Prerequisites are basic courses in physiology and differential equations.

BME 5550s. VIRTUAL REALITY METHODS AND BIOMEDICAL APPLICATIONS. (4 cr; A-F; prereq BME 5450 or equivalent) Robb

A hands-on introduction to the concepts, methods and applications of virtual reality simulations in biomedical research and clinical procedures.

BME 5740f. MAGNETIC RESONANCE IMAGING SYSTEMS.
(3 cr; A-F; offered odd years; prereq advanced calculus, Fourier analysis, and a course in modern physics) Riederer
Introduction to physics and engineering aspects of modern diagnostic magnetic resonance imaging (MRI).

BME 5800su. PHYSICS AND TECHNICAL PRINCIPLES OF MEDICAL IMAGING. (3 cr; A-F; prereq general and modern physics, calculus, and Fourier analysis or consent of instructor) McCollough
An introductio n to the fundamental principles of medical image formation. Diagnostic imaging modalities to be covered include: radiographic x-ray imaging, x-ray computed tomography, digital radiography, nuclear medicine, ultrasound, and magnetic resonance imaging.

BME 5802f,s. PRINCIPLES OF BIOMECHANICS. (3 cr; A-F; prereq BME 5453) An Advanced concepts of orthopedic biomechanics, including kinematics and kinetics, mechanics of deformable bodies, stress analysis, tissue engineering and fluid mechanics.

BME 5850w. ULTRASONOGRAPHY - PHYSICS, INSTRUMENTATION AND QUANTITATION. (3 cr; A-F) Belohlavek
Introductory topics will include fundamental principles of ultrasound signal propagation and image formation in conventional and Doppler ultrasonography. Special topics will cover quantitative analysis and enhancement of ultrasound images including tissue characterization, noise reduction, boundary recovery, and advanced imaging techniques such as multidimensional echocardiography.

BME 8000i. TUTORIAL IN EXERCISE PHYSIOLOGY. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Joyner
This course is designed for selected physiology graduate students who seek a broad overview in integrative physiology. The focus will be on presenting broad biological concepts related to integration, regulation, homeostasis, and the multitude of organ systems and how they adapt to various environmental and physical stresses. The course meets once a week for 1½ to 2 hours. It is taught using a collegial problem solving approach. Students take a major role in where the course goes. The course runs one full academic year.

BME 8100f. MEDICAL HEALTH PHYSICS. (2 cr; A-F; prereq BME 5100 or equivalent, or consent of instructor) Vetter
Radiation protection philosophy and principles as applied to the medical environment: protection of patients, public, and employees; procedures for obtaining Nuclear Regulatory Commission license.

BME 8151w. RADIATION ONCOLOGY PHYSICS. (3 cr, A-F; prereq BME 5150)

Herman, Kline
Physics principles and application in radiation therapy, including dose calculation, treatment planning/dosimetry, brachytherapy and quality assurance.

BME 8300i. TUTORIAL IN NEUROPHYSIOLOGY. (3 cr; A-F; offered only once per year with consent of instructor required prior to registration) Sieck
This course will provide an understanding of the basic concepts in cell and neurophysiology. The application of current experimental methods and techniques will be emphasized. Classic papers from the literature will be assigned and discussed. Laboratory demonstrations and computer modeling will be included if class size permits.

BME 8302i. TUTORIAL IN ULTRASONIC IMAGING. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Fatemi
Principles and methods of imaging tissue and related parameters.

BME 8304i. TUTORIAL IN PHYSIOLOGICAL IMAGING.
(2 cr; A-F; consent of instructor required prior to registration) Ritman
X ray imaging of physiological systems and analysis of resulting data.

BME 8350s. ADVANCED CONCEPTS IN MOLECULAR BIOPHYSICS. (4 cr; A-F; offered even years) Sine
This course is an introduction to the electrical and mechanical properties of single proteins and other polymers. The course offers didactic lectures focused on the biophysics of ion channels, molecular motors, membrane fusion and elastic proteins. A set of technical lectures will cover design and operation of patch-clamp amplifiers and molecular force measuring probes; mathematical methods and programming tools for the analysis of single molecule records and PCR techniques for single protein studies. Throughout the course, the students will participate in experiments demonstrating various types of single protein recording modalities.

