Biomedical Engineering

Chairperson: Frank A. Pintar, Ph.D.
Department of Biomedical Engineering website (http://www.marquette.edu/engineering/biomedical/)

The Department of Biomedical Engineering offers curriculum that leads to a bachelor of science degree in biomedical engineering. Within this one degree, there are three major options: Biocomputing, Bioelectronics and Biomechanics.

The Marquette University and Medical College of Wisconsin Department of Biomedical Engineering brings together the engineering education and research expertise of Marquette and the medical research, technology and clinical expertise of MCW to provide an inclusive education model for the next generation of engineers, scientists and physicians. Click here (https://mcw.marquette.edu/biomedical-engineering/) to link to the joint department website with more information.

Mission

The Department of Biomedical Engineering consists of a dedicated team of faculty and staff committed to the Jesuit tradition of the pursuit of truth. We develop leaders and problem solvers skilled at applying engineering, science and design principles to improve health in the service of humanity by:

- Discovering and disseminating new knowledge.
- Guiding students to meaningful and ethical professional and personal lives.
- Fostering interdisciplinary and collaborative research and education through academic and industrial alliances.
- Continuing innovative leadership in education, research and industrial relationships.
- Inspiring faculty and students to serve others.

Studies in biomedical engineering incorporate courses in biology, chemistry, mathematics, computing and engineering. These courses, in combination, emphasize the interdisciplinary elements of biomedical engineering not presently offered in the more traditional departments of engineering. A solid foundation in the mathematical, physical and life sciences is necessary for the engineer to function effectively in a medically or biologically oriented problem-solving environment. In this environment, the engineer needs to be able to communicate with physicians, to describe and model complex biological systems, to collect and analyze experimental or clinical data, to understand the capabilities and limitations of sophisticated instrumentation and to understand the principles of design.

There are three majors in the biomedical engineering curriculum: biocomputing, bioelectronics and biomechanics. The bioelectronics major includes rigorous training in electrical engineering within the interdisciplinary framework of the curriculum. Such training, which includes courses in electric circuits and analog and digital electronics, supports interests focused on the measurement of bioelectric signals and biomedical instrumentation design. In the senior year, the culmination of the training features intensive biomedical instrument design and computer laboratories emphasizing modern bioelectric applications. In addition, a senior year capstone design course sequence places the student in a multidisciplinary design team situation to solve an actual industrial bioelectronic design problem.

The biomechanics major includes rigorous training in mechanical engineering within the interdisciplinary framework of the curriculum. Such training, which includes courses in materials and solid mechanics, supports interests focused on the application of biomechanics and biomaterials. In the senior year, the culmination of the training features intensive biomedical instrument design and computer laboratories emphasizing modern biomechanical applications. In addition, a senior-year capstone design course sequence places the student in a multidisciplinary design team situation to solve an actual industrial biomechanical or biomaterial design problem.

The biocomputer engineering curriculum integrates computer engineering and the life sciences, with a solid foundation in mathematics, physics, chemistry and engineering methods. The curriculum combines foundational computer engineering knowledge with biocomputer engineering applications, integrating biology, physiology, medicine, biomedical software design, biosignal processing and bioinstrumentation. In the senior year, the training culminates with a comprehensive, biocomputer engineering, design laboratory experience that incorporates engineers from industry and emphasizes medical device design and methods for biomedical informatics. In addition, a senior capstone design course places students in a multidisciplinary team working with industry to solve biocomputer design problems.

All majors in biomedical engineering have been designed to be compatible with other programs offered by the Opus College of Engineering. Each major fulfills the requirements of the Marquette Core Curriculum and requires 129 credits for graduation. Students can earn an optional minor in either electrical or mechanical engineering as well as biology, chemistry, business administration or others. In addition, the majors retain many of the core courses of the initial two years and allow the student to elect the co-op/internship program. Since the majors satisfy the entrance requirements of many professional schools, the student can, usually without additional preparation, pursue studies in medical school, dental school, schools of veterinary medicine, law school and graduate schools in biomedical engineering or traditional areas of engineering.

The Department of Biomedical Engineering operates biomedical image and signal processing laboratories, biocomputer, bioelectronic and biomechanical design laboratories, and students have access to computer, electrical and mechanical engineering laboratories as well as the college and university computer facilities. In addition, collaborative programs exist between Marquette University, the Medical College of Wisconsin, the Milwaukee County Medical Complex, Froedtert Memorial Lutheran Hospital, and the Zablocki Veterans Administration Medical Center. These proximate

collaborative research programs, some active for three decades, provide a uniquely enhanced laboratory experience that has significantly contributed to the success of biomedical engineering at Marquette.

