

Biomedical-Oriented Courses for Undergraduate Engineering Students at VT

Engineering undergraduate students interested in Biomedical Engineering are encouraged to use the following list as a guideline for choosing courses which may be applicable to their future interests in the biomedical area. These courses are useful whether you are considering graduate study in BME or simply wanting to fulfill a general interest in the area. Some of them are approved for being used to obtain the new BME minor. *Please note that many of these courses carry pre-requisites which may limit eligibility to enroll in them.* Students with questions about any of these classes should inquire with the individual departments offering the courses. Non-engineering undergrads wishing to take any of these courses should check with the individual departments regarding the possibility of enrolling without being an engineering student.

Please note that SBES degrees are degrees in *engineering*, therefore it is expected that students entering the program will have a strong background in the particular engineering major chosen for the undergraduate degree. It is also assumed that all undergraduate engineering programs include sufficient coursework in mathematics. For that reason, math courses are not included in this list. (Non-engineering undergrads should refer to the SBES website for a listing of math background expectations.)

For BME-minor applicants: If you see a course here that interests you which is NOT currently on the approved list of BME-minor electives, please contact Dr. Pamela VandeVord (pvord@vt.edu) about the possibility of having it added to the 'approved' list.

ENGINEERING COURSEWORK

The following is a list of BME-related courses that you may want to consider if you are an undergraduate engineering student. In some cases your department may allow you to take these as technical electives. You may want to see your undergraduate advisor to get help in making appropriate choices.

Chemical Engineering:

CHE 4104: PROCESS MATERIALS

Basics of materials science as it related to the interest of the chemical engineer. The course emphasized the three fundamental areas of material science being polymer materials, metallic, and ceramic/inorganic glasses. The general molecular structure property – application behavior of each area will be presented but with a focus when possible on topics related to the field of chemical engineering. Pre: 2164, (CHEM2535 or CHEM2565). (3H,3C)

CHE 4544 (BSE 4544): PROTEIN SEPARATION ENGINEERING

Concepts, principles and applications of various unit operations used in protein separations. Properties of biological materials, such as cells and proteins, and their influences on process design. Design of processes for protein purification based on the impurities to be eliminated. Concepts and principles of scale-up of unit operations. Case studies in practical protein recovery and purification issues, with a focus on enhanced protein purification by genetic engineering. Protein purification process simulation and optimization using process simulation software. Pre: BSE 3504 or CHE 3144. (3H,3C)

Electrical and Computer Engineering:

ECE 4580: DIGITAL IMAGE PROCESSING

This course provides an introduction to basic concepts, methodologies and algorithms of digital image processing focusing on the two major problems concerned with digital images: (1) image analysis and object restoration for easier interpretation of images, and (2) image analysis and object recognition. Some advanced image processing techniques (e.g., wavelet and multiresolution processing) will also be studied in this course. The primary goal of this course is to lay a solid foundation for students to study advanced image analysis topics such as computer vision systems, biomedical image analysis, and multimedia processing & retrieval. (3H,3C)

ECE 4624: DIGITAL SIGNAL PROCESSING AND FILTER DESIGN

Analysis, design, and realization of digital filters. Discrete Fourier Transform algorithms, digital filter design procedures, coefficient quantization. Pre: C or better in 3704 (3H,3C)

Engineering Science & Mechanics:**ESM 4105-4106: ENGINEERING ANALYSIS OF PHYSIOLOGIC SYSTEMS**

Engineering analysis of human physiology. Physiologic systems are treated as engineering systems with emphasis on input-output considerations, system interrelationships and engineering analogs. 4105 - Mass and electrolyte transfer, nerves, muscles, renal system. 4106 - cardiovascular mechanics, respiratory system, digestive systems, senses. Pre: 2304, MATH 2214. (3H,3C) 4105: I,II; 4106.

ESM 4204: MUSCULOSKELETAL BIOMECHANICS

Skeletal anatomy and mechanics. Muscle anatomy and mechanics. Theory and application of electromyography. Motion and force measuring equipment and techniques. Inverse dynamics modeling of the human body. Current topics in musculoskeletal biomechanics research. Pre: 2304, (2074 or ME 2004). (3H,3C)

ESM 4224: BIODYNAMICS AND CONTROL

Study of human movement dynamics and neuromuscular control of multi-degree-of-freedom systems. Computational simulation of forward-dynamics and state-space linear control of human movement to investigate functional performance and neuromuscular pathology. Pre: 3124, 4204. (3H,3C)

