SIU CARBONDALE Southern Illinois University

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Biomedical Engineering.....1

Biomedical Engineering

Mission Statement

The mission of the School of Electrical, Computer, and Biomedical Engineering is to serve society as a center for learning and innovation in all major areas of electrical, computer, and biomedical engineering. The School accomplishes its mission by disseminating existing knowledge through teaching, by creating new knowledge through research and publications, and by converting original ideas and concepts into new technologies. Through the integration of education and research, the School creates the academic environment necessary for training innovators and leaders for the future.

The fundamental goal of the undergraduate program in Biomedical Engineering is to offer a high-quality education, designed to achieve the following specific educational objectives:

Educational Objectives

Within a few years of graduation, Biomedical Engineering graduates are expected to attain:

1. Increasing responsibility beyond that in their entry-level description in job functions within Biomedical Engineering or related employment, and/or
2. Successful progress within graduate degree programs in Biomedical Engineering or other professional degrees, such as other Engineering, Medicine, Business, or Law.
3. Continued successful professional development and adaptation to evolving technologies within their chosen field.

The program also offers a Pre-Medical specialization for students who wish to pursue a degree in medicine after graduation.

Employment opportunities exist within a wide range of organizations, including healthcare, manufacturing, medical device and instrumentation companies, rehabilitation, electronics, defense, aviation, automotive, state and federal agencies, and laboratories. Employment opportunities cover the spectrum of engineering activities, ranging from research and development to systems analysis, automation, manufacturing, customer service, support, marketing, and sales.

The undergraduate program in Biomedical Engineering is accredited by the Engineering Accreditation Commission (EAC) of ABET, http://www.abet.org, under the commission's General Criteria.

Bachelor of Science (B.S.) in Biomedical Engineering Degree Requirements

Degree Requirements	Credit Hours
University Core Curriculum Requirements	39
Foundation Skills: CMST 101, ENGL 101, ENGL 102, MATH 150 (3 credits out of 4), UNIV 101	13
CMST 101	3

Degree Requirements		Credit Hours
ENGL 101, ENGL 102	6	
MATH 150 (3 credits out of 4)	3	
UNIV 101	1	
Disciplinary Studies		23
Fine Arts	3	
Humanities [1]	6	
Social Science [2]	6	
PHSL 201 (2 credits out of 3 for Human Health)	2	
BIOL 211 (3 credits out of 4)	3	
PHYS 205A	3	
Multicultural/Diversity		3
Requirements for Biomedical Engineering Major		87
Basic Science		9
BIOL 211 (1 credit out of 4)	1	
PHYS 205B, PHSL 201 (1 credit out of 3)	4	
CHEM 200, CHEM 201	4	
Mathematics		11
MATH 150 (1 credit out of 4)	1	
MATH 250, MATH 251, MATH 305	10	
BME Required Courses		40
BME 101, BME 296, BME 296L, BME 336, BME 337, BME 338, BME 338L, BME 351, BME 355L, BME 438, BME 495A, BME 495B, ECE 222, ECE 235, ECE 235L, ECE 355		
Technical Electives [3]		27
TOTAL		126

[1] *Recommended Humanities courses: PHIL 104, PHIL 105*

[2] *Recommended Social Science courses: PSYC 102, ECON 240, ECON 241*

[3] *At least 9 credit hours are from courses in the list: BME 341, BME 356 & BME 356L, BME 417, BME 418, BME 419, BME 431, BME 435, BME 439, BME 448, BME 453, BME 470, BME 485. The remaining credit hours can be from 3xx-level or 4xx-level courses offered by the School of ECBE. At most 9 credit hours can be from 3xx-level or 4xx-level engineering courses offered by other schools in the college.*

B.S. Biomedical Engineering - Pre-Medical Specialization Degree Requirements

Degree Requirements	Credit Hours	
University Core Curriculum Requirements		39
Foundation Skills	13	
CMST 101	3	
ENGL 101, ENGL 102	6	
MATH 150 (3 credits out of 4)	3	
UNIV 101	1	
Disciplinary Studies	23	
Fine Arts	3	
Humanities [1]	6	
Social Science [2]	6	
PHSL 310 (2 credits out of 5 for Human Health)	2	
BIOL 211 (3 credits out of 4)	3	
PHYS 205A	3	
Multicultural/Diversity	3	
Requirements for Biomedical Engineering		87
Basic Science	11	
PHYS 205B	3	
BIOL 211 (1 credit out of 4)	1	
PHSL 310 (3 credits out of 5)	3	
CHEM 200, CHEM 201	4	