Educational Objectives

To provide an educational program that will prepare graduates to:

- Participate as a technical contributor and member of a design and/or development team.
- Communicate effectively with individuals and teams with a wide variety of backgrounds.
- Pursue professional or graduate degrees or employment in the biomedical industry.
- Understand the legal, ethical, economic and regulatory requirements of medical device design and biomedical engineering research.
- Define, solve and implement solutions to a problem.
- Progress in developing leadership skills.
- Identify limitations in their own knowledge base and skills and engage in lifelong learning.

Non-Biomedical Engineering Minors

Biomedical engineering students can earn minors in a wide variety of areas including computer engineering, electrical engineering, mechanical engineering, biology and chemistry. Students should consult with the Engineering Academic Advising Center to discuss the requirements of these minors. Careful planning with an academic adviser can minimize the number of additional hours beyond the normal graduation requirements.

Five Year B.S./M.S. Program

This program allows students to receive a bachelor of science degree and a master of science degree in biomedical engineering in five years. Students with grade point averages (3.500 or above) apply to the program during their junior year. They begin their thesis research the summer between their junior and senior years. Their research laboratory experience continues the summer between their senior and fifth years and throughout their fifth year, culminating in the preparation of a written thesis and defense.

- Biocomputing, BBE (https://bulletin.marquette.edu/engineering/biomedical-engineering/biocomputing-bs/)
- Bioelectronics, BBE (https://bulletin.marquette.edu/engineering/biomedical-engineering/bioelectronics-bs/)
- Biomechanics, BBE (https://bulletin.marquette.edu/engineering/biomedical-engineering/biomechanics-bs/)
- Biomedical Engineering, Minor (https://bulletin.marquette.edu/engineering/biomedical-engineering/biomedical-minor/)

Graduate Programs

- Biomedical Engineering, ME (https://bulletin.marquette.edu/graduate/biomedical-engineering-me/)
- Biomedical Engineering, MS (https://bulletin.marquette.edu/graduate/biomedical-engineering-ms/)
- Biomedical Engineering, PHD (https://bulletin.marquette.edu/graduate/biomedical-engineering-phd/)
- Clinical Immersion in Medical Device Design, Certificate (https://bulletin.marquette.edu/graduate/clinical-immersion-medical-device-design-certificate/)
- Healthcare Technologies Management, MS (https://bulletin.marquette.edu/graduate/healthcare-technologies-management-ms/)

BIEN 1100 Introduction to Biomedical Engineering Methods 1 (2 credits)
Students are introduced to biomedical engineering design and problem-solving processes. Key topics include the measurement of physiological signals, signal acquisition, biomedical instrumentation, and image processing. Students will work in cross-disciplinary teams, enhancing their collaboration, teamwork, and decision-making skills. The course emphasizes practical applications, preparing students to tackle complex issues at the intersection of engineering, medicine, and technology.
Prerequisite: Enrolled in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%201100)

BIEN 1110 Introduction to Biomedical Engineering Methods 2 (2 credits)
Students build upon concepts from BIEN 1100, covering topics in fluid mechanics, rehabilitation engineering, biomaterials and business concepts. Emphasis is placed on a hands-on design challenge, where students gain essential skills in problem identification, prototype development and technical communication. Students enhance their abilities in teamwork, critical thinking and entrepreneurial innovation, preparing them for diverse roles in biomedical engineering.
Prerequisite: BIEN 1100, CEEN 1200, EECE 1200, or GEEN 1200; enrollment in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%201110)

BIEN 1120 Introduction to Computing for Biomedical Engineers (2 credits)
Introductory hands-on experience in computer programming for biomedical engineers. Involves learning linear programming in C and creating flow-charts to solve biomedical applications. Computing topics include syntax, data types, control flow and algorithm development. Biomedical applications include analyzing physiological signals, biological event detection, and biomechanical analysis. Students learn how to use MATLAB to solve biomedical applications. Laptop required.
Prerequisite: BIEN 1100, which may be taken concurrently.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%201120)

BIEN 2100 Statistics for Biomedical Engineering (3 credits)
Numerical and graphical summary of biomedical data and the use of statistics in problem solving for a variety of case studies in biomedical research, medical device design and clinical trials.
Prerequisite: MATH 1450.
Level of Study: Undergraduate
Marquette Core Curriculum: NSM Expanding Our Horizons
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%202100)

