**BIOMEDICAL ENGINEERING**

**Dept. Code:** BME

**Degree Programs**
The Department of Biomedical Engineering offers graduate programs leading to the degrees of Master of Science (thesis or non-thesis option) and Doctor of Philosophy in Biomedical Engineering. A 5-year BS/MS option is available for qualified undergraduate students enrolled within the Department.

**Areas of Research**
The areas of research in Biomedical Engineering include:

1. Biomedical instrumentation and devices
2. Medical imaging
3. Diagnostic and therapeutic systems
4. Biomedical signal and image processing
5. Rehabilitation and neural engineering
6. Brain-computer interface
7. Biomedical optics and lasers
8. Medical physics
9. Biomechanics, biofluid dynamics, hemodynamics
10. Biomaterials, tissue and cellular engineering
11. Stem cell research
12. Lab-on-a-chip devices

**Admission Requirements**
1. The Department of Biomedical Engineering uses the same general graduate admission requirements as the College of Engineering.
2. Students who hold a Bachelor's degree in a field other than engineering may be admitted to the graduate program and to candidacy upon completion of appropriate undergraduate courses, in addition to the regular requirements for the graduate degree.

**Masters**

**Masters Programs in Biomedical Engineering**
- M.S. in Biomedical Engineering (http://bulletin.miami.edu/graduate-academic-programs/engineering/biomedical-engineering/biomedical-engineering-ms)
- B.S./M.S. Five-Year Program in Biomedical Engineering (http://bulletin.miami.edu/graduate-academic-programs/engineering/biomedical-engineering/five-year-program-biomedical-engineering-bs-ms)

**Doctoral**

**Doctoral Program in Biomedical Engineering**
- Ph.D. in Biomedical Engineering (http://bulletin.miami.edu/graduate-academic-programs/engineering/biomedical-engineering/biomedical-engineering-phd)

**Courses**

**BME 601. Unified Medical Sciences I.** 3 Credit Hours.
Treatment of the basic biological and medical elements in physiological systems. The anatomy, physiology, biophysics, biochemistry and certain aspects of clinical medicine are unified with an emphasis on cellular and subcellular systems. Not open to BME undergraduates.
**Components:** LEC.
**Grading:** GRD.
**Typically Offered:** Fall.

**BME 602. Unified Medical Sciences II.** 3 Credit Hours.
Treatment of the basic biological and medical elements in physiological systems. The anatomy, physiology, biophysics, biochemistry, and certain aspects of clinical medicine are unified with an emphasis on cardiovascular, renal, digestive, endocrine, and reproductive systems. Not open to BME undergraduates.
**Components:** LEC.
**Grading:** GRD.
**Typically Offered:** Fall.

**BME 603. Unified Medical Science III.** 3 Credit Hours.
Treatment of the basic biological and medical elements in physiological systems. The anatomy, physiology, biophysics, biochemistry, and certain aspects of clinical medicine are unified with an emphasis on neural, sensory, and muscular systems. Not open to BME undergraduates.
**Components:** LEC.
**Grading:** GRD.
**Typically Offered:** Spring.

**BME 606. Computer Aided Design in Biomedical Engineering.** 1 Credit Hour.
Laboratory course for computer based two and three-dimensional drawing and design based on ProEngineer. Parametric design, parts, features, assemblies for complex modeling. Applications in biomedical engineering design.
**Components:** LAB.
**Grading:** GRD.
**Typically Offered:** Spring.

**BME 607. LabView Applications for Biomedical Engineering.** 1 Credit Hour.
Laboratory course for computer based instrumentation and design based on Labview. Virtual instrumentation, data acquisition and display, GPIB instrument control, biomedical applications in biosignal recording, and monitoring are discussed.
**Components:** LAB.
**Grading:** GRD.
**Typically Offered:** Spring.

