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**The School of Biomedical Engineering, Science and Health Systems  
2010-2011 Undergraduate Course Descriptions**

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## Biomedical Engineering & Science Courses

### **BMES 125 - Foundns of Biomed Engineering**

This course provides students with an introduction to the fields of biomedical engineering at Drexel while covering aspects of evolutionary theory, complexity and systems biology important to biomedical engineers.

Credits: 2.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

May not have the following Classification(s):

Repeat Status: Not repeatable for credit

### **BMES 212 - The Body Synthetic**

The Body Synthetic introduces concepts underlying biological and engineering principles involved in the design and construction of prosthetic devices used to replace various parts of the human body.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Pre-Requisites: TDEC 122 Minimum Grade: D or BMES 480 Minimum

Grade: C or BIO 122 Minimum Grade: D

Repeat Status: Not repeatable for credit

### **BMES 301 - Lab I: Exp Biomechanics**

This course deals with experimental aspects of biomechanics, specifically with the testing mechanical properties of biological tissues.

Credits: 2.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Sophomore

Pre-Requisites: (TDEC 114 Minimum Grade: D or MATH 200 Minimum

Grade: D ) and (TDEC 115 Minimum Grade: D or PHYS 201 Minimum

Grade: D ) and (TDEC 211 Minimum Grade: D or ENGR 231 Minimum

Grade: D )

Repeat Status: Not repeatable for credit

### **BMES 302 - Lab II: Biomeasurements**

This course introduces students to the measurement of physiological/biological/functional signals. Four specific signals will be collected and analyzed. Students are expected to analyze type of signal to be collected, possible measurement techniques and potential data analysis and then collect and analyze each signal.

Credits: 2.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Sophomore

Pre-Requisites: (BMES 222 Minimum Grade: D or BIO 201 Minimum

Grade: D ) and ECE 201 Minimum Grade: D and (TDEC 231 Minimum

Grade: D or ENGR 103 Minimum Grade: D )

Repeat Status: Not repeatable for credit

### **BMES 303 - Lab III: Biomed Electronics**

This course introduces students to the widespread application of electronics and electronic devices in biomedical engineering. The course reinforces concepts learned in ECE 201 with hands-on experimentation related to biomedical applications such as telemedicine and medical devices.

Credits: 2.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Sophomore

Pre-Requisites: ECE 201 Minimum Grade: D or TDEC 231 Minimum

Grade: D or ENGR 103 Minimum Grade: D

Repeat Status: Not repeatable for credit

### **BMES 304 - Lab IV: Ultrasound Images**

This course introduces students to the engineering principles of acoustical measurements by combining hands-on laboratory experiences with lectures. Students will learn the engineering/physical principles of measuring sound velocity in different materials, attenuation, and directivity of a circular transducers.

Credits: 2.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Sophomore

Pre-Requisites: BIO 201 Minimum Grade: D and BIO 203 Minimum

Grade: D and ECE 201 Minimum Grade: D and (TDEC 231 Minimum

Grade: D or ENGR 103 Minimum Grade: D )

Repeat Status: Not repeatable for credit

### **BMES 305 - Lab V: Musculoskeletal Anatomy for BME**

This course provides an opportunity for students to study the anatomy and biomechanics of select articulations of the human body. While the main emphasis will be on the musculoskeletal structures associated

with each articulation, major neural and vascular structures will be studied as well.

Credits: 2.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

Pre-Requisites: BIO 201 Minimum Grade: D and BIO 203 Minimum

Grade: D and MEM 202 Minimum Grade: D

Repeat Status: Not repeatable for credit

### **BMES 310 - Biomedical Statistics**

This course is designed to introduce biomedical engineering students to the fundamentals of biostatistics necessary for medical research. Topics covered include measurements, sampling, basic hypothesis testing, analysis of variance and regression. Medical applications are emphasized.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Pre-Requisites: (TDEC 114 Minimum Grade: D or MATH 200 Minimum

Grade: D ) and (TDEC 232 Minimum Grade: D or ENGR 103 Minimum

Grade: D )

Repeat Status: Not repeatable for credit

### **BMES 315 - Exp Design in Biomed Research**

This course is designed to introduce students to the fundamental principles of experimental design and statistical analysis as applied to biomedical research with animals and humans. Topics to be covered include experimental design, clinical design, and protocol submission and review.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Pre-Requisites: BMES 310 Minimum Grade: C

