

# Biomedical Engineering (BIEN)

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## **BIEN 1100 Introduction to Biomedical Engineering Methods 1 (2 credits)**

Introduction to biomedical engineering design and problem solving using. Key elements include: physiologic signals and data acquisition, instrumentation, graphics, measurement and error, teamwork and decision-making. Problem-solving elements are applied to real-world biomedical problems introduced by practicing biomedical engineers, as well as, faculty.

*Prerequisite:* Enrolled in the Opus College of Engineering.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%201100>)

## **BIEN 1110 Introduction to Biomedical Engineering Methods 2 (2 credits)**

Continuation of BIEN 1100. Key elements include: modeling, fluid mechanics, rehabilitation engineering and entrepreneurship. Problem-solving and design elements are applied to real-world biomedical problems introduced by practicing biomedical engineers, as well as, faculty.

*Prerequisite:* BIEN 1100, CEEN 1200, EECE 1200, or GEEN 1200; enrollment in the Opus College of Engineering.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term

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, MATLAB, and Solid Modeling and CAD 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. Solid modeling and CAD are studied in the context of biomedical engineering design. Laptop required.

*Prerequisite:* BIEN 1100, which may be taken concurrently.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%201120>)

## **BIEN 2100 Statistics for Biomedical Engineering (1-3 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

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%202100>)

## **BIEN 2200 3D Modeling in SolidWorks (1 credits)**

Introduction to the fundamentals of computer-aided design (CAD) using the SolidWorks platform. Topics include parametric modeling principles, navigation of SolidWorks 3D, solid modeling, assembly and design analysis. 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. Use of P-Spice software. Analysis and design. 3 hrs. lec., 3 hrs. lab Enrolled in the Opus College of Engineering.

*Prerequisite:* PHYS 1004 or PHYS 1014.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%202300>)

## **BIEN 2400 Medical Device Design Constraints (1 credits)**

Students learn about legal, ethical, regulatory, economic, environmental, cultural, and social constraints that affect the design of medical devices. Students identify relevant, applicable design constraints and understand the impact of these constraints on the design process and the project schedule. BIEN major, or cons. of instr.

*Prerequisite:* Soph. stndg.

*Level of Study:* Undergraduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%202400>)

**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

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

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. BIEN 1120 or concurrent enrollment.

*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.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

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

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

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, dentists 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 and dental 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

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

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

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204220>)

**BIEN 4230 Intelligent Biosystems (3 credits)**

Use of emerging tools in systems biology and soft computing to explore how biosystems with highly distributed "intelligence" are designed to adapt to self- and environmentally-induced perturbations. Students obtain a basic understanding of key soft computing tools and use fuzzy expert system models. Applications to smart healthcare monitoring and future product design will be explored.

*Prerequisite:* Jr. stndg. and BIEN 4700.

*Level of Study:* Undergraduate

*Last four terms offered:* 2017 Spring Term, 2015 Fall Term, 2014 Spring Term, 2009 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204230>)

**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 4220, BIEN 3300, and BIEN 3200.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

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

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term

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

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204320>)

**BIEN 4380 Bioelectronics Design Lab 1 (3 credits)**

Understanding the principles of operation, safe operating procedures and methods of medical instrument selection. Design of experiments to measure physiological parameters. Typical experiments include: electrical safety; myography; force measurement; operational amplifier characterization; active filter; respiration monitoring. Actual medical instruments used under approximate clinical conditions. Report writing. 2 hrs. lec., 3 hrs. lab.

*Prerequisite:* EECE 2015, EECE 2035, ELEN 3030.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204380>)

**BIEN 4390 Bioelectronics Design Lab 2 (3 credits)**

Design of circuits used in research and clinical instrumentation. Experiments include the design, fabrication and evaluation of specific circuits. Typical projects include circuits used for: patient isolation from electrical hazard, measurement of heart rate, multiplexing and demultiplexing and analog to digital conversion. Design projects incorporating microprocessors are also included. Students required to submit reports. 2 hrs. lec., 3 hrs. lab.