BIEN 2200 Engineering Design with SolidWorks (1 credits)
Computer-aided design (CAD) with SolidWorks includes 3D solid part/component and assembly modeling and drafting with various modeling techniques to create virtual and actual 3D computer models, along with the introduction to engineering graphics fundamentals with orthographic project views and geometric dimensioning & tolerancing (GD&T) rules and standards to create professional engineering document drawing. Students develop practical CAD skills for internships and full-time employment.
Prerequisite: Enrolled in Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%202200)

BIEN 2300 Biomedical Circuits and Electronics (4 credits)
An experience in electrical circuits (AC and DC), electronic devices (Junction, Transistor, Operational, Amplifier) bridges, digital circuits and Boolean implementation, combinational and sequential logic, memories. Analysis and design. 3 hrs. lec., 3 hrs. lab
Prerequisite: PHYS 1004 or PHYS 1014. Enrolled in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%202300)

BIEN 3200 Computer Applications in Biomedical Engineering (3 credits)
Design and implement computer techniques for the acquisition and analysis of biomedical data and the modeling of physiologic phenomena. Emphasis on physiological data acquisition, statistical description of physiological data, time domain and frequency domain methods for physiological signal conditioning and processing and numerical methods for quantitative interpretation of physiological data using C programming language.
Prerequisite: BIEN 1120 or equiv.
Level of Study: Undergraduate
Marquette Core Curriculum: NSM Crossing Boundaries
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%203200)

BIEN 3300 Signals and Systems for Biomedical Engineering (3 credits)
Mathematical models of continuous-time signals and systems are studied. The time domain viewpoint is developed for linear time invariant systems using the impulse response and convolution integral. The frequency domain viewpoint is also explored through the Fourier Series and Fourier Transform. Basic filtering concepts including simple design problems are covered. Application of the Laplace transform to block diagrams, linear feedback and stability including Bode plots are discussed. The sampling theorem, the z-transform and the Discrete Fourier Transform are introduced. Examples of electrical, mechanical and biomedical signals and systems are used extensively throughout the course. 3 hrs. lec.
Prerequisite: One of the following: ELEN 2020 with minimum grade of C and MATH 2451; or BIEN 2300 with minimum grade of C and MATH 2451; or ELEN 2020 with minimum grade of C and MATH 2455; or BIEN 2300 with minimum grade of C and MATH 2455. BIEN 1120 or concurrent enrollment.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%203300)

BIEN 3310 Control Systems for Biomedical Engineering (3 credits)
Provides an introduction to the principles of control systems theory for biomedical engineers. Mathematical techniques to characterize and design control systems will be studied in the context of physiological, bioelectrical, biochemical and biomechanical systems. Topics include frequency and time-domain modeling of physiological control systems, feedback, stability, steady-state error, design, root-locus, state-space techniques, and nonlinear control. Simulation using MATLAB and Simulink will be used to provide hands-on experience in the design of biomedical control systems.
Prerequisite: BIEN 3300.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%203310)

BIEN 3400 Clinical and Regulatory Issues in Medical Device Design (3 credits)
Students develop clinical literacy in areas including medical terminology, working with medical professionals, professional conduct in the clinical environment, operating room workflow and the technical needs of surgeons, nurses, and other stakeholders. They observe procedures in the clinical environment and learn to identify problems, unmet needs and opportunities for new product development. Students participate in field trips to obtain hands-on experience with various medical devices. Lecture topics include clinical perspectives and current needs and regulatory issues associated with the medical device design. A project proposal for a new medical device or technology is required at the end of the course.
Prerequisite: BIEN major and Jr. stndg; or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%203400)

BIEN 4220 Embedded Biomedical Instrumentation (3 credits)
Fundamentals of digital circuit design and analysis and the application to embedded biomedical instrumentation. Topics include microprocessor principles and programming and system design constraints for medical electronics. Laboratory will provide applications of concepts introduced in class.
Prerequisite: BIEN 2300.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204220)

BIEN 4280 Biocomputers Design Lab 1 (3 credits)
Hands-on experience in software design and validation, microprocessors, computer architecture, real-time computing, embedded software, graphical user interface and networking. An emphasis on medical devices with embedded software and hardware.
Prerequisite: BIEN 2300, BIEN 3300 and BIEN 4220.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204280)

BIEN 4290 Biocomputers Design Lab 2 (3 credits)
Continuation of BIEN 4280 with emphasis on high performance computing in workstation environments.
Prerequisite: BIEN 4280.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204290)