Repeat Status: Not repeatable for credit

### **BMES 325 - Principles of Biomedical Engineering I**

This course is the first part of a two-term sequence which introduces biomedical engineering students to engineering principles applied to biological and physiological systems. This course focuses on bioethical questions, biomechanics, human performance engineering, biomaterials and tissue engineering.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

Pre-Requisites: BIO 122 Minimum Grade: D and CHEM 102 Minimum Grade: D and BIO 203 Minimum Grade: D and MEM 202 Minimum Grade: D and ENGR 220 Minimum Grade: D and ENGR 232 Minimum Grade: D

Repeat Status: Not repeatable for credit

### **BMES 326 - Principles of Biomedical Engineering II**

This course is the second part of a two-term sequence which introduces biomedical engineering students to engineering principles applied to biological and physiological systems. This course focuses on bioinformatics, neuroengineering, biosignal processing, biosensors, and medical imaging.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

Pre-Requisites: BMES 325 Minimum Grade: C and BIO 201 Minimum

Grade: D and CS 123 Minimum Grade: D

Repeat Status: Not repeatable for credit

### **BMES 330 - Biorhythm Pharm/Toxicol**

This course covers the fundamentals of biological rhythms with particular emphasis on the influence these cycles have on the susceptibility of organism to physical, chemical, and /or toxic agents.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Pre-Requisites: BIO 203 Minimum Grade: C

Repeat Status: Not repeatable for credit

### **BMES 331 - Computers in Health Systems I**

Introduces the allied health professional to basic computer applications on personal computers. Includes word processing, spreadsheets, databases, and networking (e.g., e-mail and information search and retrieval) in a primarily Windows environment. Designed for individuals with little or no computer background. Students are encouraged to bring in their own work-related problems or projects to provide immediate application of knowledge learned to the student's professional healthcare environment.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

Pre-Requisites:

Repeat Status:

**BMES 332 - Computers in Health Systems II**

Continues the general overview of computers for people in the allied health professions, using specific examples from health care. Offers further study of and practice with special scientific (e.g., statistics, graphing) and medical clinical decision-support software. Introduces algorithms and formal programming methods.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Pre-Requisites:

Repeat Status: Not repeatable for credit

**BMES 335 - Biomedical Informatics I**

Introduces information and information handling systems for people in the allied health professions, with specific examples drawn from health care. Covers locating, manipulating, and displaying information in the health system setting.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

May not have the following Classification(s):

Freshman

Sophomore

Repeat Status: Not repeatable for credit

**BMES 336 - Hosp & Pat Info/Informatics II**

Continues BMES 335. Emphasizes medical records and hospital and patient information handling. Examines the problems of patient information flow within the health care system. Introduces conventional and proposed patient and hospital information systems.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Pre-Requisites: BMES 335 Minimum Grade: C

Repeat Status: Not repeatable for credit

**BMES 338 - Biomedical Ethics and Law**

Introduces the wide spectrum of ethical, regulatory, and legal issues facing health care practitioners and health-related research workers. Helps students become aware of the ethical and legal issues involved in their work. Helps students understand how legal and ethical decisions should be made in health-related matters, as well as what sources of help and guidance are available.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

May not have the following Classification(s):

Freshman

Repeat Status: Not repeatable for credit

**BMES 340 - Health Care Administration**

This course provides students with an analysis of health care administration process, including: planning, organizing, designing, decision-making, leading, and controlling. Presents methods and techniques that can contribute to the effective performance of administrative duties.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

May not have the following Classification(s):

Freshman

Pre-Requisites:

Repeat Status: Not repeatable for credit

**BMES 350 - Med & Bio Effects Of Light**

Examines the role of environmental lighting in human physiological and psychological processes. Topics include vitamin D synthesis and calcium regulation; light effects on bilirubin in newborns; photoactivation and DNA in skin; effects of nonionizing radiation on the immune systems; environmental lighting and human vision; light effects on biological rhythms and sleep; photosensitivity diseases related to interior lighting; the therapeutic uses of light; and light and the aging eye.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Pre-Requisites: BIO 203 Minimum Grade: D