Degree Requirements		Credit Hours
Mathematics		11
MATH 150 (1 credit out of 4)	1	
MATH 250, MATH 251, MATH 305	10	
Required Courses		54
BME 101, BME 296, BME 296L, BME 336, BME 337, BME 338, BME 338L, BME 351, BME 355L, BME 438, BME 495A, BME 495B, ECE 222, ECE 235, ECE 235L, ECE 355, CHEM 210, CHEM 211, CHEM 340, CHEM 341, CHEM 350, CHEM 351		
Technical Electives [3]		11
Total		126

[1] *Recommended Humanities courses: PHIL 104, PHIL 105*

[2] *Recommended Social Science courses: PSYC 102, ECON 240, ECON 241*

[3] *At least 9 credit hours are from courses in the list: BME 341, BME 356 & BME 356L, BME 417, BME 418, BME 419, BME 431, BME 435, BME 439, BME 448, BME 453, BME 470, BME 485. The remaining credit hours can be from 300-level or 400-level engineering courses offered by the School of ECBE or other schools in the college.*

Capstone Option for Transfer Students

The SIU Carbondale Capstone Option is available to students who have earned an Associate in Engineering Science (A.E.S.) degree with a minimum cumulative 2.0/4.0 GPA on all accredited coursework prior to the completion of the A.E.S., as calculated by the transfer institution's grading policies. The Capstone Option reduces the University Core Curriculum requirements from 39 to 30 hours, therefore reducing the time to degree completion. Students interested in the Capstone Option should contact the College of Engineering, Computing, Technology, and Mathematics Advisement Office to develop a personal coursework pathway to degree completion.

Pre-Engineering in Biomedical Engineering

The Pre-Engineering program in Biomedical Engineering is designed for students who apply to the Biomedical Engineering program with the potential to be successful, but who do not meet admission requirements for the program. The Pre-Biomedical Engineering advisors will develop an individualized program of study aligned with the curricular guide of Biomedical Engineering program offered in the College with the goal of preparing these students to enter a major in Biomedical Engineering. All students must achieve satisfactory math placement, as determined by the College, before being formally admitted to the Biomedical Engineering program.The advisors will consider math placement when developing the individualized program of study. In addition, pre-engineering students are required to enroll in ENGR 111A, ENGR 111B or ENGR 111C.

Biomedical Engineering Courses

BME101 - Introduction to Biomedical Engineering This course introduces the students to the following topics in biomedical engineering: history of biomedical engineering, bridging the gap between engineering and medical sciences, career outlook, bioethics, anatomy and physiology, biomechanics, bioelectricity, bioinstrumentation, bioinformatics, neuroengineering, tissue engineering, biosensors, biomedical signal and image processing, biophotonics, and physiological modeling. Lecture and laboratory. Restricted to BME majors. Project-based fee: $50. Credit Hours: 3

BME296 - Introduction to Deep Learning, Robotics, and Microcontrollers This course introduces Python programming and microcontroller-based systems using Arduino for robotics and sensor applications. Students will learn Python fundamentals, including data types, control structures, functions, and libraries such as NumPy and OpenCV. The course covers hands-on projects on sensor integration, including temperature, motion, proximity sensors, and ladder logic for programmable logic controllers. Basic deep learning concepts will be introduced through interactive Python modules, allowing students to explore image processing, gesture recognition, and optical character recognition (OCR) in an introductory way. Prerequisite: ECE 222 with a grade of C or better. Credit Hours: 2

BME296L - Introduction to Microcontrollers and Robotics Lab Hands-on application of microcontrollers for developing basic biometric and medical applications and performing data acquisition using various sensors. Application of interpreted programming languages to interact with various hardware. Application of an interpreted programming language and C++ to interact with various hardware. Co-requisite: BME 296. Prerequisite: ECE 222 with a grade of C or better. Lab fee: $25 to help defray cost of software licenses and equipment. Credit Hours: 2