ESM 4234: MECHANICS OF BIOLOGICAL MATERIALS AND STRUCTURES

Anatomy and physiology of connective tissue. Techniques for determining the mechanical response of biological soft and hard tissues. Includes static, viscoelastic, creep, fatigue, and fracture. Simplified models of biological structures. Creation of geometric models from medical imaging and computational modeling. Specific topics may include bone, cartilage, ligaments, tendon, teeth, and skin. Pre: 3054, (2074 or ME 2004). (3H,3C)

ESM 4245—4246: MECH ANIMAL LOCOMOTION

Mechanical and biological principles of terrestrial animal locomotion, including walking, running, climbing, burrowing, and crawling. Terrestrial locomotion –based bio-inspired design. Pre: 3045 rfor5 44245, 3015 for 4246. (3H,3C)

ESM 4304: HEMODYNAMICS

Study of the human cardiovascular system and blood flow. Anatomy and physiology of the human heart, vascular system, and its organization. Blood physiology and rheology. Non-Newtonian blood flow models. Steady and pulsatile blood flow in rigid and elastic arteries. Pressure waves in elastic arteries. Three-dimensional blood flow in the aortic arch and flow around heart valves. Pre: 3016 or ME 3404. (3H,3C)

ESM 4574: BIOMATERIALS

Lectures and problems dealing with materials used to mimic/replace body functions. Topics include basic material types and possible functions, tissue response mechanisms, and considerations for long term usage. Integrated design issues of multicomponent materials design in prosthetic devices for hard and soft tissues are discussed. Must meet prerequisite or have graduate standing in the College of Veterinary Medicine. Pre: MSE 3054 or ESM 3054. (3H,3C) Cross-listed with MSE 4574.

Industrial Systems Engineering:**ISE 3614: INTRODUCTION TO HUMAN FACTORS ENGINEERING**

Survey of human factors engineering emphasizing the systems approach to workplace and machine design. Discussion of basic human factors research and design methods, visual processes and design methods, selection of statistical techniques for application to human factors data, visual and auditory processes, display and control design and effects of environmental stressors on humans. Pre: STAT 4105. (2H,3L,3C) I,IV.

ISE 3624: INDUSTRIAL ERGONOMICS

Introduction to ergonomics with an emphasis on people at work. Discussion of ergonomic methods for measurement, assessment, and evaluation, with major topics including manual materials handling, cumulative trauma disorders, environmental stresses, safety, and legal issues. A grade of C- or better required in ISE prerequisite 3014. I,II. Pre: 3014, ESM 2104. (3H,3C)

ISE 4624: WORK PHYSIOLOGY

Anthropometry, skeletal system, biomechanics, sensorimotor control, muscles, respiration, circulation, metabolism, climate. Ergonomic design of task, equipment, and environment. A grade of C- or better required in prerequisite ISE 3614. Pre: 3614. (3H,3C)

Materials Science & Engineering:

MSE 4574 (ESM 4574): BIOMATERIALS

Lectures and problems dealing with materials used to mimic/ replace body functions. Topics include basic material types and possible functions, tissue response mechanisms, and considerations for long term usage. Integrated design issues of multicomponent materials design in prosthetic devices for hard and soft tissues are discussed. Must meet prerequisite or have graduate standing in the College of Veterinary Medicine. Pre: 3054. (3H,3C)

MSE 4584: BIOMIMETIC MATERIALS

Introduction to structure property relationships in biological materials such as wood, bone, shells, spider silk, connective tissue, blood vessels and jellyfish. Proteins and polysaccharides, biosynthesis and assembly, biomineralization, hierarchical organization. Introduction to tissue engineering and regenerative medicine. Life cycle, environmental aspects of biofabrication. Pre: CHEM 1036 or BIOL 1106 or MSE 2034 or MSE 3094 or AOE 3094. (3H,3C)

MSE 4614: NANOMATERIALS

Synthesis of 0-dimensional nanoparticles, 1-dimensional nanotubes, nanowires, and nanorods; 2-dimensional nanoribbons and nanofilms, and specialized nano-features on substrates. Characterization of nanomaterials. Processing into higher order dimensions. Chemical, physical, mechanical, and electrical properties of nanomaterials. Application of nanomaterials. Pre: 4034. (3H,3C)

Mechanical Engineering:

ME 4034: BIO-INSPIRED TECHNOLOGY

Introduction to engineering solutions inspired by biological system. Overview over the approach of bio-inspired technology and the state of the art. Exploration of the relationship between engineered and natural biological systems. Explanation of concepts of biological systems, such as evolutionary optimization, sensing, actuation, control, system integration, assembly and materials in engineering terms. Practice of interdisciplinary analysis skills in technical report writing projects where man-made and biological systems are evaluated for parallels to engineering and their technological potential. Pre: (PHYS 2205, PHYS2206) or (PHYS 2305, PHYS2306). (3H,3C)