*Prerequisite:* BIEN 4380 and EECE 3015.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204390>)

**BIEN 4400 Transport Phenomena (3 credits)**

Applications of mass, momentum, and mechanical energy balances to biomedical fluid systems. Study of physiological phenomena with an emphasis on cardiovascular systems and blood rheology.

*Prerequisite:* Jr. stndg. and PHYS 1003, or cons. of instr.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204400>)

**BIEN 4410 Applied Finite Element Analysis (3 credits)**

Introduces the finite element solution method for linear, static problems. Includes calculation of element stiffness matrices, assembly of global stiffness matrices, exposure to various finite element solution methods, and numerical integration. Emphasizes structural mechanics, and also discusses heat transfer and fluid mechanics applications in finite element analysis. Computer assignments include development of finite element code (FORTRAN or C) and also use of commercial finite element software (ANSYS and/or MARC)., BIEN 1110 and GEEN 2130; or Sr. stndg., GEEN 1210, and GEEN 2130.

*Prerequisite:* Sr. stndg.

*Level of Study:* Undergraduate

*Last four terms offered:* 2021 Fall Term, 2017 Spring Term, 2016 Spring Term, 2012 Spring Term

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 cons. of instr.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Spring Term, 2020 Spring Term, 2019 Spring Term, 2018 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204420>)

**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

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

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

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term

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

*Last four terms offered:* 2016 Spring Term, 2013 Fall Term, 2011 Fall Term, 2008 Fall Term

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

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2019 Fall Term, 2017 Fall Term

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, 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 stimulating electrodes and stimulus parameters for electrical stimulation and artificial control. Examples of how engineering interfaces with neural tissue show increasing promise in the rehabilitation of individuals of neural impairment.

*Prerequisite:* PHYS 1004 or PHYS 1014.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2021 Spring Term, 2018 Fall Term, 2017 Fall Term

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

*Last four terms offered:* 2013 Spring Term, 2012 Spring Term, 2011 Spring Term, 2010 Spring Term

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

*Last four terms offered:* 2008 Spring Term, 2007 Spring Term, 2004 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204620>)

**BIEN 4630 Rehabilitation Engineering: Prosthetics, Orthotics, Seating and Positioning (3 credits)**

Presents an overview of biomedical engineering as it applies to Rehabilitation Engineering, specifically, the design and prescription of prosthetic limbs, orthotic devices, and seating and positioning systems. Topics include medical terminology, musculoskeletal anatomy, muscle mechanics, soft tissue mechanics, gait/locomotion, amputation surgery, lower extremity prosthetics, lower extremity orthotics, hand function, electromyography, upper extremity prosthetics, upper extremity orthotics, seating and positioning and assistive devices.

*Prerequisite:* GEEN 2120.

*Level of Study:* Undergraduate

*Last four terms offered:* 2016 Fall Term, 2015 Fall Term, 2014 Fall Term, 2013 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204630>)

**BIEN 4640 Bioengineering of Living Actuators (3 credits)**

Overview of muscle tissue as a living actuator from the perspective of engineering design, systems biology, muscle modeling and adaptive control.

*Prerequisite:* BIEN 4700, BIEN 3300.

*Level of Study:* Undergraduate

*Last four terms offered:* 2010 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204640>)

**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. Computer techniques and relevant instrumentation are incorporated. Experts on related topics are invited to speak as they are available.

*Prerequisite:* BIOL 1001 and BIOL 1002 and Jr. stndg.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

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

*Last four terms offered:* 2020 Fall Term, 2016 Fall Term, 2015 Spring Term, 2014 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204710>)

**BIEN 4720 Cardiopulmonary Mechanics (3 credits)**

Examination of the physiological behavior of the cardiovascular and pulmonary systems from an engineering perspective. Emphasis is on understanding the mechanical basis of physiologic phenomena via experimental models.; and BIEN 4400, which may be taken concurrently, or equiv.; or cons. of instr.

*Prerequisite:* BIEN 4700, which may be taken concurrently, or equiv.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2020 Fall Term, 2019 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204720>)

**BIEN 4920 Principles of Design (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.; co-op students, jr. stndg. Cross-listed with COEN 4920, ELEN 4920 and MEEN 4920.

*Prerequisite:* Sr. stndg.

