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Biomedical Engineering

Academic Objectives

The program, consistent with the mission and priorities of the University, is designed to achieve the following academic objectives:

- To provide high quality education in the field of biomedical engineering and to prepare the graduates for successful and rewarding employment as engineers or for continuing their education through the doctoral level.
- To provide the students with the training necessary to successfully apply the fundamental concepts and methods of biomedical engineering to selected areas of employment or research and development.
- To enhance the research environment and productivity of the School for the benefit of the students.

Master of Engineering (M.E.) in Biomedical Engineering

Admission

Individuals holding a Bachelor's degree or equivalent in engineering, science, or related field may apply. Qualified applicants with Bachelor's degree in other areas may be able to enroll in the program with additional preparation (approved by the program Director on a case-by-case basis).

Admission to the M.E. in Biomedical Engineering program is based on the following factors: grade point average of 2.75 or higher on a scale of 4.0 on approximately the last 60 credit hours of undergraduate coursework, class ranking, and faculty recommendation letters.

GRE scores are not required for admission. However, out-of-state or international students whose GRE Verbal score or Quantitative score percentile is 80% or higher will have the advantage of paying in-state graduate tuition rate. Also, GRE scores, especially Quantitative, may be considered for fellowships, assistantships, or scholarships. The minimum TOEFL score requirement for international applicants is 550 (paper based) or 80 (computer based). The application fee for all applicants, and any other documentation specifically required for international students will be in accordance to the requirements of the Graduate School.

Curriculum

The Master of Engineering (M.E.) in Biomedical Engineering program requires the completion of 30 hours of graduate level credit. It does not require a thesis. At least 6 courses must be selected from the core BME courses. ECE 592 and ECE 580 (seminar) will not count towards the degree. The remaining courses can be selected from the ECE 500-level courses. A maximum of 6 credit hours from academic units outside the School of ECBE can be applied towards the degree. Online/distance education credit hours offered by the University can be applied towards the degree. The degree can be completed in 3 semesters.

Biomedical Engineering Core

BME 417: Neuroengineering (3 CH)

BME 418: Biomedical Electronics and Biosensors (3 CH)
BME 435: Computational Methods in Biomedical Engineering (3 CH)
BME 485: Cellular and Molecular Biomechanics (3 CH)
BME 521: Neuromodulation (3 CH)
BME 531: Biophotonics (3 CH)
BME 532: Introduction to Biomedical Imaging (3 CH)
BME 536: Biomedical Signal Analysis (3 CH)
BME 538: Medical Instrumentation: Application and Design (3 CH)
BME 539: Biomechanics I (3 CH)
BME 541: Diagnostic Ultrasound (3 CH)
BME 592: Biomedical Capstone Design (1-3 CH) (thesis option only; requires approval from the unit)

Retention

Any student whose cumulative grade point average falls below 3.0 on courses that count towards the degree will be placed on academic probation. Any graduate student on academic probation whose grade point average remains below 3.0 on courses that count towards the degree for two consecutive semesters in which she or he is enrolled, excluding summer sessions, will be permanently suspended from the program, unless the School grants an exception.

Master of Science (M.S.) in Biomedical Engineering

Admission Requirements

Individuals holding a Bachelor's degree or equivalent in engineering, science, or related field may apply. Qualified applicants with Bachelor's degree in other areas may be able to enroll in the program with additional preparation (approved by the Director on a case-by-case basis).

Admission to the M.S. in Biomedical Engineering program is based on the following factors: grade point average of 3.0 or higher on a scale of 4.0 on approximately the last 60 credit hours of undergraduate coursework, class ranking, and faculty recommendation letters.

GRE scores are not required for admission. However, out-of-state or international students whose GRE Verbal score or Quantitative score percentile is 80% or higher will have the advantage of paying in-state graduate tuition rate. Also, GRE scores, especially Quantitative, may be considered for fellowships, assistantships, or scholarships. The minimum TOEFL score requirement for international applicants is 550 (paper based) or 80 (computer based). The application fee for all applicants, and any other documentation specifically required for international students will be in accordance to the requirements of the Graduate School.

Curriculum

The Master of Science (M.S.) in Biomedical Engineering program has two tracks: i) The non-thesis track is coursework-oriented; ii) The thesis track is research oriented and is designed for students who want to pursue research or a Ph.D. degree. The degree (non-thesis/thesis) can be completed in 3-4 semesters.

Non-thesis option: total of 30 hours of graduate level credit. At least 6 courses must be selected from the core BME courses. ECE 592 and ECE 580 (seminar) will not count towards the degree. The remaining courses can be selected from the ECE 500-level courses.

Thesis option: total of 30 hours of graduate level credit. At least 6 courses must be selected from the BME courses in the core. Six credit hours of thesis (BME 599) are required. ECE 580 (seminar) will not count towards the degree.