**BME 610. Introduction to Medical Robotics.** 3 Credit Hours.
This course will discuss the basic principles of robotics and focus on its medical applications. The course integrates previously learned math, programming and imaging knowledge into an application platform to enable students to understand fundamentals of robotics methods in biology and medicine and to train students to build a robotics prototype through hands-on projects.
**Components:** LEC.
**Grading:** GRD.
**Typically Offered:** Offered by Announcement Only.
BME 612. Regulatory Control of Biomedical Devices. 3 Credit Hours.
Regulatory agencies and requirements, Food and Drug Administration, 510(k) and premarket approval (PMA), international regulatory requirements, ISO 9000 series, CE, UL, product and process validation, quality engineering, quality improvement programs, rapid prototyping, packaging and sterilization, and project management are discussed.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

BME 620. Medical Imaging System. 3 Credit Hours.
Engineering and scientific principles of medical imaging systems. The concepts of instrumentation and diagnostic applications of different techniques and systems are presented. Demonstrations or exhibitions of medical systems are given in the visits to clinical and research laboratories. Topics include digital image and image processing fundamentals, radiographic (X-ray, CT), magnetic resonance (MRI) and radio-isotopic (PET) systems, and associated image reconstruction techniques. Basic concepts and simulation of imaging systems are emphasized.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

BME 621. Medical Imaging Applications. 3 Credit Hours.
Medical applications of imaging systems and image processing techniques. Topics include image fundamentals (resolution, format, and storage), image processing fundamentals (transformation, compression, enhancement, segmentation, registration, and reconstruction), and image analysis fundamentals (calibration, quantification, correlation, linearity and depiction). Course includes dedicated computer laboratory projects and demonstrations given in clinical and research laboratories at the medical campus. Corequisite: BME 570 or equivalent.
Components: LEC.
Grading: GRD.

BME 622. Scanning Electron Microscopy in Biomedical Devices. 3 Credit Hours.
Physics and operating principles of scanning electron microscope (SEM), transmission electron microscope (TEM), and optical light microscope. Biological tissue preparation, storage, fixation and digital image storage. Each student will learn to use the SEM in the design and/or analysis of a biomedical device.
Components: LAB.
Grading: GRD.
Typically Offered: Spring.

BME 625. Special Problems. 1-3 Credit Hours.
Research and/or design projects consisting of an individual investigation of current problems. Offered by special arrangement only.
Components: THI.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.

BME 626. Special Problems. 1-3 Credit Hours.
Research and/or design projects consisting of an individual investigation of current problems. Offered by special arrangement only.
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

BME 631. Technical Entrepreneurship I. 1 Credit Hour.
The first half of a two-semester sequence that simulates the work of a product development team to gain experience in technical entrepreneurship. The students propose product ideas, assess those collectively, select a few, form teams, define the product, and perform market analysis. The course is concluded with a business and technical development plan for the team's project. Lectures are presented on a variety of entrepreneurial topics.
Components: LEC.
Grading: GRD.

BME 632. Technical Entrepreneurship II. 2 Credit Hours.
The second half of a two-semester sequence that simulates the work of a product development team to gain experience in technical entrepreneurship. The students complete the development of a working prototype and refine their marketing and business plan based on experience gained during the development phase. Lectures are presented on relevant entrepreneurial topics.
Components: LEC.
Grading: GRD.

BME 635. Advanced Biomaterials. 3 Credit Hours.
Applications of biomaterials in different tissue and organ systems. Relationships between physical and chemical structure of materials and biological system response are discussed as well as choosing, fabricating, and modifying materials for specific biomedical applications.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 640. Microcomputer-Based Medical Instrumentation. 3 Credit Hours.
Principles and design of microcomputer-based biomedical instruments, analog and digital signal conversion, microcomputer hardware and software design, algorithm development for medical applications, medical signal processing with microcomputers, software safety in life support systems, and current applications are discussed.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 641. Medical Electronic Systems Laboratory. 2 Credit Hours.
Components: LAB.
Grading: GRD.