*Level of Study:* Undergraduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2020 Fall Term, 2019 Fall Term

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

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

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., 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.

*Prerequisite:* Jr. stndg.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Fall Term, 2021 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204995>)

**BIEN 4998 Senior Design Project (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. Cross-listed with COEN 4998, ELEN 4998 and MEEN 4998.

*Prerequisite:* BIEN 4920.

*Level of Study:* Undergraduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term

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.

*Level of Study:* Undergraduate

*Last four terms offered:* 2020 Spring Term, 2019 Spring Term, 2018 Spring Term, 2015 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%204999>)

**BIEN 5220 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 provides applications of concepts introduced in class.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205220>)

**BIEN 5230 Intelligent Biosystems (3 credits)**

Use of emerging tools in systems biology and soft computing to explore how biosystems with highly distributed "intelligence" are designed to adapt to self- and environmentally-induced perturbations. Students obtain a basic understanding of key soft computing tools and use fuzzy expert system models. Applications to smart healthcare monitoring and future product design will be explored.

*Prerequisite:* BIEN 4700/5700.

*Level of Study:* Graduate

*Last four terms offered:* 2017 Spring Term, 2015 Fall Term, 2014 Spring Term, 2009 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205230>)

**BIEN 5320 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.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205320>)

**BIEN 5400 Transport Phenomena (3 credits)**

Applications of mass, momentum, and mechanical energy balances to biomedical fluid systems. Study of physiological phenomena with an emphasis on cardiovascular systems and blood rheology.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205400>)

**BIEN 5410 Applied Finite Element Analysis (3 credits)**

Introduces the finite element solution method for linear, static problems. Includes calculation of element stiffness matrices, assembly of global stiffness matrices, exposure to various finite element solution methods, and numerical integration. Emphasizes structural mechanics, and also discusses heat transfer and fluid mechanics applications in finite element analysis. Computer assignments include development of finite element code (FORTRAN or C) and also use of commercial finite element software (ANSYS and/or MARC).

*Level of Study:* Graduate

*Last four terms offered:* 2021 Fall Term, 2017 Spring Term, 2016 Spring Term, 2012 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205410>)

**BIEN 5420 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 cons. of instr.

*Level of Study:* Graduate

*Last four terms offered:* 2022 Spring Term, 2020 Spring Term, 2019 Spring Term, 2018 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205420>)

**BIEN 5500 Medical Imaging Physics (3 credits)**

Examines 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. Addresses practical issues such as beam generation, dose limitations, patient motion, spatial resolution and dynamic range limitations, and cost-effectiveness. Emphasizes diagnostic radiological imaging physics, including the planar X-ray, digital subtraction angiography mammography, computed tomography, nuclear medicine, ultrasound, and magnetic resonance imaging modalities.

*Level of Study:* Graduate

*Last four terms offered:* 2016 Spring Term, 2013 Fall Term, 2011 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205500>)

**BIEN 5510 Image Processing for the Biomedical Sciences (3 credits)**

Introduces biomedical image processing. Topics explored include: 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.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2019 Fall Term, 2017 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205510>)

**BIEN 5520 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:* Physics, analog circuits, or cons. of instr.

*Level of Study:* Graduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205520>)

**BIEN 5600 Neural Engineering (3 credits)**

Basic principles of neural engineering, 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 stimulating electrodes and stimulus parameters for electrical stimulation and artificial control. Examples of how engineering interfaces with neural tissue show increasing promise in the rehabilitation of individuals of neural impairment.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2021 Spring Term, 2018 Fall Term, 2017 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205600>)

**BIEN 5610 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.

*Level of Study:* Graduate

*Last four terms offered:* 2013 Spring Term, 2012 Spring Term, 2011 Spring Term, 2010 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205610>)

**BIEN 5620 Rehabilitation Engineering: Telerehabilitation Research Tools (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.

