BIOMEDICAL ENGINEERING (BMD_ENG)

BMD_ENG 304-0 Quantitative Systems Physiology (1 Unit)
Cardiovascular, respiratory, and immune systems, including physiology and pathophysiology. Case studies and a design team project. Integrated lab activities; no separate section.
Prerequisite: Students must have taken PHYSICS 135-2; junior standing recommended.

BMD_ENG 305-0 Quantitative Systems Physiology (1 Unit)
Cellular mechanisms of and quantitative systems' approach to human renal, digestive, endocrine, and metabolic physiology. Integrated lab activities; no separate section.
Prerequisite: junior standing recommended.

BMD_ENG 306-0 Quantitative Systems Physiology (1 Unit)
Functional/structural aspects of vertebrate nervous system. Neural biophysics. Integrated lab activities; no separate section.
Prerequisite: PHYSICS 135-2; junior standing recommended.

BMD_ENG 311-0 Computational Genomics (1 Unit)
The course introduces state-of-the-art genomic sequencing technologies and computational modeling of high-throughput sequencing datasets. Through the course, students will learn how to apply these experimental and computational genomics technologies to study gene expression regulation underlying various biological processes, such as oncogenesis. Students will also apply computational and statistical skills, using linux and R/Matlab/Python.
Prerequisites: BMD_ENG 220-0; BIOL_SCI 201-0 or BIOL_SCI 202-0.

BMD_ENG 312-0 Biomedical Applications in Machine Learning (1 Unit)
Supervised learning tasks such as regression and classification, Convolutional Neural Networks and image analysis techniques and hidden Markov models, unsupervised learning approaches such as clustering and dimensionality reduction will be applied to both structured (numerical) and image data. All models will be implemented in Python, either from scratch or using high-level libraries.
Prerequisites: BMD_ENG 220-0, GEN_ENG 205-1, MATH 220-1, MATH 220-2.

BMD_ENG 313-0 Wearable Devices: From Sensing to Biomedical Inference (1 Unit)
This course will review the challenges and opportunities associated with using wearable devices to infer biomedical information about individuals and populations. It will cover techniques from signal processing, machine learning, and artificial intelligence relevant to this objective. Content will be taught using a series of projects relevant to the quantification of human movement and rehabilitation medicine.
Prerequisites: BMD_ENG 207-0 and BMD_ENG 220-0.

BMD_ENG 317-0 Biochemical Sensors (1 Unit)
Theory, design, and applications of biochemical sensors used in medical diagnosis, biomedical research, and patient monitoring. Detection of biomolecules with optical, electrochemical, mass spectrometry and other sensors. Start-up translation of sensor technology.
Prerequisites: BIOL_SCI 201-0; CHEM 215-1.

BMD_ENG 325-0 Introduction to Medical Imaging (1 Unit)
Diagnostic X-rays; X-ray film and radiographic image; computed tomography; ultrasound. Prerequisites: Undergraduate students must have completed PHYSICS 135-3 and BMD_ENG 309 (or equivalent course covering Fourier transform and other Signals concepts) to enroll in this course.

Prerequisites: Students must have completed PHYSICS 135-3 and knowledge of Fourier concepts.

BMD_ENG 327-0 Magnetic Resonance Imaging (1 Unit)
Nuclear magnetic resonance; two-dimensional Fourier transform, spinecho and gradientecho imaging; gradient and RF hardware.
Prerequisite: PHYSICS 135-3.

BMD_ENG 333-0 Modern Optical Microscopy & Imaging (1 Unit)
Rigorous introduction to principles, current trends, emerging technologies, and biomedical applications of modern optical microscopy.
Prerequisites: BMD_ENG 220-0, GEN_ENG 205-4, PHYSICS 135-3.

BMD_ENG 340-0 Pharmaceutical Engineering: From Discovery to Therapeutics (1 Unit)
This course will take students through the process of drug development from initial innovative concept and identified medical need, to proof of efficacy, clinical trials, and translation to 'big pharma'. Professor Moskal will draw upon his experience from academia and industry to chart out each critical step of drug development; additional industry experts will present guest lectures.
Prerequisites: CHEM 215-1 or be BME MS/PhD student to enroll in this class.