BME 645. Biomedical Optical Instruments. 3 Credit Hours.
Introduction to geometrical optics, light sources, detectors, and fiber optics with an emphasis on engineering aspects and medical applications. Fiber-optic delivery systems for medical applications, optics of the eye and visual instruments, and optical instruments used in medicine (microscopes, endoscopes, ophthalmic instruments) are discussed. Hands-on sessions in the laboratory are included.
Components: LEC.
Grading: GRD.
BME 646. Medical Applications of Lasers. 3 Credit Hours.
Review of geometrical optics, fiber optics, wave optics, laser physics, and technology. Medical laser systems, optical properties of tissue, light propagation in tissue, laser-tissue interactions, and surgical applications of lasers are also covered. Hands-on sessions in the laboratory are included.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

BME 655. Fundamentals of Computational Neuroscience. 3 Credit Hours.
Major concepts include neural signaling and communication from the single neuron to system of neural ensembles and the role of neural computation in engineering applications. Theory and principles of information processing in the brain are presented. Experimental data and computer simulations are used to provide real examples for students experimentation.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

BME 660. Biomedical Transport Phenomena. 3 Credit Hours.
Fundamentals of transport phenomena in biological systems including diffusion, osmosis, convection, electrophoresis, and transport with binding. Applications to cell electrophysiology and drug delivery. Introduction to physiological fluid flow in tissues.
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

BME 665. Principles of Cellular and Tissue Engineering. 3 Credit Hours.
Introduction to cellular and tissue engineering. Current therapeutic approaches for lost/damaged tissue or organ function, tissue engineering strategies to replace/repair tissue or function: infusion of cells, production and delivery of tissue-inducing substances, cells placed on or within biomaterial scaffolds, examples of tissue engineering applications: skin, heart muscle, blood vessels, and blood.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

BME 666. Cell and Tissue Engineering Laboratory. 1 Credit Hour.
The principles of cell and tissue engineering will be presented in a hands-on laboratory experience. General techniques learned will include sterile methods, cell culture techniques and integration of cells within biomaterials. Cell engineering topics include cell cycle/metabolism, adhesion, signal transduction, and assessment. Tissue engineering topics include fabrication, biomaterials/scaffolds and cell integration, and functional assessment.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

BME 670. Advanced Biomedical Signal Processing. 3 Credit Hours.
This course provides an overview of advanced topics in biomedical signal processing with an emphasis on practical applications. Topics include quantitative description, analysis, on-line and real-time processing of biophysical and physiological signals (cardiovascular, neural, sensory, muscular, respiratory and other) using adaptive, learning, pattern recognition and data dimension reduction methods.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

BME 671. Introduction to Biosignal Processing Lab. 1 Credit Hour.
Laboratory course in conjunction with BME 570 course. Corequisite: BME 570.
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

BME 675. Biomechanics II. 3 Credit Hours.
Applications of linear and nonlinear viscoelastic concepts to the biomedical characteristics of biological tissues and structures at small and large deformations of blood flow, experimental methods of analysis, artificial organs, and life-support systems.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 681. Radiation Biology and Physics. 3 Credit Hours.
The principles, methods, and results of radiation biology with physics applications in radiation therapy will be introduced in the course. The course will focus on mechanisms of radiation and biological system interaction, biological aspects of the foundation of radiation therapy, and mathematical models for radiobiological analysis. Corequisite or prerequisite: BME 502 or permission of instructor.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

BME 682. Radiation Therapy Physics. 3 Credit Hours.
The principles and instrumentation of radiation dosimetry with focus on the applications in radiation therapy will be introduced in this course. The course will emphasize radiation dose computation algorithms and applications in treatment dose planning. The course will also cover a categorized dosimetric analysis of radiation therapy to different clinical conditions.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 683. Radiation Protection. 3 Credit Hours.
This course covers radiation safety principles for all areas of clinical medical physics, including regulatory requirements for personnel, equipment and facilities and detailed structural shielding design requirements for medical facilities. The student will become proficient in practical aspects of radiation safety objectives and regulatory requirements in clinical practice, including those for patients, members of the general public and staff. Students will learn the principles for designing and installing structural shielding in clinical facilities that satisfies both regulatory requirements and clinical needs.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.
BME 687. Finite Element Analysis for Engineers. 3 Credit Hours.
Introduction to the finite-element method. Hands-on applications of
FEMLAB software to the analysis of structural, thermal, chemical,
electro-magnetic, optical, and fluid flow problems.
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

BME 699. Cooperative Education. 1 Credit Hour.
Practical application of classroom theory through alternating semester
or summer employment with firms offering positions consistent with the
student's field of study. Course may be repeated. Periodic reports and
conferences are required.
Components: THI.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 705. Master's Design Project I. 3 Credit Hours.
Comprehensive M.S. design project in biomedical engineering. Open to
students in the BS/MS and MS programs.
Components: LEC.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.