For both non-thesis and thesis tracks, with the approval of the school, a maximum of 3 online/distance education credit hours offered by the School of ECBE, and a maximum of 6 credit hours from academic units outside the school may be applied towards the degree.

Biomedical Engineering Core

BME 417: Neuroengineering (3 CH)

BME 418: Biomedical Electronics and Biosensors (3 CH)
BME 435: Computational Methods in Biomedical Engineering (3 CH)
BME 485: Cellular and Molecular Biomechanics (3 CH)
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BME 539: Biomechanics I (3 CH)
BME 541: Diagnostic Ultrasound (3 CH)
BME 592: Biomedical Capstone Design (1-3 CH) (thesis option only; requires approval from the unit)

Retention

Any student whose cumulative grade point average falls below 3.0 on courses that count towards the degree will be placed on academic probation. Any graduate student on academic probation whose grade point average remains below 3.0 on courses that count towards the degree for two consecutive semesters in which she or he is enrolled, excluding summer sessions, will be permanently suspended from the program, unless the School grants an exception.

Biomedical Engineering Courses

BME417 - Neuroengineering 417-3 Neuroengineering. Applying engineering techniques to study brain function. Topics include: cerebral cortex; sensory, motor, and association areas; neurons and glial cells; pathways and synapses; information processing in visual, auditory, and somatosensory cortices; analyses of brain recordings; brain-computer interfacing, multisensory integration models; context effect models; memory encoding and retrieval models. Restricted to Senior or Graduate Standing.

BME418 - Bioelectronics & Biosensors 418-3 Bioelectronics and Biosensors. 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. Microfluidics and Photometric 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 with a C or better or Graduate standing.

BME435 - Computation Methods BME 435-3 Computational Methods in Biomedical Engineering. Algorithmic and statistical foundations of biomedical engineering and bioinformatics. Maps, sequences, and genomes. Protein sequence analysis, sequence alignment, microarray data, gene expression analysis, gene selection. Bioinformatics programming in R. Prerequisite: ECE 222 with a grade of C or better.

BME481 - Design/Implement Vision System 481-3 Design and Implementation of 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. Prerequisites: ENGR 296 or ME 222 or consent of instructor.

BME485 - Cell & Molecular Biomechanics 485-3 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 senior or graduate standing.

BME501 - Statistics for Biomed Engrs 501-3 Statistics for Biomedical Engineers. Theoretical introduction to the basic principles of statistical modeling and estimation focusing on biomedical engineering applications such as genetics and genetic-related disorders. Prerequisite: PHSL 410A or consent of instructor.

BME521 - Neuromodulation 521-3 Neuromodulation. Principles and practice of neuromodulation. Topics include: introduction to electrophysiology; cellular and neuronal patch-clamp techniques; spinal cord stimulation; deep brain stimulation; neuromodulation for pain. Restricted to Graduate standing.

BME531 - Biophotonics 531-3 Biophotonics. Fundamental principles of optics and photonics, biology, and medicine; imaging, spectroscopy, and optical biosensors. This course is designed for graduate students as well as senior-level undergraduate students in related disciplines who are interested in the interdisciplinary field of biophotonics. This course provides the fundamentals of light and its interaction with matter, optical imaging, lasers, and tissue optical properties. This course also provides the diagnostic applications of biophotonics, which includes biomedical imaging, microscopy techniques, and optical biosensors. Prerequisites: ECE 375, PHYS 320 or 328, with grades of C or better, or consent of instructor.

BME532 - Intro to Biomedical Imaging 532-3 Introduction to Biomedical Imaging. (Same as ECE 467 and ECE 567) Biomedical imaging. X-ray imaging. Computed tomography (CT). Ultrasound. Magnetic resonance imaging (MRI). Image quality. Image reconstruction. Prerequisite: MATH 305 with a grade of C or better or consent of instructor. Lab fee: \$30 to help defray cost of software licenses and equipment.

BME533 - Speech Processing 533-3 Speech Processing. (Same as ECE 474, ECE 533) Fundamentals of speech production system, signal analysis of speech, speech coding, linear prediction analysis, speech synthesizing, and speech recognition algorithms. Prerequisite: MATH 250, ECE 355 with grades of C or better, or consent of instructor.

BME534 - Bio Sensors & Measurements 534-3 Biomedical Sensors & Measurements. Design and evaluation of sensors with application in biomedical engineering. Instrumentation and Techniques for measurements related to biomedical applications. Prerequisite: PHSL 410A, CHEM 444, or consent of instructor.