BME 8420s. WAVE PROPAGATIONS AND BIOMEDICAL APPLICATIONS. (2 cr; A-F; prereq college physics) Fatemi
Wave propagation is a fundamental phenomenon of acoustics, electromagnetics, and optics. This course will emphasize the wave propagation of ultrasound and their applications to medical imaging and tissue property identification. New beams such as limited diffraction beams and localized waves and their potential medical applications will be studied.

BME 8470f. TWO-DIMENSIONAL DIGITAL SIGNAL PROCESSING. (3 cr; A-F; offered every third year {2009}; prereq BME 8704 or working knowledge of linear system theory and one-dimensional digital signal processing) Ottesen
Fundamentals of 2-D digital signal processing, including discrete Fourier and Z-transforms, discrete cosine transforms, and finite impulse response filters. Other topics covered are histogram equalization, edge-detection methods, morphology, compression routines and fuzzy logic filters. This class is a foundation for image

processing. There will be homework, case studies, and class projects.
Non-PhD students are required to pay tuition for this class.

BME 8490s. ADVANCED TOPICS IN BIOMEDICAL IMAGE PROCESSING. (3 cr; A-F; offered even years; prereq BME 5450, Core 6750 or equivalent experience/coursework) Manduca
An in-depth study of difficult problems in imaging science as they relate to biomedical images. Areas of study include image segmentation, image registration, texture analysis, shape description and matching, deconvolution, multispectral analysis, 3-D and 4-D image reconstruction and display (volume rendering).

BME 8500i. SPECIAL TOPICS IN IMAGING SCIENCE. (2 cr; A-F; prereq BME 5450, Core 6750; consent of instructor required prior to registration) Robb
Special topics in the imaging sciences applied to biomedical problems and data; including 3-D imaging, volume rendering, surface rendering, image segmentation, image registration and fusion, shape description and analysis, multi-spectral analysis and classification, virtual reality visualization, image modeling.

BME 8600i. BIOMEDICAL ENGINEERING SEMINARS.
(1 cr.; S-N; consent of instructor required prior to registration) Manduca
Presentations of research in topics related to biomedical engineering. In addition to outside lecturers, students are required to give a presentation related to their own research project. Students are required to give two short (15 min) presentations, one being at prior to start of winter quarter in their 3rd year and the second to happen in their 5th year. Students should register in the quarter in which they give their second presentation. First and second year students are required to attend all seminars which are held 11-1, please plan appropriately.
Register in fall quarter only (1cr/yr). Attendance required fall, winter and spring.

BME 8650i. BME JOURNAL CLUB. (1 cr; S-N) Fatemi, Sussman, Alizad
The Biomedical Engineering Journal Club provides a forum for discussion of recent advances in biomedical engineering and physiology. Development of critical reading and writing skills will be incorporated as they apply to manuscript and grant reviewing and writing. Each student is expected to present at least one paper per year. Faculty will be invited to participate as appropriate.
Register in fall quarter only (1cr./yr). Attendance required fall, winter and spring.

BME 8704s. DIGITAL SIGNAL PROCESSING I. (3 cr; A-F) Ottesen
First of a two-part series starts with discrete time signals and systems, and the effects of sampling. It moves into the areas of Discrete Fourier Transforms (DFT), Z-transforms, convolutions, signal flow-graphs, and various methods for design of common digital filters of the Infinite Impulse Response (IIR) and Finite Impulse Response (FIR) types. There will be homework, case studies, and class projects.
Non-PhD students are required to register and pay tuition for this class directly to

the U of MN.

BME 8705f. DIGITAL SIGNAL PROCESSING II. (4 cr; A-F; offered every third year {2008}; prereq BME 8704 or consent of instructor) Ottesen
Covered is advanced designs of digital filters, spectral and cepstral analysis and estimation of signals, the Fast Fourier Transform (FFT), the effects of different types of noise, introductions of the discrete median, Wiener and fuzzy logic filters. There will be homework, case studies and class projects.
Non-PhD students are required to register and to pay tuition for this class directly to the U of MN.