BIEN 4320 Biomedical Instrumentation Design (3 credits)
Fundamental knowledge and skills needed to solve instrumentation problems relating to biomedical and physiological measurements in the laboratory and clinic. Key elements include biosignals, signal conditioning, sensors and transducers, data acquisition, instrument design and safety requirements. Includes hands-on experiences in basic instrumentation lab skills, needs identification, design, implementation, testing and troubleshooting, and report writing.
Prerequisite: BIEN 2300 or ELEN 2020; and BIEN 3300, which may be taken concurrently.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204320)

BIEN 4380 Bioelectronics Design Lab 1 (3 credits)
Students learn the principles of medical device design, safe operating procedures and the practical issues associated with designing and validating electronic systems to measure physiological parameters. Emphasis is placed on open ended design examples and hands-on experience designing, troubleshooting, and validating electronic systems. Topics include electrical safety; myography; force measurement; minimizing sources of noise, operational amplifier characterization; active filtering; microprocessors. Students gain experience conveying information using different styles of reporting. 2 hrs. lec., 3 hrs. lab.
Prerequisite: EECE 2015, EECE 2035, ELEN 3030.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204380)

BIEN 4390 Bioelectronics Design Lab 2 (3 credits)
Students integrate the concepts from Design Lab 1 to design, implement and test an example medical device based in research and clinical applications. Emphasis is placed on open ended design examples and hands-on experience designing, troubleshooting and validating electronic systems. Topics include patient isolation from electrical hazard, biopotential measurement, myoelectric control, EMF and inductive loads, signal multiplexing and demultiplexing, analog to digital conversion, and electrical stimulation. Design projects incorporating microprocessors are also included. Students gain experience conveying information using different styles of reporting. 2 hrs. lec., 3 hrs. lab.
Prerequisite: BIEN 4380 and EECE 3015.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204390)

BIEN 4400 Transport Phenomena (3 credits)
Introduction to fluid mechanics and its applications in biomedical engineering. Covers key concepts in fluid mechanics, such as conservation of mass, momentum, and energy in fluids, the Reynolds number, laminar vs. turbulent flows, Poiseuille flow, the Bernoulli equation, and the Navier-Stokes equations. Concepts are applied to physiological phenomena with an emphasis on the cardiovascular and respiratory systems.
Prerequisite: Jr. stndg. and PHYS 1003, or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204400)

BIEN 4410 Applied Finite Element Analysis (3 credits)
Introduction to the finite element method, used for numerical integration of partial differential equations in solid mechanics, fluid mechanics and heat transfer. Summarizes various numerical integration schemes. Assignments include development of finite element code (e.g., Matlab or Python) and/or use of commercial software (e.g., ANSYS, Abaqus). Emphasis is on the application of the finite element method to biomedical applications, such as cardiovascular flows, respiratory flows, or orthopedic biomechanics.
Prerequisite: Sr. stndg., BIEN 1110 and GEEN 2130; or Sr. stndg., GEEN 1210, and GEEN 2130.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204410)

BIEN 4420 Biomaterials Science and Engineering (3 credits)
Designed to introduce the uses of materials in the human body for the purposes of healing, correcting deformities and restoring lost function. The science aspect of the course encompasses topics including: characterization of material properties, biocompatibility and past and current uses of materials for novel devices that are both biocompatible and functional for the life of the implanted device. Projects allow students to focus and gain knowledge in an area of biomaterials engineering in which they are interested.
Prerequisite: MEEN 2460 or equiv.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204420)

BIEN 4430 Introduction to Tissue Engineering (3 credits)
Introduces the scientific field of tissue engineering, a discipline of biomedical engineering that uses a combination of living cells, biomaterials, and biomechanical and biochemical stimuli to restore or replace damaged or diseased biological tissues. Covers advanced topics in foundational sciences as applicable to the engineering of living tissues. Topics include stem cell biology, biomaterials, immunology, bioreactors and molecular biology. Discusses pathophysiology and engineering strategies for specific tissues, along with examples of current research. Covers the following tissue applications: skin, blood vessels, nervous tissue, heart tissue, heart valves, tendons, ligaments, bone and whole organs.
Prerequisite: Jr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204430)