BME535 - Info Process Biomedical Engr 535-3 Information Processing in Biomedical Engineering. Methods for evaluating different approaches in signal processing systems for biomedical applications; provides familiarity with the variety of exciting software and hardware systems. Prerequisite: PHSL 410A, CHEM 444, or consent of instructor.

BME536 - Biomedical Signal Analysis 536-3 Biomedical Signal Analysis. (Same as ECE 498, ECE 534) The nature of biomedical signals. Electricity in living tissue. Biomedical signal processing and modeling. Modeling and simulation of biomedical systems. Prerequisite: MATH 250, ECE 355, with grades of C or better, or consent of instructor. Project-based fee: \$20 to help defray cost of software licenses.

BME537 - Emb Micro System Design 537-3 Embedded Microprocessor System Design. Design, analysis, and evaluation of microprocessor-based systems for biomedical implementation. Prerequisite: ECE 424 or consent of instructor.

BME538 - Medical Instrumentation 538-3 Medical Instrumentation: Application and Design. (Same as ECE 438 and ECE 538) This course introduces the students to the field of medical instrumentation. Medical instrumentation is the application of advanced engineering technology to problems in biology and medicine. The course will focus on fundamentals of instrumentation systems, sensors, amplifiers, and signal precondition. In addition, the course also includes design and applications of medical instrumentation, biopotential measurement, biosensor, biomedical signal processing, and other related topics. Prerequisite: MATH 305 with a grade of C or better, or consent of instructor. Lab fee: \$45 to help defray cost of software licenses and equipment.

BME539 - Biomechanics I 539-3 Biomechanics I. Introduction to mechanical behavior of biological tissues and systems, influence of material properties on the structure and function of organisms, methods for the analysis of both rigid body and deformational mechanics with application to include biological tissues such as bone, muscle, and connective tissues. Prerequisite: ME 470 or consent of instructor.

BME540 - Tissue Engineering 540-3 Tissue Engineering. (Same as ME 540) Fundamentals of tissue engineering will be discussed. Developing biomaterials for artificial scaffolds and cell populations within the scaffolds will be discussed. Stem cells for cell-based therapy will be highlighted. Design of various organ-on-chips will be covered. Other topics include recent advances in 3D bioprinting for organ engineering/regenerative medicine. Advances in in-vitro tumor models will be discussed. Ethical considerations will be emphasized.

BME541 - Diagnostic Ultrasound 541-3 Diagnostic Ultrasound. (Same as ECE 494 and ECE 539) Diagnostic ultrasound is an ultrasound-based biomedical 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 250 with a grade of C or consent of instructor. Project-based fee: \$30 to help defray cost of software licenses and equipment.

BME542 - Biomaterials 542-3 Biomaterials. This course addresses the bulk and surface properties of biomaterials used for medical applications. Artificial Organs and Tissues and Tissue Engineering are included. Analytical techniques pertinent to biomaterial evaluation, and testing. Prerequisite: ME 410 or consent of instructor.

BME577 - Bioprocess Engineering 577-3 Bioprocess Engineering. (Same as ME 577) The course objective is to introduce bioprocessing concepts to ME and BME students. This will introduce the idea of designing a system to achieve a biological reaction objective. It will have content in pharmaceutical production, production of enzymes and other bioproducts, research involving cell culture reactors, pharmacokinetics and other bioprocessing. Special approval needed from the instructor.

BME592 - Biomedical Capstone Design 592-3 to 6 Biomedical Capstone Design. Individual advanced project, with heavy emphasis on design, selected by the student and approved by his advisor. The project must be strongly related to biomedical engineering. This project normally will be equivalent to three credit hours. However with the approval of the BME program coordinator, the project could be equivalent to a maximum of six credit hours. Special approval needed from the instructor.

BME593C - Adv Topics BME Biotech 593C-1 to 3 Advanced Topics in Biomedical Engineering - Biotechnology. This course covers advanced scientific and engineering topics behind a rapidly evolving, multi-disciplinary biotechnology. Special approval needed from the instructor.

BME593H - Adv Topics BME Bioelectronics 593H-1 to 3 Advanced Topics in Biomedical Engineering - Bioelectronics. Lectures on advanced topics of special interest to students in various areas of bioelectronics. This course is designed to offer and test new experimental courses in biomedical engineering. Special approval needed from the instructor.

BME593K - Adv Topics BME Control Apps 593K-1 to 3 Advanced Topics in Biomedical Engineering - Control Applications. Lectures on advanced topics of special interest to students in various areas of control applications in biomedical engineering. This course is designed to offer and test new experimental courses in biomedical engineering. Special approval needed from the instructor.

BME596 - Principles of Biomedical Engr 596-3 Principles of Biomedical Engineering. (Same as ECE 460, ECE 596) Principles of biomechanics, biomaterials, electrophysiology, modeling, instrumentation, biosignal processing, medical imaging, and biomedical optics. Professional moral and ethical issues in biomedical research and development. Prerequisite: MATH 250 with a C or better or consent of instructor.