BME 706. Master's Design Project II. 3 Credit Hours.
Comprehensive M.S. design project in biomedical engineering. Open to
students in the BS/MS.
Components: LEC.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.

BME 713. Application of Computers in Medicine. 3 Credit Hours.
Applications in the clinical and medical research laboratories for
physiological data acquisition, analysis, and management of patient
records. Differences among computer systems and languages for clinical
and research activities are also covered.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 722. Scanning Electron Microscopy Special Projects. 3 Credit
Hours.
An advanced course for graduate students with basic skills in SEM.
The course is open only to masters or Ph.D. students. Students will have
an opportunity to do independent research under supervision of the
instructor on special projects of interest that may be related to their field
of study as long as it is not part of their thesis or dissertation.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

BME 723. Neural Engineering. 3 Credit Hours.
Biophysics of neural communication, quantitative
electroencephalography and evoked potentials, sleep, seizure, anesthesia
and intraoperative monitoring, neural stimulation, artificial and biological
neural networks, cochlear and visual implants, brain and muscle
stimulation.
Prerequisite: BME 503 and BME 570.
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

BME 724. Neuroengineering and Neurorehabilitation. 3 Credit Hours.
Advances in Neural Engineering have led to improved medical-device
designs with novel functions. This course focuses on the engineering
approaches, R&D advances, and the technical principles of NeuroMotor
medical implants. Neural Engineering theory and applications from
the perspectives of electronics design, neural signal analysis, and
neurophysiology will be covered.
Prerequisite: BME 603.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

BME 725. Special Problems. 1-3 Credit Hours.
Research and/or design projects through an individual investigation of
current problems. Offered by special arrangement only.
Components: THI.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.

BME 726. Special Problems. 1-3 Credit Hours.
Research and/or design projects through an individual investigation of
current problems. Offered by special arrangement only.
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

BME 728. Advanced Topics. 1-3 Credit Hours.
Subject matter offerings based upon student demand and availability
of faculty. Subtitles describing the topics to be offered will be shown in
parentheses in the printed class schedule, following the title "Advanced
Topics".
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

BME 729. Advanced Medical Imaging. 3 Credit Hours.
Analysis of contemporary medical imaging systems and the associated
technologies. The course focuses on principles of advanced medical
imaging systems. Topics include multimodality imaging, three-
dimensional image reconstruction and visualization, clinical and research
applications, and derivation and comparison of algorithms.
Prerequisite: BME 520. Or Requisite: Permission of Instructor.
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

BME 730. Advanced Topics. 1-3 Credit Hours.
Subject matter offerings based upon student demand and availability
of faculty. Subtitles describing the topics to be offered will be shown in
parentheses in the printed class schedule, following the title "Advanced
Topics."
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

BME 731. Advanced Topics. 1-3 Credit Hours.
Subject matter offerings based upon student demand and availability
of faculty. Subtitles describing the topics to be offered will be shown in
parentheses in the printed class schedule, following the title "Advanced
Topics."
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.
BME 735. Auditory and Visual Neural Systems. 3 Credit Hours.
Design and application of auditory and visual neural systems and devices for medical purposes. Methodologies and instrumentation using electrophysiological, psychophysical and other measurements are explored focusing on diagnostic and therapeutic applications.
Prerequisite: BME 603.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 740. Implantable Biomedical Devices. 3 Credit Hours.
Development and advances in implantable materials and devices especially those used as electrically driven prostheses. Topics include pacemakers, defibrillators, catheters, neurological stimulators, heart assist, bone repair, and other diagnostic and therapeutic devices. The historical, medical significance, business, economic, and technical aspects of these devices and the associated instruments for monitoring are discussed. Fundamentals of electrochemical corrosion and stimulation as well the technology of implantable power sources are reviewed.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 745. Biomedical Optical Imaging and Diagnostics. 3 Credit Hours.
Review of geometrical optics, fiber optics, and tissue optics. Introduction to physical optics: interference, diffraction, and polarization; optical imaging resolution limits, super-resolution imaging, advanced optical microscopy, and optical coherence tomography (OCT). Imaging through scattering tissue, imaging and diagnostics with polarized light, fluorescence, infrared, and Raman spectroscopy and applications are also discussed. Optical diagnostics using scattered light: laser Doppler flowmetry, and dynamic light scattering; and opto-chemical and evanescent wave sensors are also covered.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 750. Advanced Biomedical Transport Phenomena. 3 Credit Hours.
Continuum mixture theory and applications to mass transport in biological tissues, hydrogels, and other porous media. Mechanoelectrochemical coupling phenomena in biological tissues and cells.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 760. Fundamentals of Cellular and Tissue Engineering. 3 Credit Hours.
Principles and advanced topics on cellular and tissue engineering. Topics include biodegradable and non-biodegradable biomaterials, cytokines, the traditional and stem cell-based tissue engineering approaches, bioreactors and special topics such as bone, cartilage and other tissues.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