Repeat Status: Not repeatable for credit

**BMES 363 - Robotics in Medicine I**

This course provides an introduction to the use of haptics (the use of somatosensory information) in the design of robotic devices in surgery. Topics covered include actuators, sensors, nonportable feedback, portable force feedback, tactile feedback interfaces, haptic sensing and control systems.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter  
Pre-Requisites: MEM 238 Minimum Grade: D  
Repeat Status: Not repeatable for credit

### **BMES 365 - Robotics in Medicine II**

This course covers the use of robots in surgery and included aspects of safety, robot kinematics, analysis of surgical performance using robotic devices, inverse kinematics, velocity analysis and acceleration analysis. Various types of surgeries in which robotic devices are or could be used are presented on a case study basis.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Pre-Requisites: BMES 363 Minimum Grade: C

Repeat Status: Not repeatable for credit

### **BMES 372 - Biosimulation**

This course provides the foundation for the mathematical analysis of biomedical engineering systems. It focuses on the essential mathematical methods necessary for further development of modeling and simulation skills in other courses (materials, mechanics, fluids/transport, signals/control system, etc). The course applies the skills in calculus, differential equations and linear algebra gained in ENGR 231 and ENGR 232 to developing analytical techniques for biomedical applications.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

Pre-Requisites: BIO 201 Minimum Grade: D and BIO 203 Minimum

Grade: D and ENGR 231 Minimum Grade: D and ENGR 232 Minimum

Grade: D

Repeat Status: Not repeatable for credit

### **BMES 375 - Computational Bioengineering**

This course introduces undergraduate students to the mathematical and computational analysis of biological systems. The systems analyzed include the genome, protein and gene networks, cell division cycles, and cellular level disease. Mathematical tools include matrix algebra, differential equations, cellular automata, cluster analysis, etc.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

Must have the following Classification(s):

Junior

Senior

Pre-Requisites: BIO 203 Minimum Grade: D and BMES 325 Minimum

Grade: C and BMES 372 Minimum Grade: C and (MATH 290 Minimum

Grade: D or ENGR 231 Minimum Grade: D ) and (TDEC 221 Minimum Grade: D or ENGR 232 Minimum Grade: D )

Repeat Status: Not repeatable for credit

### **BMES 381 - Junior Design Seminar I**

This is the first course in a two-course sequence intended to present the basics of engineering design, project management, product development and translational research. This first course focuses on engineering design and product development. A case-study approach is used to illustrate best practices and common mistakes in engineering design.

Credits: 2.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Graduate Quarter

Undergraduate Quarter

May not have the following Classification(s):

Freshman

Pre-Junior

Sophomore

Repeat Status: Not repeatable for credit

### **BMES 382 - Junior Design Seminar II**

This is the second course in a two-course sequence intended to present the basics of engineering design, project management, product development and translational research. This second course focuses on project management and quality control. A case-study approach is used to illustrate best practices and common mistakes in management and evaluation of engineering projects.

Credits: 2.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Graduate Quarter

Undergraduate Quarter

May not have the following Classification(s):

Freshman

Pre-Junior

Sophomore

Pre-Requisites: BMES 381 Minimum Grade: C

Repeat Status: Not repeatable for credit

### **BMES 391 - Biomedical Instrumentation I**

This course introduces the student to the medical instrumentation and provides background on the physical, chemical, electronic and computational fundamentals by which medical instrumentation operates. It is an analytical course exploring the design, operation, safety aspects and calibration of primary electronic instruments.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

May not have the following Classification(s):

Freshman

Sophomore

Pre-Requisites: ECE 201 Minimum Grade: D and (TDEC 202 Minimum Grade: D or ENGR 210 Minimum Grade: D ) and (TDEC 221 Minimum Grade: D or ENGR 231 Minimum Grade: D )

Repeat Status: Not repeatable for credit

### **BMES 392 - Biomedical Instrumentation II**

Continues BMES 391. Explores the operation, safety aspects, and calibration of primarily optical and acoustical instruments, as well as those involving ionizing radiation. Also examines instrumentation primarily intended for particular departments and areas, such as anesthesia and infusion.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

May not have the following Classification(s):