BME599 - Thesis 599-1 to 6 Thesis. Students are eligible to register for thesis when they have approval of the instructor who will act as thesis advisor. Prerequisite: Consent of thesis advisor.

BME601 - Continuing Enrollment 601-1 Continuing Enrollment. For those graduate students who have not finished their degree programs and who are in the process of their thesis or capstone design course. The student must have completed all other course requirements to be eligible to register in this course. Concurrent enrollment in any other course is not permitted. Graded S/U or DEF only. Prerequisites: Completion of course work except BME 592 or 599.

Biomedical Engineering Faculty

Electrical, Computer, and Biomedical Engineering Faculty:

Ahmed, Shaikh S., Professor, Ph.D., Arizona, 2005; 2007. Nanotechnology, semiconductor devices and circuit design, simulation and characterization.

Anagnostopoulos, Iraklis, Assistant Professor, Ph.D., National Technical University of Athens, 2014; 2015. Many-core architectures, run-time resource management, embedded systems.

Aruma Baduge, Gayan, Assistant Professor, University of Alberta, 2013; 2016. Communications theory, wireless communications, massive MIMO systems, millimeter-wave communications, cooperative relay networks, wireless energy harvesting for IoTs, physical-layer security.

Asrari, Arash, Assistant Professor, Ph.D., University of Central Florida, 2015; 2017. Power systems operation and planning, power systems optimization, smart grid.

Chen, Kang, Assistant Professor, Ph.D., Clemson University, 2014; 2015. Software-defined networking (SDN), network function virtualization (NFV), vehicular networks, mobile opportunistic/ad hoc networks.

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.

Haniotakis, Themistoklis, Associate Professor, Ph.D., University of Athens, 2008; 2013. Digital VLSI design and test, RF IC design and test, low power VLSI design, and fault-tolerant systems.

Harackiewicz, Frances J., Professor, Ph.D., University of Massachusetts-Amherst, 1990; 1989. Electromagnetics, antenna theory and design, microwaves, microstrip phased arrays and anisotropic materials.

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

Komae, Arash, Assistant Professor, Ph.D., University of Maryland, College Park, 2008; 2015. Control systems, microrobotics, signal processing, estimation theory.

Lu, Chao, Associate Professor, Ph.D., Purdue University, 2012; 2015. VLSI system design, device-circuit co-design, 3D IC.

Qin, Jun, Associate Professor, Ph.D. Duke University, 2008; 2012. Sensors and instrumentation, data acquisition, medical devices, therapeutic ultrasound, haptics.

Sayeh, Mohammad R., Professor, Ph.D., Oklahoma State University, 1985; 1986. Neural networks, optical computing, image processing, stochastic modeling, quantum electronics.

Tragoudas, Spyros, Professor and Director, Ph.D., University of Texas at Dallas, 1991; 1999. Design and test automation for VLSI, embedded systems, computer networks.

Wang, Haibo, Professor, Ph.D., University of Arizona, 2002; 2002. Mixed-signal VLSI design and testing, digital VLSI, VLSI design automation.

Weng, Ning, Professor, Ph.D., University of Massachusetts at Amherst, 2005; 2005. High performance routers, network processors, system-on-a-Chip, computer architectures.

Mechanical Engineering and Energy Processes (MEEP) Faculty:

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

Emeriti Faculty

Botros, Nazeih M., Professor, Emeritus, Ph.D., University of Oklahoma, 1985; 1985.

Daneshdoost, Morteza, Professor, Emeritus, Ph.D., Drexel University, 1984; 1984.

Galanos, Glafkos D., Professor, Emeritus, Ph.D., University of Manchester, England, 1970; 1987.

Gupta, Lalit, Professor, Emeritus, Ph.D., Southern Methodist University, 1986; 1986

Hatziadoniu, Konstantine, Professor, Emeritus, Ph.D., West Virginia University, 1987; 1987.

Osborne, William, Professor, Emeritus, Ph. D., New Mexico State University, 1970; 2005.

Pourboghrat, Farzad, Professor, Emeritus, Ph.D., University of Iowa, 1984; 1984.

Viswanathan, Ramanarayanan, Professor, Emeritus, Ph.D., Southern Methodist University, 1983; 1983.

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Catalog Year Statement:

Students starting their collegiate training during the period of time covered by this catalog (see bottom of this page) are subject to the curricular requirements as specified herein. The requirements herein will extend for a seven calendar-year period from the date of entry for baccalaureate programs and three years for associate programs. Should the University change the course requirements contained herein subsequently, students are assured that necessary adjustments will be made so that no additional time is required of them.