*Level of Study:* Graduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205620>)

**BIEN 5630 Rehabilitation Engineering: Prosthetics, Orthotics, Seating and Positioning (3 credits)**

Presents an overview of biomedical engineering as it applies to Rehabilitation Engineering, specifically, the design and prescription of prosthetic limbs, orthotic devices, and seating and positioning systems. Topics include medical terminology, musculoskeletal anatomy, muscle mechanics, soft tissue mechanics, gait/locomotion, amputation surgery, lower extremity prosthetics, lower extremity orthotics, hand function, electromyography, upper extremity prosthetics, upper extremity orthotics, seating and positioning and assistive devices.

*Level of Study:* Graduate

*Last four terms offered:* 2016 Fall Term, 2015 Fall Term, 2014 Fall Term, 2013 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205630>)

**BIEN 5640 Bioengineering of Living Actuators (3 credits)**

Overview of muscle tissue as a living actuator from the perspective of engineering design, systems biology, muscle modeling and adaptive control.

*Prerequisite:* BIEN 4700/5700.

*Level of Study:* Graduate

*Last four terms offered:* 2010 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205640>)



**BIEN 5700 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. Computer techniques and relevant instrumentation are incorporated. Experts on related topics are invited to speak as they are available.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205700>)

**BIEN 5710 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.

*Level of Study:* Graduate

*Last four terms offered:* 2020 Fall Term, 2016 Fall Term, 2015 Spring Term, 2014 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205710>)

**BIEN 5720 Cardiopulmonary Mechanics (3 credits)**

Examination of the physiological behavior of the cardiovascular and pulmonary systems from an engineering perspective. Emphasis is on understanding the mechanical basis of physiologic phenomena via experimental models.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2020 Fall Term, 2019 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205720>)

**BIEN 5931 Topics in Biomedical Engineering (1-3 credits)**

Course content announced prior to each term. Students may enroll in the course more than once as subject matter changes. Possible topics include biomechanics, experimental methods, neuroanatomy, telemetry, etc.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%205931>)

**BIEN 6120 Introduction to the Finite Element Method (3 credits)**

Introduces finite element analysis as applied to linear, static problems. Application to problems in plane strain, plane stress, and axisymmetry. Development of shape functions and element stiffness matrices. Although primarily structural analysis, also considers problems in heat transfer and fluid mechanics. Use of user-written and packaged software.

*Prerequisite:* GEEN 2130; and matrix/linear algebra or equiv.

*Level of Study:* Graduate

*Last four terms offered:* 2010 Fall Term, 2007 Spring Term, 2002 Fall Term, 2001 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206120>)

**BIEN 6121 Applied Finite Element Analysis and Modeling (3 credits)**

Advanced finite element analysis as applied to nonlinear (both material and geometric nonlinearities), dynamic problems. Use of penalty methods and perturbed Lagrangian methods. Use of user-written and packaged software. Critical reviews of finite element analysis in biomechanical research.

*Prerequisite:* BIEN 6120; or CEEN 6120 or equiv.

*Level of Study:* Graduate

*Last four terms offered:* 1998 Spring Term, 1997 Spring Term, 1996 Spring Term, 1995 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206121>)

**BIEN 6200 Biomedical Signal Processing (3 credits)**

Introduces students to statistical processing of biomedical data. Topics include: data acquisition, probability and estimation, signal averaging, power spectrum analysis, windowing, digital filters and data compression. Students complete several computer projects which apply these processing methods to physiologic signals.

*Prerequisite:* MATH 2451; and proficiency in C or FORTRAN.

*Level of Study:* Graduate

*Last four terms offered:* 2022 Fall Term, 2021 Fall Term, 2019 Spring Term, 2012 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206200>)

**BIEN 6210 Advanced Biomedical Signal Processing (3 credits)**

Covers modern methods of signal processing encountered in the bio-medical field including parametric modeling, modern spectral estimation, multivariate analysis, adaptive signal processing, decimation/interpolation, and two-dimensional signal analysis. Students complete several computer projects which apply these modern techniques to physiologic data.; knowledge of C or FORTRAN.

*Prerequisite:* BIEN 6200 or equiv.

*Level of Study:* Graduate

*Last four terms offered:* 2013 Fall Term, 2010 Spring Term, 2009 Spring Term, 2007 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206210>)

**BIEN 6220 Multidimensional Biomedical Time Series Analysis (3 credits)**

Theory and implementation of methods used to collect, model and analyze multidimensional time series encountered in biomedical applications such as functional imaging, electrophysiologic mapping and the study of physiologic control systems.