BME336 - Biomechanics Biomechanics through a rigorous mathematical standpoint while emphasizing the biological aspect. Engineering analysis of the human body. Stress, strain, and deformable body mechanics. Mechanical properties of biological tissues. Prerequisites: PHYS 205A and MATH 251 with a grade of C or better. Project fee to defray cost of software license: $45. Credit Hours: 3

BME337 - Bioelectricity Sources of electrical signals in biologic systems, such as nerve, brain and muscle. Bioproperties and electrical properties of membranes and ion channels. Action potentials and Hodgkin-Huxley model. Electrical signal propagation between neurons. Synaptic transmission. Nerve electrical stimulation. Electrocardiography (ECG), Electroencephalography (EEG), Electromyography (EMG) and measurement techniques. Prerequisite: MATH 305 with a grade of C or better. Restricted to BME majors. Credit Hours: 3

BME338 - Biomedical Measurements Fundamental biomedical techniques. Topics include: Fundamentals on wet-lab technique; fundamentals on cell culture techniques; microscopy, electrocardiography; electromyography; pulmonary function, blood pressure, bioelectrodes, bio-electric circuit design; bio-amplifiers and filters; ion channel current recording. Prerequisite: BME 101 with a grade of C or better. Co-requisite: BME 338L. Restricted to BME majors. Credit Hours: 2

BME338L - Biomedical Measurements Lab Fundamental biomedical techniques. Topics include: basic wet-lab techniques; cell culture techniques; microscopy, electrocardiography; electromyography; pulmonary function, blood pressure, bioelectrodes, bio-electric circuit design; bio-amplifiers and filters; ion channel current recording. Prerequisite: BME 101 with a grade of C or better. Co-requisite: BME 338. Restricted to BME majors. Lab fee: $50 to help defray cost of equipment and software licenses. Credit Hours: 2

BME341 - Biomechanics of Human Movement An introductory course to the analysis of human movement through the use of mathematical methods from an engineering viewpoint. Human dynamics, linear kinematics and kinetics, angular kinematics and kinetics, and impulse and momentum. Prerequisites: BME 336, MATH 251, PHYS 205A with grades of C or better. Project fee to defray cost of software license: $45. Credit Hours: 3

BME351 - Probability and Statistical Analysis for Engineers Probability: Axioms of probability, discrete and continuous random variables, probability distributions, moments, correlation and covariance, conditional probabilities and densities, functions of random variables/vectors and their distributions, convergence of a sequence of random variables and limit theorems, and probabilistic models for BME applications. Statistical analysis: Parameter estimators, confidence intervals, hypothesis tests, regression

and curve fitting, Monte Carlo estimation, and statistical analysis for BME applications. Prerequisite: MATH 305 with grade of C or better. Credit Hours: 3

BME355L - BME Signals and Systems Lab Introduction to Matlab programming, operations on biomedical signals, time-domain analysis, impulse response and stability, Fourier series and transform, Laplace transform, applications to biomedical signals, frequency response techniques. Prerequisite: ECE 235 and MATH 305 or concurrent enrollment with grades of C or better. Concurrent enrollment in ECE 355 or ECE 355H required. Restricted to enrollment in BME program. Lab fee: $20 to help defray cost of software licenses and equipment. Credit Hours: 1

BME356 - Physiological Modeling and Control Introduction to signals, linear systems theory, Laplace transform, modeling of dynamic systems and circuits, dynamic response, basic properties of feedback PID control, root-locus design method, and frequency-response design method. Prerequisites: ECE 235, ECE 315, ECE 355, and MATH 250. BME 356L may also be taken concurrently. Credit Hours: 3

BME356L - Physiological Modeling and Control Laboratory Introduction to robotics, dynamics and control of robotic manipulators, path-planning, introduction to haptics, haptic interfaces and their applications, kinesthetic haptic devices. Prerequisite: BME 356. Credit Hours: 1

BME417 - Neuroengineering This course offers a comprehensive introduction to neuroengineering principles and electrophysiology techniques. Topics include foundational neuroengineering concepts, electrophysiology (Ephy) setup, circuitry, and laboratory applications, as well as neuromodulation and neurostimulation strategies. Advanced modules explore deep brain, spinal cord, and dorsal root ganglion stimulation, including high-frequency spinal cord stimulation. Designed for students with foundational knowledge in biology, physics, or engineering. Prerequisites: None. Restrictions: Open to 3rd Year students, 4th Year students and graduate students or with instructor approval. Lab fee: $20 to help defray cost of equipment. Credit Hours: 3