ME 4754: IMPACT BIOMECHANICS

Introduction to impact biomechanics. Covers in-depth background of human tolerance to impact loading. Emphasis on the interdisciplinary nature of impact biomechanics. Use of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Real world examples from automobile safety, military applications, and sport biomechanics. Pre: ESM 2204, ESM 2304. (3H,3C)

ME 4864: MICRO/NANO-ROBOTICS

Overview of Micro/Nano-robotic systems. Physics of reduced length scaled (scaling effects in the physical parameters, surface forces, contact mechanics, and micro/nano-scale dynamical phenomena). Basics of micro/nano-manufacturing, microfabrication and soft lithography. Biomimetic design strategies for mobile micro-robots. Principle of transduction, material properties and characteristics of Micro/nano-actuators (piezoelectric, shape-memory alloy, and a variety of MEMS and polymer actuators). Control requirements and challenges of micro/nano-actuators, Micro/nano sensors for mobile microrobotic applications, Micro/nano-manipulation (scanning probe microscopy, operation principles, designing experiments for nanoscale mechanical characterization of desired samples). Pre: MATH 2214, ME 3404, ME 3514I. (3H,3C)

LIFE-SCIENCE COURSEWORK

Success in Biomedical Engineering requires a strong background in the life sciences. If you decide to pursue a graduate degree, you will be required to take a number of life science courses. The following list presents some possibilities for choices that would offer a good head-start in this area at the undergraduate level. Again, please see your undergraduate student advisor about using these types of courses as electives for your particular program.

Biology:

BIOL 2104: CELL AND MOLECULAR BIOLOGY

Fundamental molecular mechanisms essential for the function of prokaryotic and eukaryotic cells. Topics will include: organization and maintenance of cellular structure, energy production, transcriptional regulation, protein synthesis, regulatory pathways, cell-cell interactions and reproduction. Pre: (1005 or 1105 or 1205H), (1106 or 1206H or 1006), (CHEM 1036 or CHEM 1056 or CHEM 1016 or CHEM 1036H or CHEM 1056H). (3H,3C) I,II

BIOL 3124: CELL PHYSIOLOGY

Cell structure and metabolism, including enzymes, energy production, photosynthesis, membranes, nerve conduction, muscle contraction, and regulation of cellular activity. Pre: 2104, CHEM 2536. (3H,3C) I,II.

BIOL 3404: INTRODUCTORY ANIMAL PHYSIOLOGY

A comparative systems level approach to the physiology of animals, emphasizing vertebrates: metabolic, temperature, osmotic, and ionic regulation; function of respiratory, circulatory, digestive, muscle, nervous, and locomotory systems; endocrine regulation and biological rhythms. Must have prerequisites or instructor's permission. Pre: (1005, 1006) or (1105, 1106). (3H,3C) II

BIOL 3774: MOLECULAR BIOLOGY

Advanced study of the molecular biology of prokaryotic and eukaryotic cells, including mechanisms of gene expression and regulation, relative merits of experimental model systems, and practical applications in agriculture and medicine. Pre: 2104 or ALS 3104. (3H,3C) II.

BIOL 4434: MAMMALOGY

Biology of mammals including evolution, systematics, anatomy, physiology, and ecology. Laboratory on systematics, morphology, zoogeography, and diversity of North American mammals. I Pre: 2804. (3H,3L,4C)

BIOL 4504: HISTOLOGY

Microanatomy of cells, tissues, and organs and correlation of microanatomical structure with cellular function. Senior Standing. (3H,6L,5C) II.

BIOL 4874: CANCER BIOLOGY

The molecular and cellular basis of cancer, including viral and cellular oncogenes, tumor suppression mechanics, cellular immortality, genomic integrity, angiogenesis, metastasis, and traditional and developing theories. Pre: 2004, 2104. (3H,3C)

BIOL 4884: CELL BIOLOGY

Advanced study of the inner workings of eukaryotic cells, including membrane structure and function, protein secretion, the cytoskeleton, cell cycle control and intercellular communication. Pre: 3774 or BCHM 4116. (3H,3C) II.

Biochemistry:**BCHM 2024: CONCEPTS OF BIOCHEMISTRY**

Short course in fundamentals of the chemistry of living systems. Introduction to major categories of biochemical substances, metabolic pathways, and principles of biochemical information transfer. (No credit for majors). Pre: CHEM 2514 or CHEM 2535. (3H,3C) II.