BMD_ENG 343-0 Biomaterials and Medical Devices (1 Unit)
Structure-property relationships for biomaterials. Metal, ceramic, and polymeric implant materials and their implant applications. Interactions of materials with the body.
Prerequisites: BIOL_SCI 201-0, BIOL_SCI 202-0 (can be taken concurrently), CHEM 215-1, MAT_SCI 201-0.

BMD_ENG 344-0 Biological Performance of Materials (1 Unit)
Structure-property relationships of materials, physical chemistry of surfaces and interfaces, materials-tissue interactions, applications to the selection and design of materials for medical implants and devices.
Prerequisites: BIOL_SCI 201-0, BIOL_SCI 202-0 (can be taken concurrently), CHEM 215-1, MAT_SCI 201-0.

BMD_ENG 346-0 Tissue Engineering (1 Unit)
In vivo molecular, cellular, and organ engineering, with emphasis on the foundations, techniques, experiments, and clinical applications of tissue engineering.
Prerequisites: BIOL_SCI 201-0, BIOL_SCI 202-0 (can be taken concurrently), CHEM 215-1.

BMD_ENG 347-0 Foundations of Regenerative Engineering (1 Unit)
Embryonic development, stem cell engineering, somatic regeneration, genome and transcriptome modifications, cell and tissue-level regenerative engineering.
Prerequisites: BIOL_SCI 201-0 or BIOL_SCI 202-0.

BMD_ENG 348-0 Applications of Regenerative Engineering (1 Unit)
Mechanisms of human disease, development and application of molecular, cellular, and tissue-level regenerative engineering strategies to selected human disorders, including neurodegenerative disorders, stroke, cystic fibrosis, cirrhosis, diabetes, muscular degenerative disorders, and skin injury.
Prerequisite: BIOL_SCI 201-0 or BIOL_SCI 202-0.

BMD_ENG 353-0 Bioelectronics (1 Unit)
Development and design of sensors, stimulators, and their medical devices for biointegrated electronics. Materials design and fabrication of passive and active components for sensitive, multimodal, and robust wearable and implantable devices.

BMD_ENG 354-0 Bioelectronics Lab (1 Unit)

Laboratories focused on the practical implementation, instrumentation, and fabrication of wearables and skinsensing. Applications range from vital sign monitoring to rehabilitation.
Prerequisites: BMD_ENG 353 or MAT_SCI 353. Concurrent enrollment is acceptable.

BMD_ENG 365-0 Control of Human Limbs and Their Artificial Replacements (1 Unit)
Human movement, biomechanics, skeletal and muscular anatomy, comparative anatomy, muscle physiology, and locomotion. Engineering design of artificial limbs.
Prerequisite: senior standing with engineering or physical science background.

BMD_ENG 366-0 Biomechanics of Movement (1 Unit)
Engineering mechanics applied to analyze human movement, including models of muscle and tendon, kinematics of joints, and dynamics of multi-joint movement. Applications in sports, rehabilitation, and orthopedics.
Prerequisite: BMD_ENG 271-0.

BMD_ENG 371-0 Mechanics of Biological Tissue (1 Unit)
Stress and strain for small and large deformations. Nonlinear elastic, viscoelastic, pseudo-elastic, and biphasic models.
Prerequisites: BMD_ENG 271-0; GEN_ENG 205-3; GEN_ENG 205-4.

BMD_ENG 377-0 Intermediate Fluid Mechanics (1 Unit)
Fundamental concepts of fluid dynamics. Kinematics, mass and momentum balances, constitutive relations. Navier-Stokes equations and methods of solution. Sealing techniques.
Prerequisite: BMD_ENG 270-0 or consent of instructor.

BMD_ENG 380-0 Medical Devices, Disease & Global Health (1 Unit)
Health systems and technologies to address health problems of the world's underserved populations, with special emphasis on developing countries.

BMD_ENG 388-SA Health Systems Engineering (1 Unit)
Introduction to health systems in the context of disease burden with special emphasis in developing countries. We examine healthcare systems, financing, data and analytics. The course focuses primarily on health-related issues confronting South Africa and the associated social and economic impact.
Prerequisite: consent of instructor.

BMD_ENG 389-SA Health Technology Management (1 Unit)
This course provides an introduction to formal concepts and methodologies used in support of health technology planning, assessment and adoption - and related decision making - as part of cost-effective healthcare delivery. Open to participants in the Global Health Technologies Program only.