BME418 - Bioelectronics and Biosensors (Same as ECE 442) The sources of electrical signals in biological systems. Methods and types of sensors for sensing bioelectrical signals, including amperometric, potentiometric, piezo-electric, impedance, and FET based biosensors. Interface between biosensors and electronics for sensor signal condition and data acquisition. Precision electronics for biosensor signal acquisition, including potentiostat, current, charge, capacitance and impedance sensing circuit, lock-in amplifier. Prerequisite: BME 337 or ECE 345 with a grade of C or better. Credit Hours: 3. Credit Hours: 3

BME419 - Biomedical Microelectromechanical Systems (Same as ECE 459) The course is designed to introduce students with fundamentals of MEMS and its applications. The emphasis will be on physical principle in sensors and corresponding fabrication techniques, with supplemental discussion of the state-of-art applications in industry and research. Students will learn to analyze and design systems by solving regular homework problems and active participation during lectures and in-class examples. Topics: Introduction of MEMS, fundamentals of microfabrication and nanofabrication, fundamentals of physics in sensors, a case study of electrostatic sensing, microfluidics and biomedical applications, projects. Prerequisites: MATH 251, PHYS 205A, PHYS 205B, BME 336 each with a grade of C or better. Project-based fee: $50 to help defray cost of software licenses and equipment. Credit Hours: 3

BME431 - Biomedical Optics (Same as ECE 451) Fundamental theories of light, including the wave theory of light and the particle theory of light; Fundamental interactions between light and matter, including reflection, refraction, absorption, scattering, fluorescence, and polarization; Biology of cells and tissues; Tissue optical properties; Tissue-targeted contrast agents; Coherence and interference; Light transport in turbid media; Diagnostic applications of light, including microscopy, spectroscopy, fluorescence imaging, fluorescence-lifetime imaging, optical coherence tomography, diffuse optical tomography, and/or biosensors; Therapeutic applications of light, including photodynamic therapy, photothermal therapy, and/or laser ablation. Prerequisites: ECE 355, MATH 251, and PHYS 205B with a grade of C or better. Credit Hours: 3. Credit Hours: 3

BME435 - Computational Methods in Biomedical Engineering Algorithmic, statistical, and data mining concepts in biomedical engineering and bioinformatics. Programming in R: Vectors, Matrices, Lists, Data Frames, Factors, Tables. Classification techniques. ROC curves. Biomarker gene selection. DNA and

protein sequence analysis, sequence alignment. Prerequisite: BME 351 or equivalent with a grade of C or better. Credit Hours: 3. Credit Hours: 3

BME438 - Medical Instrumentation: Application and Design (Same as ECE 438) This course introduces BME undergraduate students to the field of medical instrumentation. Medical instrumentation is the application of advanced engineering technology to problems in biology and medicine. The course focuses on fundamentals of instrumentation systems, sensors, amplifiers, and signal precondition. In addition, the course also includes design and applications of medical instrumentation, biopotential measurement, biomedical signal processing, and other related topics. Prerequisite: MATH 305 and ECE 355 with a grade of C or better, or consent of instructor. Restricted to enrollment in BME programs. Project-based fee: $45 to help defray cost of software licenses and equipment. Credit Hours: 3

BME439 - Diagnostic Ultrasound Diagnostic ultrasound is an ultrasound-based medical imaging technique used to visualize muscles, tissue, and many internal organs, to capture their size, structure and any pathological lesions. This course is an introduction to the principles and applications of biomedical ultrasound. This course will focus on fundamentals of acoustic theory, principles of ultrasonic detection and imaging, design and use of currently available tools for performance evaluation of diagnostic devices, and biological effects of ultrasound. Prerequisite: MATH 305 and ECE 355 with a grade of C or consent of instructor. Restricted to enrollment in BME programs. Project-based fee: $30 to help defray cost of software licenses and equipment. Credit Hours: 3