Freshman

Sophomore

Pre-Requisites: BMES 391 Minimum Grade: C

Repeat Status: Not repeatable for credit

### **BMES 401 - Biosensors I**

Introduces the general topic of microsensors, discusses basic sensing mechanisms for microsensors, and presents various types of conductometric, acoustic, silicon, and optical microsensors. Uses two case studies that include an acoustic immunosensor and silicon glucose sensor to provide students with in-depth knowledge and hands-on experience. Provides additional experience through three laboratory sessions that support the lectures and familiarize students with practical aspects of microsensors. Also discusses applications of microsensors in the medical, chemical, pharmaceutical, environmental, aeronautical, and automotive industries.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must have the following Classification(s):

Junior

Senior

Pre-Requisites: (BMES 222 Minimum Grade: C or BMES 326 Minimum Grade: C ) and (TDEC 202 Minimum Grade: D or ENGR 210 Minimum Grade: D ) and (TDEC 221 Minimum Grade: D or ENGR 231 Minimum Grade: D ) and ECE 201 Minimum Grade: D

Repeat Status: Not repeatable for credit

### **BMES 402 - Biosensors II**

Investigates modern biosensor design methods and addresses the challenges associated with fabrication technologies and

instrumentation techniques. Topics include theory and modeling of biosensors, biosensor fabrication steps, and electronic and clinical testing methods. Discusses local and distant sensor data acquisition techniques. Students will design, fabricate and test a biosensor. Essential stages of biosensor manufacturing processes will be outlined. Some or all pre-requisites may be taken as either a pre-requisite or co-requisite. Please see the department for more information.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must have the following Classification(s):

Junior

Senior

Pre-Requisites: BMES 401 Minimum Grade: C (May be taken concurrently)

Repeat Status: Not repeatable for credit

### **BMES 403 - Biosensors III**

Covers recent advances in biosensor technology and applications, business aspects, and technology transfer issues. Topics include new sensing mechanisms, new technologies, new biomedical applications, the starting of small sensor companies, and the introduction of new sensor technologies into industrial settings. Requires students to develop a technical proposal in the area of biosensors and to review proposals written by their peers. Presentations by regular faculty and industrial and government researchers form an integral part of the course.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must have the following Classification(s):

Junior

Senior

Pre-Requisites: BMES 402 Minimum Grade: C

Repeat Status: Not repeatable for credit

### **BMES 405 - Physiological Control Systems**

Introduces the basic concepts of feedback and feed forward controls systems, including characterizations in terms of prescribed constraints, study of input and output relationships for various types of physiological systems, and stability and time-delay problems. Covers mathematical models of physiological systems, with emphasis on non-linear and adaptive systems study.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

Pre-Requisites: BIO 201 Minimum Grade: D and BIO 203 Minimum Grade: D and ECES 356 Minimum Grade: D and BMES 372 Minimum Grade: C

Repeat Status: Not repeatable for credit

#### **BMES 409 - Entrepreneurship for BMES**

This course serves as the foundation course in entrepreneurship and is designed to provide students with a complete working knowledge of the modern entrepreneurial and business planning process.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Repeat Status: Not repeatable for credit

#### **BMES 411 - Chronoengr I: Bio Rhythms**

Introduces students to the concepts of biological, and especially circadian, rhythmicity. Advances students' knowledge of biological time-keeping and adaptive functions of biological clocks. Topics include biochemical and physiological models of biological clocks, adjustment to environmental cycles, rhythms in behavior and physiological functions, sleep-wake cyclicity, adaptability of circadian systems, and influences of rhythms on human physiology and behavior. Designed to give students a thorough understanding of the role rhythms play in animal and human behavior, physiology, and medicine.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Sophomore

Pre-Requisites: BIO 203 Minimum Grade: D and (BMES 222 Minimum

Grade: C or BMES 326 Minimum Grade: C )

Repeat Status: Not repeatable for credit

#### **BMES 412 - Chronoengr II: Sleep Functions**

Continues BMES 411. Enhances students' education in the concepts of biological, and especially circadian, rhythmicity. Focuses on sleep patterns, rhythms, evolution, neurology, psychology, and overall function.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Sophomore