BMD_ENG 390-3 Biomedical Engineering Design (1 Unit)
Continuation of a design project; independent study. May not be repeated for credit.
Prerequisites: BMD_ENG 390-1 or BMD_ENG 390-2; consent of instructor.

BMD_ENG 391-SA HealthCare Techology Innovation and Design (1 Unit)
Principles and practice of medical device design for the developing world. Evaluation of user needs in the environment of under-resourced segments of South African health care system. Validation and verification of engineering design solutions. Open to participants in the Global Health Technologies Program only.

BMD_ENG 396-0 Special Topics (0.5 Unit)
Special Topics in Biomedical Engineering, Laboratory emphasis.

BMD_ENG 398-0 Special Topics in Biomedical Engineering (0.34 Unit)

Special Topics in Biomedical Engineering, Laboratory emphasis.

BMD_ENG 404-1 Special Topics in Systems Physiology (0 Unit)
Course will train biomedical engineering PhD students in critical analysis of scientific papers, specifically in systems physiology. Instruction in the presentation of scientific data in a manner appropriate for delivery at professional scientific meetings. BMD_ENG 404-1 will cover neural systems physiology, BMD_ENG 404-2 will cover cardiovascular and respiratory physiology, and BMD_ENG 404-3 will cover endocrine, gastrointestinal, hepatic and renal physiology.

BMD_ENG 404-2 Special Topics in Systems Physiology (0 Unit)
Course will train biomedical engineering PhD students in critical analysis of scientific papers, specifically in systems physiology. Instruction in the presentation of scientific data in a manner appropriate for delivery at professional scientific meetings. BMD_ENG 404-1 will cover neural systems physiology, BMD_ENG 404-2 will cover cardiovascular and respiratory physiology, and BMD_ENG 404-3 will cover endocrine, gastrointestinal, hepatic and renal physiology.
Prerequisite: BMD_ENG 404-1.

BMD_ENG 404-3 Special Topics in Systems Physiology (1 Unit)
Course will train biomedical engineering PhD students in critical analysis of scientific papers, specifically in systems physiology. Instruction in the presentation of scientific data in a manner appropriate for delivery at professional scientific meetings. BMD_ENG 404-1 will cover neural systems physiology, BMD_ENG 404-2 will cover cardiovascular and respiratory physiology, and BMD_ENG 404-3 will cover endocrine, gastrointestinal, hepatic and renal physiology.
Prerequisite: BMD_ENG 404-2.

BMD_ENG 407-0 Experimental Design and Measurement (1 Unit)
Introductory quantitative skills required to conduct experimental research and analyze resulting data. Principles of measurement, modeling of experimental data, and statistical design of experiments.
Prerequisites: registration is reserved for Biomedical Engineering PhD students only.

BMD_ENG 414-0 Deep Learning for Biomedical Imaging (1 Unit)
The course will cover basic image processing techniques, the fundamentals of deep learning, and their applications in medical image analysis. Students will learn how to apply deep learning algorithms to analyze and interpret medical images such as X-rays, CT scans, and MRI scans.

BMD_ENG 426-0 MRI Modeling of Brain Physiology (1 Unit)
Modeling of brain activity, blood flow, and tissue properties using different MRI data, including fMRI, Arterial Spin Labeling, and Diffusion Weighted Imaging. Programming-based analysis assignments in real and simulated data. Critical analysis of the literature to develop new research questions in a clinical or neuroscience application of the student's choice. Students should have already completed an MRI course.

BMD_ENG 427-0 Advanced MR Imaging (1 Unit)
The use and design of MR pulse sequences; emphasis on image contrast mechanisms and some of the more widely used MR acquisition strategies.
Prerequisite: BMD_ENG 327-0.

BMD_ENG 429-0 Advanced Physical and Applied Optics (1 Unit)
Theory and applications of the state-of-the-art physical optics. Topics include wave optics, Gaussian optics, Fourier optics, light propagation in continuous and turbid media, light scattering, statistical optics, and fiber optics.

BMD_ENG 443-0 Biological Phenomena in Cell/Cell-Free Systems (1 Unit)

This course will focus on principles that guide how a cell senses, responds, moves, and ultimately functions by considering four major concepts that include molecular binding, enzyme catalysis, molecular transport, and mechanical deformation. Identification of how the four major concepts change as we move from a molecular length scale to a cell-free or cellular one.