BIEN 4480 Biomechanics Design Lab 1 (3 credits)
Intended for those students pursuing the Biomedical Engineering Biomechanics option. The application of principles of engineering mechanics, data acquisition and basic electronics in the design and utilization of biomechanical instrumentation. Principles of transduction, mechanics, sampling theory, strain, temperature, and flow measurement as applied to biomechanical systems. A background in data acquisition, electrical safety, operational amplifier and bridge circuits, and measurements is provided. Experiments investigate biomechanics of the musculoskeletal and cardiovascular systems and include design content. Report writing. 2 hrs. lec., 3 hrs. lab.
Prerequisite: BIEN 2300, GEEN 2120, and GEEN 2130.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204480)

BIEN 4490 Biomechanics Design Lab 2 (3 credits)
Provides students with experience in the design and implementation of appropriate experimental procedures to analyze biomechanical problems. Students will become familiar with various types of advanced transducers which will be used in conjunction with data acquisition workstations to obtain thermal, flow, strain, and related physiological data from biomechanical systems. Topics include mechanical properties of active muscle; analysis of human motion; postural stability; thermal regulation; cardiovascular mechanics; stress distribution in skeletal system; and comparison of static and dynamic biomechanical responses to load. 2 hrs. lec., 3 hrs. lab.
Prerequisite: BIEN 4480.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204490)

BIEN 4500 Medical Imaging Physics (3 credits)
Students learn how light, X-rays, radiopharmaceuticals, ultrasound, magnetic fields, and other energy probes are generated and how they interact with tissues and detectors to produce useful image contrast. Practical issues such as beam generation, dose limitations, patient motion, spatial resolution and dynamic range limitations, and cost-effectiveness will be addressed. Emphasis is placed upon diagnostic radiological imaging physics, including the planar X-ray, digital subtraction angiography mammography, computed tomography, nuclear medicine, ultrasound, and magnetic resonance imaging modalities.
Prerequisite: PHYS 1004 or PHYS 1014.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204500)

BIEN 4510 Image Processing for the Biomedical Sciences (3 credits)
This course serves as an introduction to biomedical image processing. Topics explored included the human visual system, spatial sampling and digitization, image transforms, spatial filtering, Fourier analysis, image enhancement and restoration, nonlinear and adaptive filters, color image processing, geometrical operations and morphological filtering, image coding and compression image segmentation, feature extraction and object classification. Applications in diagnostic medicine, biology and biomedical research are emphasized and presented as illustrative examples.
Prerequisite: MATH 1450 and MATH 1451 or MATH 1455; knowledge of C programming; or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204510)

BIEN 4520 Introduction to Optics for Biomedical Engineers (3 credits)
Introduces the fundamentals of optics, the science and technology of how light is generated, propagated, interacts with matter and detected. Concentrates on geometrical (or ray) optics, which focuses on light reflection, refraction, lenses, mirrors, prisms, fiber optics, GRIN lens and simple imaging systems, as well as wave optics, which focuses on wave equations, superposition, diffraction, interference, polarization, dispersion and electro-optic effects. Also studies more advanced topics, such as fluorescence imaging, optical microscopy, diffuse optical tomography, optical coherence tomography and optical spectroscopy.
Prerequisite: PHYS 1004, BIEN 4320.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204520)

BIEN 4600 Neural Engineering (3 credits)
Basic principles of neural engineering and the nervous system, properties of excitable tissues, quantitative models used to examine the mechanisms of natural and artificial stimulation. Basic concepts for the design of neuroprosthetic devices for sensory, motor and therapeutic applications. Design issues including electrode type, biomaterials, tissue response to implanted electrodes, stimulus parameters for electrical stimulation and artificial control and emerging neuromodulation technologies such as optogenetics. Examples of how neural interfaces show increasing promise in the rehabilitation of individuals with various motor or sensory impairments.
Prerequisite: PHYS 1004 or PHYS 1014; programming experience in MATLAB or equiv.
Level of Study: Undergraduate
Marquette Core Curriculum: NSM Cgntn, Lang, Mmry/Intlgnc
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204600)

BIEN 4610 Introduction to Rehabilitation Robotics (3 credits)
Presents the fundamentals of robotics as it is applied to rehabilitation engineering. Specific topics include: the fundamentals of analysis and design of robot manipulators with examples and mini-projects taken from rehabilitation applications pertaining to robotic therapy devices and personal assistants. Additional topics include: overview of rehabilitation robotics field, human-centered design of rehabilitation robots issues and challenges, robot configurations, rigid motions and homogeneous transformations, Denavit-Hartenberg representation, robot kinematics, and inverse kinematics, Euler-Lagrange equations, trajectory generation, sensors, actuators, independent joint control, force control and safety.
Prerequisite: Jr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204610)