Pre-Requisites: BMES 411 Minimum Grade: C

Repeat Status: Not repeatable for credit

#### **BMES 421 - Biomed Imaging Sys. I: Images**

Provides an overview of the field of medical imaging. Covers aspects of light imaging; systems theory, convolutions, and transforms; photometry, lenses, and depth of field; image perception and roc theory; three-dimensional imaging; image acquisition and display; and image processing operations, including scanning and segmentation.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must have the following Classification(s):

Senior

Pre-Requisites: (TDEC 115 Minimum Grade: D or PHYS 201 Minimum

Grade: D ) and BIO 203 Minimum Grade: D and (MATH 311 Minimum

Grade: D or BMES 310 Minimum Grade: C ) and (TDEC 222 Minimum

Grade: D or ENGR 231 Minimum Grade: D ) and (MATH 290 Minimum

Grade: D or ENGR 232 Minimum Grade: D ) and ECES 302 Minimum

Grade: D and ECES 304 Minimum Grade: D

Repeat Status: Not repeatable for credit

#### **BMES 422 - Biomed Imaging Systems II**

Intended for students who would like to gain an adequate understanding of diagnostic ultrasound imaging principles and become familiar with developments in this rapidly expanding field. Introduces medical visualization techniques based on ultrasound propagation in biological tissues. Topics include generation and reception of ultrasound, imaging techniques (A-mode, B-mode, M-mode, and Doppler), typical and emerging diagnostic applications, elements of ultrasound exosimetry, and safety aspects from the clinical point of view.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must have the following Classification(s):

Senior

Pre-Requisites: BMES 421 Minimum Grade: C

Repeat Status: Not repeatable for credit

#### **BMES 423 - Biomed Imaging Systems III**

Covers volumetric and functional imaging systems. Discusses the principles and algorithms of projection tomography, XCAT, SPECT, PET; the principles of MRI: Bloch equation, slice selection, K-space scanning, volumetric MRI; biochemical imaging; chemical equilibrium equations and Scatchard plots, specific and nonspecific labeling; autoradiography; and flow and dynamical systems: Doppler, mass transport, and phase (MRI) measurement of flow.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must have the following Classification(s):

Senior  
Pre-Requisites: BMES 422 Minimum Grade: C  
Repeat Status: Not repeatable for credit

#### **BMES 430 - Neural Aspects of Posture and Locomotion**

Students will study the physiology of sensory/motor systems, with emphasis on modeling of neural systems and biomechanical aspects of functional tasks. Combines information on basic nerve cell activities, synaptic communication and structure/function relationships of skeletal muscle with basic mechanics to study spinal, vestibular and ocular reflexes. Culminates with the study of the control of motor systems with respect to bipedal motion.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

Pre-Requisites: BIO 201 Minimum Grade: D and BIO 203 Minimum Grade: D and MEM 202 Minimum Grade: D

Repeat Status: Not repeatable for credit

#### **BMES 432 - Biomed Systems and Signals**

Introduces various aspects of biomedical signals, systems, and signal processing. Covers topics in the origin and acquisition of biomedical signals; discrete-time signals and linear systems; frequency analysis of discrete-time signals, spectral estimation, data records and digital filters; and compression of biomedical signals through time-domain and frequency-domain coding.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Pre-Junior

Sophomore

Pre-Requisites: ECES 302 Minimum Grade: D and ECES 304 Minimum Grade: D and ECES 352 Minimum Grade: D

Repeat Status: Not repeatable for credit

#### **BMES 440 - Introduction to Biodynamics**

The objective of the course is to prepare students for biomechanical modeling, modeling methods, formulation of equations of motion and methods of determination of strength will be applied to human body dynamics. Particular emphasis is placed on the use of Rigid Body and Multi-Body Dynamics.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Pre-Requisites: MEM 202 Minimum Grade: D and MEM 230 Minimum Grade: D and MEM 238 Minimum Grade: D

Repeat Status: Not repeatable for credit

#### **BMES 441 - Biomechanics I:**

Teaches students to use mechanical tools to get an introductory appreciation for solving biomechanical problems. Models human performance by using static, quasi-static, and dynamic approaches. Assesses overall loading of the musculoskeletal system during functional activities. Demonstrates some introductory methods of estimation of forces in the joints and muscles and evaluates the endurance of the human tissues under traumatic loading conditions. Builds on existing knowledge in mechanics, such as the basic variables of mechanics, modeling methods, formulation of the equations of motion, and methods of determination of strength, then practices actual illustration of the application of the mechanical tools in the determination of human systems performance.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must have the following Classification(s):