BME 8710w. NUMERICAL METHODS IN BIOMEDICAL RESEARCH. 3 cr; A-F) Bajzer, Manduca
This course provides an overview of numerical methods commonly used in biomedical research including: solving of ordinary and partial differential equations, random systems, common transforms, function fitting, optimization and search algorithms, and filtering and time series analysis.

BME 8730f. LABORATORY METHODS IN MAGNETIC RESONANCE IMAGING. (2 cr; S-N; offered odd years; prereq BME 5740, previous or concurrent registration) Ward
Introduction to MRI laboratory methods. Firsthand experience in basic and advanced MR image acquisition strategies, experimental tradeoffs, image reconstruction, and data interpretation.

BME 8740w. ADVANCED TOPICS IN MAGNETIC RESONANCE IMAGING SYSTEMS. (3 cr; S-N; offered even years; prereq BME 5740) Riederer
A technical study of advanced topics in contemporary magnetic resonance imaging (MRI). Topics to be discussed include vascular imaging and flow assessment, motion effects and compensation, echo-planar imaging, cardiac imaging, and neuro-functional MRI.

BME 8750f,s. MAGNETIC RESONANCE TECHNICAL SEMINAR.
(1 cr; S-N; consent of instructor required prior to registration) Riederer
Seminar held weekly consisting of a presentation of some contemporary technical research topic in magnetic resonance.

BME 8770f. FUZZY LOGIC THEORY AND APPLICATIONS.
(3 cr, A-F; offered every third year {2010}; prereq BME 8704 and an interest in intelligent systems and decision and control) Ottesen
Fuzzy Logic Theory and Applications is intended for students and practicing scientists and engineers. It covers the applied concepts of fuzzy logic to several application areas. There will be homework, case studies, and class projects.
Non-PhD students are required to register and to pay tuition for this class directly to the U of MN.

BME 8830w. LABORATORY METHODS IN PHYSIOLOGY.

(2 cr; A-F) Blanco
The purpose of this course is to provide hands-on experience in the use of common methods and techniques in physiology. Lab directors will teach students advanced methodology used in labs such as calcium imaging, gel electrophoresis, RT-PCR, patch clamp, etc.

BME 8853i. READINGS IN BIOMEDICAL ENGINEERING.
(2 cr; S-N; consent of instructor required prior to registration) Sieck
Review of contemporary topics in Biomedical Engineering literature to be arranged with individual staff members.

BME 8855i. TUTORIAL IN CARDIOVASCULAR PHYSIOLOGY.
(3 cr; A-F; offered only once per year with consent of instructor required prior to registration) Miller
Students will be exposed to advanced topics in cardiovascular physiology with an emphasis on integrative control mechanisms in health and disease, structure and function, sex-based medicine and translational approaches to investigations. Students will be required to critically evaluate current literature, provide a historical overview of a specific topic and to write a grant using a multiple investigator approach.

BME 8856i. TUTORIAL IN RESPIRATORY PHYSIOLOGY. (3 cr; A-F; offered only once per year with consent of instructor required prior to registration) Hubmayr, Sieck
The goal of this course is to provide an in-depth account of the functional components of the respiratory system and their integration in health and disease.

BME 8857i. TUTORIAL IN CELLULAR MECHANICS. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Hubmayr
Detailed review of cellular structure and function relationships, diffusion, micro-mechanics, mechano-chemical signal transduction.

BME 8858i. TUTORIAL IN SMOOTH MUSCLE PHYSIOLOGY. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Qian, Gibbons
Students will be exposed to advanced topics related to smooth muscle signaling pathways, intracellular calcium regulation, pharmaco-mechanical coupling, etc.

BME 8859i. TUTORIAL IN RENAL PHYSIOLOGY. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Romero
Renal hemodynamics, glomerular function, mechanisms and regulation of electrolyte transport. Two laboratory sessions demonstrating basic renal function and the effects of diuretics.