BME441 - Cellular and Tissue Engineering This course offers an introduction to cell and tissue engineering, focusing on the integration of cell biology, molecular biology, and material science in the development of innovative tissue-engineered therapies. Topics include molecular biology, transport phenomena, stem cell engineering, tissue engineering, artificial organs, and the design of drug delivery systems and devices. Prerequisite: BME 338 with a grade of C or better. Lab fee: $50 to help defray cost of software licenses and equipment. Credit Hours: 3

BME444 - Introduction to Computer Vision (Same as ECE 444) Introduction to computer vision, computer vision applications, image fundamentals and image formation, image filtering, deep learning for computer vision, computer recognition and detection, 3D computer vision, motion and video. Prerequisite: ECE 315 and ECE 355 with a minimum grade of C- or consent of instructor. Credit Hours: 3

BME448 - Optical Imaging and Photonics (Same as ECE 448) Geometrical optics, including refraction and reflection; Physical optics, including interference, diffraction, and polarization; Optical aberrations, including causes and effects; Fourier optics, with applications to imaging; Light sources, including LEDs and lasers; Photodetectors, including photodiodes and image sensors; Lens systems; Microscopes. Prerequisites: ECE 355, MATH 251, and PHYS 205B with a grade of C or better. Lab fee: $125 to help defray the cost of equipment, supplies, and software packages. Credit Hours: 4

BME453 - Image Sensors (Same as ECE 453) Fundamentals of semiconductor physics, including the use of doping and biasing to control electronic potentials in devices; Fundamentals of integrated circuits, including the design and fabrication of diodes, transistors, and interconnects; Fundamental interactions between light and matter, including reflection, refraction, and absorption; Structure and operating modes of photodiodes; Architectures and operating principles for charge coupled device (CCD) image sensors and complementary metal-oxide-semiconductor (CMOS) image sensors; Performance metrics for image sensors, including the noise floor, the full-well capacity, the quantum efficiency, and fixed pattern noise; Construction of color image sensors; Signal processing for image sensors, including color interpolation and color correction. Prerequisite: ECE 355 and PHYS 205B with a grade of C or better. Credit Hours: 3

BME458 - Digital Image Processing I (Same as ECE 458) Basic concepts, scope and examples of digital image processing, digital image fundamentals, image sampling and quantization, an image model, relationship between pixels, enhancement in the spatial domain, enhancement in the frequency domain, image segmentation, basics of color image processing. Prerequisite: ECE 355 with a grade of C- or consent of instructor. Project-based fee: $30 to help defray cost of software licenses and equipment. Credit Hours: 3

BME458A - Magnetic Resonance Imaging This course provides a comprehensive overview of Magnetic Resonance Imaging (MRI), covering fundamental principles, technology, and clinical applications. Students will explore MRI physics, pulse sequence design, hardware components, safety protocols, and imaging techniques. At the undergraduate level, the topics Emerging Technologies in MRI and

Quantitative MRI will only be tested in assignments and will not be part of the final exam. Prerequisite: ECE 355 with a grade of C or better. Credit Hours: 3

BME467 - Introduction to Biomedical Imaging (Same as ECE 467) Principles associated with x-ray imaging, computed tomography, ultrasound, magnetic resonance imaging, and optical imaging. Image quality. Image reconstruction. Prerequisite: MATH 305 and ECE 355 with a grade of C- or better, or consent of instructor. Project-based fee: $30 to help defray cost of equipment. Credit Hours: 3. Credit Hours: 3

BME470 - Fundamentals of Neural Networks in Data Science (Same as ECE 470) Anatomy and physiology of the cerebral cortex, Feed-forward Networks, Multilayer Perceptrons, Recurrent Networks, Hopfield Networks, Selforganizing Networks, Convolutional Neural Network, Applications to pattern recognition, robotics, image processing, and speech processing. Prerequisite: MATH 305 or ECE 315 or BME 351 with a C or better or consent of instructor. Credit Hours: 3. Credit Hours: 3

BME481 - Design and Implementation of a Vision System (Same as ME 481) This course provides an introduction to a vision system and instrumentation with engineering applications including optical microscopy. A vision system is an essential tool in most of the application, and optical microscopy is a powerful scientific tool to study microscale worlds. Topics covered in basic geometrical optics, Optoelectronic devices, basic electronics for illumination system, optical microscopy, actuators in the microscope, fundamentals of fluorescence microscopy, and advanced imaging techniques. Prerequisite: ENGR 296 or ME 222 with a grade of C or better or consent of instructor. Credit Hours: 3