Senior

Co-Requisites: BMES 440

Pre-Requisites: MEM 202 Minimum Grade: D and MEM 230 Minimum Grade: D and MEM 238 Minimum Grade: D and (BMES 222 Minimum Grade: C or BMES 326 Minimum Grade: C ) and BIO 203 Minimum Grade: D

Repeat Status: Not repeatable for credit

#### **BMES 442 - Biomechanics II**

Teaches students to think biomechanically. Reviews and categorizes the various functional components (tissues) of the musculoskeletal system. Considers constraints of the joints and action of the soft and hard tissues, along with corresponding models. Computes joint and muscle forces. Discusses some aspect of postural stability of the whole musculoskeletal structure and reviews various methods of task performance.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must have the following Classification(s):

Senior

Pre-Requisites: BMES 441 Minimum Grade: C

Repeat Status: Not repeatable for credit

#### **BMES 443 - Biomechanics III**

Provides more advanced knowledge of mechanics of materials and offers a general description of mechanical behavior of the variety of the soft and hard tissues of the human body. Considers some prosthetic replacements of tissues as well as entire bone, joint, soft tissue, and



system prosthetics. Reviews some specific orthopedic appliances and covers limb prosthetics if time permits. Students plan design projects.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must have the following Classification(s):

Senior

Pre-Requisites: BMES 442 Minimum Grade: C

Repeat Status: Not repeatable for credit

#### **BMES 444 - Biofluid Mechanics**

This course introduces flow-related anatomy and pathophysiology, and biomedical flow devices and their design challenges. Analysis methods to solve biological fluid mechanics design problems will be introduced and several interdisciplinary team projects will be assigned to apply fluid mechanics to practical biological or medical problems.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Pre-Requisites: BMES 451 Minimum Grade: C

Repeat Status: Not repeatable for credit

#### **BMES 451 - Trans. Phenomena in Living Sys**

Introduces students to applications of chemical engineering concepts in biological systems. Shows that chemical engineering approaches to problem solving are ideally suited to investigation of biology. Approaches include material and energy balances, transport phenomena, and kinetics.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Pre-Junior

Sophomore

Pre-Requisites: (TDEC 115 Minimum Grade: D or PHYS 201 Minimum

Grade: D ) and (BMES 222 Minimum Grade: C or BMES 326 Minimum

Grade: C ) and BIO 203 Minimum Grade: D and (TDEC 202 Minimum

Grade: D or ENGR 210 Minimum Grade: D )

Repeat Status: Not repeatable for credit

#### **BMES 452 - Trans. Phen in Living Sys II**

Continues BMES 451. Advances students' understanding of the engineering principles of membrane transport and its consequences at the subcellular (mitochondria), cellular (neuron), and organ (kidney) level. Introduces concepts associated with pharmacokinetics. Provides students with a kinetic approach to analysis of receptors, including the

kinetics of ligand-receptor binding, rate constants, and signal transduction.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

May not have the following Classification(s):

Freshman

Pre-Junior

Sophomore

Pre-Requisites: BMES 451 Minimum Grade: C

Repeat Status: Not repeatable for credit

#### **BMES 460 - Biomaterials I**

First course in a three-quarter sequence designed to acquaint students with the behavior of materials used in biomedical application under load (i.e., mechanical properties), their modes of failure and as a function of their environment. This course provides students with the fundamentals needed to proceed with Biomaterials II

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Pre-Requisites: MEM 230 Minimum Grade: D and CHEM 241 Minimum

Grade: D and CHEM 242 Minimum Grade: D

Repeat Status: Not repeatable for credit

#### **BMES 461 - Biomaterials II**

Second course in a three-quarter sequence in biomaterials. The goal of this course is with an understanding of, and ability to select, appropriate materials for specific applications taking into account mechanical, thermal, and rheological properties taught in Biomaterials I and combining them with the biocompatibility issues covered in the present course.