BMD_ENG 444-0 Organic Nanomaterials (1 Unit)
The materials science and chemistry of soft nanomaterials for myriad applications including nanomedicine. Preparative and synthetic approaches to organized, assembled, discrete nanomaterials will be described. Course will include an in depth discussion of advanced characterization techniques and strategies for this class of material.

BMD_ENG 445-0 Principles of Immunoengineering (1 Unit)
This course covers therapeutically relevant recent advancements in immunology and resulting applications in the field of immunoengineering. Biomaterials and in particular nanomaterials are presented as a tool for modifying immune responses. Applications for cancer immunotherapy, vaccine development and the treatment of autoimmune disorders will be discussed.

BMD_ENG 446-0 Biomaterials in Synthetic Biology (1 Unit)
A course that focuses on the emerging principles in synthetic biology that have the capability to expand the functionality of biomaterials: what properties of biomaterials 'matter', emerging techniques to control the biological-material interface, and ways of inscribing the vital functions found in biological systems into synthetic materials.

BMD_ENG 448-0 Cardiovascular Biology and Engineering (1 Unit)
Molecular basis of cardiovascular development, performance, and pathogenesis; engineering analysis of cardiovascular functions; and fundamentals of cardiovascular engineering and regeneration.

BMD_ENG 452-0 Transport Through Connective Tissue (1 Unit)
Use of porous media theory to examine principles governing fluid flow and mass transfer in extracellular matrices and the application of these principles to tissue engineering.

BMD_ENG 462-0 Sensory Acquisition (1 Unit)
The class involves a neuroethological approach to the nervous system, comparing how information is encoded and processed across sensory modalities, and examining the relation between sensing and movement.

BMD_ENG 463-0 Advanced Signal Processing Methods in Neuropathophysiology (1 Unit)
A quantitative approach to the study and treatment of neurological diseases, including stroke, SCI and visual deficits. Incorporates neuropathophysiology, computer modeling and systems analysis.

BMD_ENG 465-0 Biomechanical Modeling & Simulation of Human Movement (1 Unit)
This course is designed to familiarize the student with the development and use of biomechanical models to simulate motion.

BMD_ENG 467-0 Biomedical Robotics (1 Unit)
A perspective on robotics technologies applied to, and inspired by, themes of biomedical research and practice.

BMD_ENG 468-0 Decision-Making in the Wild: Measurement and Models (1 Unit)
A survey of the most recent science and quantitative models of high stakes non-reactive decision making. The class will look at the evolutionary basis of high efficiency rapid learning and decision making in animals, current understanding of mechanisms from the neuroscience and psychology literature, and algorithms to model the phenomena in the low data limit that animals excel in. There will be a significant computational component, in Python.

BMD_ENG 469-0 Neural Control and Mechanics of Movement (1 Unit)
Muscle mechanics and relevant spinal cord neurophysiology as the basis for understanding neural control of movement.

BMD_ENG 478-0 Transport Fundamentals (1 Unit)
Fundamental and biomedical applications of diffusive and convective heat and mass transfer with problems appropriate for graduate students.

BMD_ENG 481-0 Cardiovascular Engineering and Technology (1 Unit)
This course will integrate fundamental scientific knowledge and engineering technological advances involved in cardiovascular medicine with an emphasis on the most challenging unmet clinical needs, such as heart failure, hypertension, ischemic disease, myocardial infarction, metabolic disease, atrial fibrillation, and sudden cardiac death. The course will introduce gene and cell therapies, computational cardiology, design of implantable and wearable devices, ablation of cardiac arrhythmias.

BMD_ENG 495-0 Special Advanced Topics in Biomedical Engineering (1 Unit)
Current topics of interest for graduate students. May be repeated for credit with change of topic.

BMD_ENG 499-0 Projects (1-3 Units)
Permission of instructor and department required. May be repeated for credit.

BMD_ENG 512-0 Graduate Research Seminar in Biomedical Engineering (0 Unit)
A series of seminars covering current research interests in biomedical engineering. Attendance by first-year Biomedical Engineering graduate students required.

BMD_ENG 590-0 Research (1-4 Units)
Independent investigation of selected problems pertaining to thesis or dissertation. May be repeated for credit.