BIEN 4620 Rehabilitation Science and Engineering (3 credits)
Introduces rehabilitation science as the study of tissue and functional change, including:overview of key human sensory modalities and neuromotor systems in the context of functional capabilities and human performance metrics; review of spontaneous recovery mechanisms in response to various types of tissue trauma; review of roles of genetics and gene transcription networks in pathology and functional recovery prognosis; and the concept of rehabilitative assessment and therapeutic interventions as an optimization problem. Also focuses on the use of assistive technology to enhance access to independent living and to optimize the delivery of rehabilitative healthcare services. Includes rehabilitation biomechanics of physical interfaces, use of access and usability engineering in product design and innovative assessment and intervention strategies for neurorehabilitation.
Prerequisite: BIEN 2300 or equiv.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204620)

BIEN 4700 Systems Physiology (3 credits)
Analyses of the underlying physiologic and bioengineering aspects of the major cell and organ systems of the human from an engineer's point of view. Classic physiologic approaches used to introduce topics including cell functions, nervous system, nerve, muscle, heart, circulation, respiratory system, kidney, reproduction and biomechanics. Design problems including models of cell-organ-system function and problems in biomechanics illuminate topics covered. Experts on related topics are invited to speak as they are available.
Prerequisite: BIOL 1001 and Jr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204700)

BIEN 4710 Analysis of Physiological Models (3 credits)
Development of continuous (compartmental), and distributed-in-space-and-time mathematical models of physiological systems and molecular events. Analytical and numerical methods for solving differential equations of the initial and boundary value types. Simulation of model response, and estimation of model parameters using linear and nonlinear regression analysis.
Prerequisite: Jr. stndg. and MATH 2451; or jr. stndg. and MATH 2455.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204710)

BIEN 4720 Cardiopulmonary Mechanics (3 credits)
Examination of cardiovascular and respiratory physiology from an engineering perspective. Emphasis is on understanding the mechanical basis of physiologic phenomena via mathematical and computational models.
Prerequisite: BIEN 4700, which may be taken concurrently, or equiv.; and BIEN 4400, which may be taken concurrently, or equiv.; or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204720)

BIEN 4920 Senior Capstone Design 1 (3 credits)
Course content focuses on a structured product design and development process that includes project definition, customer needs identification, product specification, concept generation, and concept selection. Course also focuses on issues related to teamwork, project management, and effective communication. Student team design projects culminate in the development of a technically and economically viable concept and a proposal for future development of this concept (done in the second semester of this two-course sequence). 2 hr. lec., 1 hr. disc.
Prerequisite: Sr. stndg.; co-op students, jr. stndg. Cross-listed with COEN 4920, ELEN 4920 and MEEN 4920.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204920)

BIEN 4931 Topics in Biomedical Engineering (1-3 credits)
Course content announced prior to each term. Students may enroll in the course more than once because subject matter changes. Possible topics include biomechanics, experimental methods, neuroanatomy, telemetry, etc.
Prerequisite: Jr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204931)

BIEN 4995 Independent Study in Biomedical Engineering (1-4 credits)
Undergraduate independent study project of either a theoretical or experimental nature.
Prerequisite: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch.; or Sr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204995)

BIEN 4998 Senior Capstone Design 2 (3 credits)
Course focuses on detailed design, prototyping, and testing design concepts. Course includes topics directly relevant to student design projects and careers in the engineering profession. Student team design projects culminate in a final report that documents the performance and details (engineering drawings and/or documentation) of their final design. 2 hrs. lec., 1 hr. disc.
Prerequisite: BIEN 4920. Cross-listed with COEN 4998, ELEN 4998 and MEEN 4998.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204998)

BIEN 4999 Senior Thesis within the Department of Biomedical Engineering (3 credits)
Preparation of a thesis by approved students to gain experience in the type of critical research and analysis that an advanced degree requires. The associated extended project is designed to enhance research and communication skills leading to a high quality manuscript that could be submitted for peer-reviewed journal publication.
Prerequisite: MU GPA greater than or equal to 3.5, BIEN 4995, cons. of dept. ch. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204999)

BIEN 9002 Student Study/Research Placeholder in Biomedical Sciences (0 credits)
Used to enroll a MU or non-MU student who is not enrolled in the term, but is on campus for an educational experience other than academic credit, such as work in a lab or clinic. Used for tracking purposes only. S/U grade assessment.
Prerequisite: Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%209002)