Credits: 4.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must have the following Classification(s):

Senior

Pre-Requisites: BMES 460 Minimum Grade: C

Repeat Status: Not repeatable for credit

#### **BMES 466 - Robotics in Medicine III**

This course covers topics in the design of medical robotic systems, including force and movement analysis for robotic arms, dynamics, computer vision and vision-based control. Thus use of haptics, vision systems and robot dynamics are examined in a cohesive framework.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering  
Restrictions:  
Must be enrolled in one of the following Program Level(s):  
Undergraduate Quarter  
Pre-Requisites: BMES 365 Minimum Grade: C  
Repeat Status: Not repeatable for credit

#### **BMES 471 - Tissue Engineering I**

Course is designed to familiarize students with the advanced concepts of cellular and molecular biology and physiology relevant to tissue engineering. The initial part of a two-quarter sequence combining material from cellular/molecular biology, evolutionary/developmental biology with engineering design and biomaterials to educate students in the principles, methods, and technology of tissue engineering.  
Credits: 4.00  
College: Sch.of Biomed Engr,Sci & Hlth  
Department: Sch of Biomedical Engineering  
Restrictions:  
May not be enrolled in one of the following Program Level(s):  
Continuing Education  
Must have the following Classification(s):  
Senior  
Pre-Requisites: BIO 218 Minimum Grade: D and BIO 219 Minimum Grade: D and CHEM 242 Minimum Grade: D and MEM 230 Minimum Grade: D  
Repeat Status: Not repeatable for credit

#### **BMES 472 - Tissue Engineering II**

Familiarizes students with advanced concepts of developmental and evolutionary biology relevant to tissue engineering. This second part of the two-quarter sequence combines material from cellular/molecular biology and evolutionary design and biomaterials to educate students in the principles, methods, and technology of tissue engineering.  
Credits: 4.00  
College: Sch.of Biomed Engr,Sci & Hlth  
Department: Sch of Biomedical Engineering  
Restrictions:  
May not be enrolled in one of the following Program Level(s):  
Continuing Education  
Must have the following Classification(s):  
Senior  
Pre-Requisites: BMES 471 Minimum Grade: C  
Repeat Status: Not repeatable for credit

#### **BMES 475 - Biomaterials and Tissue Engineering III**

This course provides students with in-depth knowledge of factor-mediated tissue engineering and regenerative medicine. Students learn about fundamental repair and regenerative processes and gain an understanding of specific biomaterials being used to mimic and/or enhance such processes. Students also learn about the delivery methods of agents which promote the proper functional development of specialized tissues.  
Credits: 4.00  
College: Sch.of Biomed Engr,Sci & Hlth  
Department: Sch of Biomedical Engineering  
Restrictions:

May not be enrolled in one of the following Program Level(s):  
Continuing Education  
Pre-Requisites: BMES 460 Minimum Grade: C and BMES 461 Minimum Grade: C and BMES 471 Minimum Grade: C and BMES 472 Minimum Grade: C  
Repeat Status: Not repeatable for credit

#### **BMES 477 - Neuroengineering I**

Introduces the theory of neural signaling. Students will learn the fundamental theory of cellular potentials and chemical signaling, the Hodgkin Huxley description of action potential generation, circuit representations of neurons and be able to derive and integrate equations describing the circuit as well as design computer models.  
Credits: 3.00  
College: Sch.of Biomed Engr,Sci & Hlth  
Department: Sch of Biomedical Engineering  
Restrictions:  
May not be enrolled in one of the following Program Level(s):  
Continuing Education  
Must have the following Classification(s):  
Senior  
Pre-Requisites: ECES 302 Minimum Grade: D and ECES 304 Minimum Grade: D and ECES 356 Minimum Grade: D and BIO 203 Minimum Grade: D  
Repeat Status: Not repeatable for credit

#### **BMES 478 - Neuroengineering II**

This course investigates cutting edge technologies in neuroengineering in a seminar-style format with faculty from the School of Biomedical Engineering and College of Medicine. Three modules cover topics, which vary from year to year. Students are expected to submit written and oral presentations covering each topic.  
Credits: 3.00  
College: Sch.of Biomed Engr,Sci & Hlth  
Department: Sch of Biomedical Engineering  
Restrictions:  
May not be enrolled in one of the following Program Level(s):  
Continuing Education  
Must have the following Classification(s):  
Senior  
Pre-Requisites: BMES 477 Minimum Grade: C  
Repeat Status: Not repeatable for credit