BME 780. Biomedical Engineering Seminar. 1 Credit Hour.
Presentation of biweekly seminars by selected speakers and graduate students on current topics of interest in biomedical engineering. Attendance is required of all students registered in the PhD program.
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

BME 781. Radiation Dosimetry And Physics. 3 Credit Hours.
Application of radiation physics in the field of radiation therapy. The course will cover the relevant subjects of modern physics, the basic modalities and basic instrumentations of radiation therapy, the principles of particle transport and radiation dose computation and quality assurance of radiation therapy instruments. The subject of radiation protection will also be discussed.
Prerequisite: BME 582. Or Requisite: Permission of Instructor.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 783. Radiation Therapy Physics Clinical Rotation. 3 Credit Hours.
Students will observe clinical activities at a designated radiation therapy center for ten hours per week. Rotation includes observation of daily treatment, simulation, dose planning, physics quality assurance and routine physics support activities (special physics consultation, weekly physics chart check, monitoring radiation safety activities, support of brachytherapy procedures). Students will meet with the course instructor one and a half hours/week to discuss the schedule and the progress of the rotation activities. Students need to submit reports on each radiation therapy category.
Prerequisite: BME 582. Or Requisite: Permission of Instructor.
Components: THI.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 784. Medical Physics Journal Club. 1 Credit Hour.
The course aims to keep track of recent developments in the field of Medical Physics for therapeutic and diagnostic purposes in oncology through reading, discussion and presentation of identified scientific papers from the major journals of Medical Physics among enrolled students.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

BME 810. Master's Thesis. 1-6 Credit Hours.
The student working on his/her master's thesis enrolls for credit, in most departments not to exceed six, as determined by his/her advisor. Credit is not awarded until the thesis has been accepted.
Components: THI.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.

BME 820. Research in Residence. 1 Credit Hour.
Used to establish research in residence for the thesis for the master's degree after the student has enrolled for the permissible cumulative total in BME 710 (usually six credits). Credit not granted. May be regarded as full time residence.
Components: THI.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.
BME 825. Continuous Registration--Master’s Study. 1 Credit Hour.
To establish residence for non-thesis master’s students who are preparing for major examinations. Credit not granted. Regarded as full time residence.
Components: THI.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.

BME 830. Pre-candidacy Doctoral Dissertation. 1-12 Credit Hours.
Doctoral dissertation credits taken prior to Ph.D. student’s candidacy. The student will enroll for credit as determined by his/her advisor. Not more than 12 hours of BME 730 may be taken in a regular semester, nor more than six in a summer session.
Components: THI.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.

Doctoral dissertation credits taken after Ph.D. student has been admitted to candidacy. The student will enroll for credit as determined by his/her advisor. Not more than 12 credits in BME 740 may be taken in a regular semester, nor more than six credits in a summer session.
Components: THI.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.

BME 850. Research in Residence. 1 Credit Hour.
Used to establish research in residence for the Ph.D., after the student has been enrolled for the permissible cumulative total in appropriate doctoral research. Credit not granted. May be regarded as full-time residence as determined by the Dean of the Graduate School.
Components: THI.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.