BCHM 3114: BIOCHEMISTRY FOR BIOTECHNOLOGY AND THE LIFE SCIENCES

Survey presentation of the basic principles of biochemistry as they apply to biotechnology. Topics covered include protein structure, enzymology, cellular organization, and biochemical regulation. Special emphasis will be given to gene structure, transcription, and translation, cellular organization, and cloning, sequencing, modification and expression of recombinant DNA. Examples will be given of agricultural/medical/industrial applications of cellular and molecular biochemical knowledge. Non-majors only. Pre: CHEM 2536. (3H,3C) I.

BCHM 3124: BIOCHEMICAL TECHNIQUES FOR BIOTECHNOLOGY AND THE LIFE SCIENCES

Survey of basic biochemical laboratory techniques for students interested in biotechnology, genetic engineering, and the modern life sciences. Topics include the use of buffers, spectroscopy, enzyme assays, chromatography, electrophoresis, and immunoassays in the analysis of biological macromolecules. (Non-majors only). Co: 3114. (2H,3L,3C) I.

BCHM 4115-4116: GENERAL BIOCHEMISTRY

Metabolism and chemistry of carbohydrates, proteins, lipids, and nucleic acids with emphasis on interactions and comparative aspects of microbial, plant, and animal forms. For students in the biochemistry curriculum and other students interested in a foundation course. (Students are required to have at least a C- in both CHEM 2535 and 2536 to be admitted to BCHM 4115). Pre: CHEM 2536. 4115: (4H,4C) 4116: (3H,3C) I,II.

Biomedical & Veterinary Sciences:**BMVS 4064: INTRODUCTION TO MEDICAL PHYSIOLOGY**

An introductory course to the principles of medical physiology, designed primarily for -- but not limited to -- undergraduate and graduate students majoring in biomedical engineering, and other related engineering and physical sciences majors with little or no formal background in biological sciences. The focus is on basic principles and concepts of physiology with a special emphasis on

the interactions of human systems biology in their entirety rather than individual genes and pathways. Not intended for students expecting to major in biology or planning to enter health professional fields. (3H,3C)

BMVS 4054: LABORATORY ANIMAL MANAGEMENT

This course involves a study of the principles of laboratory animal science, providing the student with a basic understanding of the laws and regulations governing the care and use of animals, husbandry and surgery of a variety of lab animal species, and variables which can adversely affect animal research. Through formal lectures, discussions, and laboratory sessions, the course is designed to complement graduate studies in biological, biomedical, and life sciences which involve the use of animals in research. (2H,3L,3C) (approved for graduate credit)

BMVS 4074: PHARMACOLOGY

A basic course in the science of pharmacology, intended to provide an understanding of the mechanisms of action and physiological systemic effects of major classes of drugs of biological, agricultural, social, and medical importance. Must have prerequisites or equivalent. Pre: CHEM 2514 or CHEM 2535 or ALS 2304 or BIOL 2406. (3H,3C) (approved for graduate credit)

BMVS 4084 (VM 9204): MEDICAL TOXICOLOGY

Adverse health effects of exposure to drugs or substances of abuse. Covers principles of toxicodynamics, toxicokinetics, biotransformation, diagnosis and treatment. Emphasis will be placed on mechanism(s) of action of the various drug classes, body system(s) affected, clinical manifestations of problems and the resulting adverse effects on human health and society. Methods of treatment and client education will also be addressed. Laws controlling and governing the use of these drugs/substances and the agencies responsible for them will also be covered. Pre: third year standing in DVM curriculum. Pre: (CHEM 2514 or CHEM 2535), (BIOL 2406 or ALS 2304), (MATH 1015). (2H,2C) (approved for graduate credit)

Human Food, Nutrition & Exercise:

HNFE 3804: EXERCISE PHYSIOLOGY

Effects of exercise on physiology: neuromuscular, metabolic, cardiopulmonary. Scientific basis of physical training. Pre: BIOL 2405, BIOL 2406. (3H,3C) I.

HNFE 3824: KINESIOLOGY

The anatomical and biomechanical basis of human motion, with applications for motor skill acquisition, and development and rehabilitative exercises. Pre: BIOL 2406, PHYS 2205. (3H,3C) I.

HNFE 4844: EXERCISE AND NEUROMUSCULAR PERFORMANCE

Functional properties of the neuromuscular system. Emphasis placed on the acute and chronic responses of muscle in exercise, rehabilitation and the factors which determine human performance. Special emphasis on the molecular biological factors responsible for skeletal muscle development and differentiation, as well as adaptation to training and disease states, including activation of signal cascades responsible for the changes in muscle performance. Pre: 3804. (3H,3C) II.