BME485 - Cellular and Molecular Biomechanics (Same as ME 485) Mechanics of living cells at the micron/nanoscale level. Molecular forces, bond dynamics, force-induced protein conformational changes. Structural basis of living cells, contractile forces, mechanics of biomembranes, nucleus, cytoskeletal filaments- actin, microtubule, intermediate filaments. Active and passive rheology, microrheological properties of cytoskeleton. Active cellular processes such as cell adhesion, cell spreading, control of cell shape, and cell migration. Discussion on experimental techniques including single-molecule approaches to understanding key cellular processes. Discussion of theoretical models that predict cellular processes and limitations. Introduction to mechanobiology. Restricted to 4th Year students or graduate standing. Credit Hours: 3

BME495A - Biomedical Engineering Capstone Design I Capstone Design part 1. Preparation for professional biomedical engineering practice with a major design experience based on earlier coursework, incorporating appropriate engineering standards and multiple constraints. Includes aspects of project development and design within a team such as communicating, establishing goals, planning tasks, meeting deadlines, analyzing risk, and fulfilling responsibilities professionally and ethically. Not for graduate credit. Prerequisites: BME 101, BME 296, BME 336, BME 337, BME 338 with grades of C or better. Restricted to 4th Year standing in Biomedical Engineering. Lab fee: $50 to defray cost of lab equipment/software licenses, materials and equipment needed for performing the 4th Year design project. Credit Hours: 3

BME495B - Biomedical Engineering Capstone Design II Capstone Design part 2. Continuation of a major design experience based on earlier coursework, incorporating appropriate engineering standards and multiple constraints. Team approach in engineering projects. Work plan/time scheduling. Design options & cost-benefit analysis. Development of the final decision. Team coordination & documentation of team member efforts, design stages, team communication and team decision making processes. Implementation of the design (if the project warrants). Evaluation of the final product. Written, oral, and poster presentation of final design. Not for graduate credit. Prerequisite: BME 495A or ECE 495C or ECE 495E with a C or better. Lab fee: $50 to defray cost of lab equipment/software licenses, materials and equipment needed for performing the 4th Year design project. Credit Hours: 3

Biomedical Engineering Faculty

Electrical and Computer Engineering (ECE) Faculty

Chen, Ying (Ada), Associate Professor, Ph.D., Duke, 2007; 2007. Biomedical imaging, image reconstruction, digital tomosynthesis, image quality analysis, signal and image processing, simulation and computing.

Chilman, Bae, Assistant Professor, Ph.D., Pennsylvania State University, 2009; 2019. Bioelectrical engineering, neuroscience, mechanobiology.

Kagaris, Dimitrios, Professor, Ph.D., Dartmouth College, 1994; 1995. VLSI design automation, digital circuit testing, communications networks, biostatistics, bioinformatics.

Komaee, Arash, Associate Professor, Ph.D., University of Maryland, College Park, 2008, 2015. Applications of control in biomedical engineering.

Li, Hui, Assistant Professor, Ph.D., Pennsylvania State University, 2019; 2022. Biomedical devices, advanced manufacturing, surface engineering, drug screening, precise diagnostics, and personalized medicine.

Lu, Chao, Associate Professor, Ph.D., Purdue University, 2012; 2015. Bioelectricity, bioelectronics.

Qin, Jun, Associate Professor, Ph.D. Duke University, 2008; 2012. Device development, instrumentation and sensors, medical data acquisition and analysis, medical acoustics, therapeutic ultrasound, haptics.

Sayeh, Mohammad R., Professor, Ph.D., Oklahoma State University, 1985; 1986. Biophotonics.

Wang, Haibo, Professor and Director, University of Arizona, 2002; 2002. Bioelectronics, biosensors.

Mechanical, Aerospace, and Materials Engineering (MAME) Faculty

Chowdhury, Farhan, Associate Professor, Ph.D., University of Illinois at Urbana-Champaign, 2011; 2015. Mechanobiology, single-molecule cell mechanics, biomaterials.

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