#### **BMES 480 - Spec Top Biomed Engr/Sci**

Covers topics related to the field of health care, systems, and technology. Past topics include health care administration.  
Credits: 12.00  
College: Sch.of Biomed Engr,Sci & Hlth  
Department: Sch of Biomedical Engineering  
Restrictions:  
May not be enrolled in one of the following Program Level(s):  
Continuing Education  
May not have the following Classification(s):  
Repeat Status: Course can be repeated 99 time(s) for 998.90 credit(s)

**BMES 483 - Quantitative Systems Biology**

This course uses a systems engineering approach to provide a foundation in systems biology and pathology informatics. Topics covered include the robust complex network of genes and proteins; cell as basic units of life; communication of cells with other cells and the environment; and gene circuits governing development.

Credits: 4.50

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Pre-Requisites: (TDEC 222 Minimum Grade: D or ENGR 232 Minimum Grade: D ) and BIO 203 Minimum Grade: D and BMES 375 Minimum

Grade: C and CS 172 Minimum Grade: D

Repeat Status: Not repeatable for credit

**BMES 484 - Genome Information Engineering**

This course is designed to provide students with hands-on experience in the application of genomic, proteomic, and other large-scale information to biomedical engineering. The underlying goal is to develop an understanding of high throughput underlying technologies, biological challenges, and key mathematical and computational methods relevant to biomedical engineering.

Credits: 4.50

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Pre-Requisites: BMES 483 Minimum Grade: C

Repeat Status: Not repeatable for credit

**BMES 488 - Medical Device Development**

Medical device product development must take into account a diverse set of disciplines to achieve a safe and successful product. This course exposes the student to several of these disciplines with the objective of raising the student's awareness of safety throughout the product development life cycle. Students will learn to appreciate the complex engineering decisions that support development of a safe medical device through an examination of risk management, regulatory processes, human factors and clinical studies.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

Pre-Requisites: BMES 391 Minimum Grade: C and BMES 392 Minimum Grade: C

Repeat Status: Not repeatable for credit

**BMES 491 - Senior Design Project I**

This is the first course in a three-quarter capstone design experience for senior biomedical engineering students.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):  
Continuing Education

Repeat Status: Not repeatable for credit

**BMES 492 - Senior Design Project II**

Continues senior design activities begun in BMES 492.

Credits: 2.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):  
Continuing Education

Repeat Status: Not repeatable for credit

**BMES 493 - Senior Design Project III**

Continues the design project begun in BMES 491 and continued through BMES 492.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):  
Continuing Education

Repeat Status: Not repeatable for credit

**BMES 494 - Clinical Practicum I**

This course provides biomedical engineering students with an extensive exposure to live clinical cardiology procedures, including cardiac catheterization, electrophysiology, echocardiography and nuclear stress testing. Emphasis is placed on identifying important interfaces between engineering and clinical medicine, particularly in areas where clinical needs may be addressed by advances in biomedical engineering.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must be enrolled in one of the following Major(s):

Biomedical Engineering

Repeat Status: Not repeatable for credit

**BMES 495 - Clinical Practicum II**

This course provides biomedical engineering students with an extensive exposure to live operations in an emergency department and intensive care unit. The students are expected to analyze specific operations within these environments and develop a solution to a process problem within one of these environments. System analysis, design and evaluation are emphasized.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must be enrolled in one of the following Major(s):

Biomedical Engineering

Repeat Status: Not repeatable for credit

### **BMES 496 - Clinical Practicum III**

This course provides biomedical engineering students with an opportunity to observe basic operative and postoperative procedures with the idea of both learning about such procedures and identifying the role of biomedical engineering in these clinical settings.

Credits: 3.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

Must be enrolled in one of the following Program Level(s):

Undergraduate Quarter

Must be enrolled in one of the following Major(s):

Biomedical Engineering

Repeat Status: Not repeatable for credit

### **BMES 499 - Independent Study in BMES**

Credits: .50 to 6.00

College: Sch.of Biomed Engr,Sci & Hlth

Department: Sch of Biomedical Engineering

Restrictions:

May not be enrolled in one of the following Program Level(s):

Continuing Education

Repeat Status: Course can be repeated 98 time(s) for 998.00 credit(s)