*Prerequisite:* BIEN 6200; proficiency in C or FORTRAN.

*Level of Study:* Graduate

*Last four terms offered:* 2006 Spring Term, 2001 Fall Term, 2001 Spring Term, 1999 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206220>)

**BIEN 6300 Biomedical Instrumentation (3 credits)**

Explores relationships between instruments for physiologic measurement and monitoring with living systems. Physiologic signals, noise, and available sensors and transducers and their characteristics are discussed from time and frequency domain points of view. Systems topics include various new and conventional medical instrumentation. Other topics include clinical and new clinical laboratory instrumentation, instrumentation for research, artificial organs and prostheses. Includes the use of scientific literature, literature searches, design projects, computer projects.

*Prerequisite:* BIEN 5700; or BIEN 5320; and high level computer language or equiv.

*Level of Study:* Graduate

*Last four terms offered:* 2001 Spring Term, 1999 Fall Term, 1998 Spring Term, 1996 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206300>)

**BIEN 6301 Clinical Need Finding (3 credits)**

Provides students with the tools and mindset to be able to identify needs within the clinical environment. A key element presented is the ability to employ observational research techniques to identify capability gaps, employed workarounds, and undiscovered opportunities – without exclusively relying on what the end user communicates. Topics include clinical terminology and common devices, stakeholder perspectives, U.S. FDA regulatory requirements, international standards, systems and inclusive design methodologies, observation and ethnographic skills, and bioethical considerations.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206301>)

**BIEN 6302 Clinical Observation (3 credits)**

Provides students with an immersive, experiential learning opportunity within the clinical environment. Students complete a series of immersion experiences with different clinics to facilitate clinician-designer interactions that cannot otherwise be easily replicated. These interactions will help designers to identify new opportunities, improve medical devices, or create new approaches to solve problems often encountered by clinicians and medical professionals. Students also complete simulation lab experience as part of their immersion experience.

*Prerequisite:* BIEN 6301.

*Level of Study:* Graduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206302>)

**BIEN 6310 Microprocessor Based Biomedical Instrumentation (3 credits)**

Discusses the application of microprocessors, microcontrollers, and digital signal processors to biomedical instrumentation. Complements BIEN 6300, which covers transducers, sensors, analog signal conditioning, and analog to digital conversion. Emphasizes evaluating the memory, power, resolution, cost, and computational requirements of a particular application, and then selecting a type (microprocessor, microcontroller, or digital signal processor) and particular model of processor to satisfy the system requirements. Students design at least two complete processor based systems.

*Prerequisite:* Knowledge of digital electronics and microprocessors.

*Level of Study:* Graduate

*Last four terms offered:* 2002 Spring Term, 2001 Fall Term, 2000 Spring Term, 1998 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206310>)

**BIEN 6320 Radio Frequency Applications in Biomedical Engineering (3 credits)**

Radio frequency design and applications for biomedical engineering and medicine. Circuit elements, equivalent circuits, impedance transformations, Smith Chart, two ports, scattering parameters, amplifiers, resonant circuits, mixers, receivers. Applications include telemetry, transcutaneous power transfer, hyperthermia, rf ablation, magnetic resonance imaging; HP-EESOF LIBRA and Ascent CAD are introduced as analysis and design tools. Guest speakers. Written and oral design reports.

*Prerequisite:* Undergraduate background in circuit theory and analog electronics.

*Level of Study:* Graduate

*Last four terms offered:* 2010 Spring Term, 2007 Fall Term, 2005 Spring Term, 2003 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206320>)

**BIEN 6400 Biofluid Mechanics (3 credits)**

Development of the theory of fluid mechanics as applied to living systems. Considers both steady and unsteady flows of Newtonian and non-Newtonian fluids. Topics include: viscometry, blood flow, gas and aerosol flows, pulsatile flow and wave propagation and applications to the understanding of flows in organs and to the measurement of blood pressure and flow.; or MEEN 3320 or CEEN 3150.

*Prerequisite:* BIEN 4400 or equiv.