BME 8860i. TUTORIAL IN ENDOCRINE PHYSIOLOGY. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Eberhardt, Khosla

This course focuses on several aspects of endocrine physiology, including mechanisms of hormone action, calcium homeostasis, glucose, and fatty acid metabolism, pituitary, thyroid and adrenal physiology, immunologic aspects of endocrinology, and endocrine effects on bone biology.

BME 8861i. TUTORIAL IN SKELETAL MUSCLE PHYSIOLOGY. (2 cr; A-F; offered only once per year with consent of instructor required prior to registration) Sieck, Taylor
The goal of this course is to explore muscle physiology from the protein-protein interactions that establish the molecular basis of muscle contraction to the biomechanics of movement.

BME 8870f. SYSTEMS PHYSIOLOGY I. (3 cr; A-F) Romero
In Systems Physiology I; The Cell as a Complex Biological System – the students will obtain a broader view of traditional "Cellular Physiology." All systems are made up of components which must communicate and respond. This course will focus on the fundamental organization that exists at the molecular, cellular, tissue, organism and population levels.

BME 8871w. SYSTEMS PHYSIOLOGY II. (3 cr; A-F) Sussman
Development, Growth and Regeneration – concepts of intracellular communications as taught in Systems Physiology I will be reinforced, and the concept of intercellular communication will be introduced as they relate to the development, growth, and regeneration of issues. Roles of stem and progenitor cells along with contributions from various model systems will be incorporated.

BME 8872s. SYSTEMS PHYSIOLOGY III. (3 cr; A-F) Ordog
In Systems Physiology III; Systems Interactions – the students will focus on endocrine control of physiological processes. This course builds on, reinforces, and extends concepts of intra- and intercellular communication discussed in the preceding Systems Physiology courses. Functions of the endocrine system will be introduced by reviewing various characteristics of hormonal signaling rather than by a more traditional, descriptive, organ-based approach.

BME 8875su. PHYSIOLOGICAL CONTROL SYSTEMS II – STABILITY AND OPTIMIZATION. (3 cr; A-F; prereq BME 5505 or a basic course in control systems or dynamic system modeling) Roy
The course covers stability, identification, and optimization of some physiological systems. It uses Matlab and Simulink to analyze the physiological systems under study. A laboratory session is included to prove identification and estimation concepts.

BME 8876w. ADAPTIVE AND NONLINEAR PHYSIOLOGICAL SYSTEMS. (3 cr; A-F; prereq BME 8875) Sieck
The course covers the modeling and analysis of the following complex physiological systems: Respiratory Control, Cardiac Dysrhythmias, Sleep Apnea, Neutrophil Density Regulation, Cardiovascular Variability, and Circadian

Rhythms. Adaptive and nonlinear control concepts are explained and applied to these physiological systems, and where Matlab and Simulink are used for simulation. A laboratory session and journal reviews are also planned to prove some of the above concepts and their applications.

BME 8878i. TUTORIAL IN BONE PHYSIOLOGY. (3 cr; A-F; offered only once per year with consent of instructor required prior to registration) Oursler
Lectures in physiology of both normal and abnormal bone; renal, respiratory, and endocrine physiology and function as related to bone. Studies include structure and mineralization of bone, both normal and abnormal, ion transport, mineral and hormonal metabolism as related to bone.

BME 8880w. PRINCIPLES OF SOLID MECHANICS. (3 cr; A-F) Kaufman
This course will look at concepts of vectors and coordinate systems; kinematics of rigid bodies including translation and rotation, velocity and acceleration; kinetics of rigid bodies including static and dynamic equilibrium.

BME 8881f. MECHANICS OF DEFORMABLE MATERIALS. (3 cr; A-F) An
This course examines the behavior of materials under load. Topics include load-deformation, stress-strain, elastic behavior, brittle and ductile materials, creep, stress relaxation. We also look at stress analysis including bending, torsional load, normal and shear stresses.

Research

BME 8890f,w,s,su. RESEARCH IN BIOMEDICAL ENGINEERING.
(S-N) Staff
Opportunities in research for Ph.D. students to be arranged with individual staff members.