*Level of Study:* Graduate

*Last four terms offered:* 2008 Fall Term, 2003 Fall Term, 2000 Fall Term, 1998 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206400>)

**BIEN 6410 Biological Mass Transfer (3 credits)**

Development of the theory of mass transfer. Fick's law and free diffusion. Osmosis, facilitated diffusion, active transport, transport across cell membranes and applications to cell biology and organ physiology.

*Level of Study:* Graduate

*Last four terms offered:* 2004 Fall Term, 2001 Fall Term, 2001 Spring Term, 1997 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206410>)

**BIEN 6420 Biomechanical and Biomaterial Systems Analysis (3 credits)**

Using fundamentals of biomaterials engineering and biocompatibility, analyzes the functions that organs serve and to analyze the efficacy and safety of artificial organs systems. Some organs/tissues discussed include the kidneys, liver, skeleton, skin, heart, muscles, eyes, and ears. Critically examines the suitability of state-of-the-art artificial organ systems, including artificial hearts, orthopaedic prostheses, kidney dialyzers, and cochlear devices to fulfill the functions of the replaced organs/tissues.

*Prerequisite:* BIEN 5420.

*Level of Study:* Graduate

*Last four terms offered:* 1992 Fall Term, 1990 Fall Term, 1988 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206420>)

**BIEN 6440 Biomedical Engineering Analysis of Trauma (3 credits)**

An engineering analysis of the physiological changes following impact to the head, spinal cord, and limbs, and electrical events and effects on tissues are treated.

*Level of Study:* Graduate

*Last four terms offered:* 2022 Spring Term, 2019 Spring Term, 2015 Fall Term, 2013 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206440>)

**BIEN 6450 Musculoskeletal Biomechanics 1 (3 credits)**

Emphasizes the interrelationship of force and motion as related to anatomic structure and function. Examines the forces and motions acting in the skeletal system and the various techniques used to describe them. Highlights current concepts as revealed in the recent scientific and engineering literature. Topics include: bone mechanics, joint mechanics, gait kinematics, instrumentation and measurement of biomechanical phenomena, and computer modeling of the musculoskeletal system.

*Prerequisite:* GEEN 2120 and GEEN 2130.

*Level of Study:* Graduate

*Last four terms offered:* 2012 Fall Term, 2006 Fall Term, 2002 Fall Term, 2001 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206450>)

**BIEN 6451 Musculoskeletal Biomechanics 2 (3 credits)**

Advanced concepts of kinematics and mechanics as they apply to the fields of biomechanics and rehabilitation. Covers aspects of gait, bone and joint surgery, and soft tissue surgery. Detailed study of joint mechanics, implant applications and mobility device function is performed. Includes advanced analysis and modeling as well as laboratory-based final project.

*Prerequisite:* BIEN 6450.

*Level of Study:* Graduate

*Last four terms offered:* 2016 Fall Term, 2014 Fall Term, 2010 Fall Term, 2007 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206451>)

**BIEN 6470 Biomechanics of the Spine (3 credits)**

Analyzes anatomical and functional relationships among the hard and soft tissue structures of the spine as a function of vertebral column development, aging, disease and trauma. Emphasis given to the mechanisms of external and internal load transfer. Imaging (e.g. CT), experimental and finite element methods are used to study the effects of physiologic/traumatic loading, surgery and spinal disorders. Discusses current advancements in biomechanical/clinical literature.

*Level of Study:* Graduate

*Last four terms offered:* 2000 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206470>)

**BIEN 6500 Mathematics of Medical Imaging (3 credits)**

Begins with an overview of the application of linear systems theory to radiographic imaging (pinhole imaging, transmission and emission tomography), and covers the mathematics of computed tomography including the analytic theory of reconstructing from projections and extensions to emission computed tomography and magnetic resonance imaging. Topics may also include three-dimensional imaging, noise analysis and image quality, and optimization. Contains advanced mathematical content.

*Level of Study:* Graduate

*Last four terms offered:* 2018 Spring Term, 2015 Spring Term, 2012 Spring Term, 2008 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206500>)

**BIEN 6600 Neuromotor Control (3 credits)**

Overview of current issues in neuromotor control and movement biomechanics. Special emphasis on the study of normal and impaired human movement. Topics include: muscle mechanics, biomechanics of movement, neural circuitry, strategies for the neural control of movement (including a discussion of adaptation and motor learning) and potential applications of biomedical engineering techniques to the study and improvement of impaired motor function.; or cons. of instr.

*Prerequisite:* BIEN 3300 which may be taken concurrently or equiv.

*Level of Study:* Graduate

*Last four terms offered:* 2022 Fall Term, 2016 Fall Term, 2015 Spring Term, 2011 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206600>)

**BIEN 6610 Rehabilitative Biosystems (3 credits)**

Examines the plastic changes in biological systems that occur in response to targeted stimuli. These processes involve responses by cells to chemical, mechanical, or electrical stimuli (which may be related), which may be influenced or directed using engineering techniques. Examines the homeostasis of physiologic systems and their response to pathologic and rehabilitative stimuli. Examines engineering applications involving the diagnosis and rehabilitation of musculoskeletal, neurologic and cardiopulmonary biosystems in the context of the underlying cellular mechanisms.

*Prerequisite:* BIEN 5700 which may be taken concurrently; and PHYS 1004.

*Level of Study:* Graduate

*Last four terms offered:* 2021 Spring Term, 2010 Spring Term, 2008 Fall Term, 2005 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206610>)

**BIEN 6620 Modeling Rehabilitative Biosystems (3 credits)**

Introduction to large-scale mathematical models of various physiological systems of interest in rehabilitation (e.g., cardiovascular, pulmonary, musculoskeletal, etc.). Discusses mathematical modeling, a widely used tool for testing hypotheses regarding the underlying mechanisms of complex systems such as physiological systems in health, disease and recovery. For each, simulation is used to further our understanding of the adaptive processes of these systems in response to physiological/pathophysiological stresses and rehabilitative interventions.

*Prerequisite:* BIEN 5710 and BIEN 5700.

*Level of Study:* Graduate

*Last four terms offered:* 2016 Fall Term, 2014 Fall Term, 2011 Spring Term, 2007 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206620>)

**BIEN 6700 Analysis of Physiological Systems (3 credits)**

Introduction to the use of mathematical models in quantifying physiological systems. Analyzes model formulation. Applications of analytical and numerical solution techniques and parameter estimation methods.

*Prerequisite:* BIEN 5710.

*Level of Study:* Graduate

*Last four terms offered:* 1996 Spring Term, 1994 Spring Term, 1988 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206700>)

**BIEN 6710 Cellular and Molecular Bioengineering (3 credits)**

Main topics include: cellular biomechanics with an emphasis on the cardiovascular system, molecular bioengineering, biotransport phenomena, and tissue engineering with focus on artificial internal organs. Cellular biomechanics topics covered are biomechanics of the endothelium, endothelial-immune cell interactions, and blood cell structural biomechanics. Topics in molecular bioengineering include chemotaxis and chemokinesis, and modeling of receptor-mediated endocytosis. Biotransport and tissue engineering topics include bioreactor design and the analysis and development of artificial internal organs like the liver and pancreas.

*Level of Study:* Graduate

*Last four terms offered:* 2019 Fall Term, 2002 Fall Term, 1999 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206710>)

**BIEN 6931 Topics in Biomedical Engineering (3 credits)**

Subject matter variable as determined by needs of biomedical graduate students. Students may enroll more than once as the subject matter changes. Possible topics: biostatistics, experimental methods, neuro-anatomy, etc.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206931>)

**BIEN 6932 Advanced Topics in Biomedical Engineering (3 credits)**

Advanced topics in design and analysis of biomedical instruments, devices and interfaces. Project approach drawing from current literature and current projects of laboratories of affiliated institutions. Topics include bioelectronics, biomechanics, biomaterials, and rehabilitation engineering.

*Level of Study:* Graduate

*Last four terms offered:* 2014 Spring Term, 2013 Spring Term, 2009 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206932>)

**BIEN 6947 Medical College of Wisconsin/Joint Degree (1-8 credits)**

Graduate-level course in selected areas of the life sciences offered at the Medical College of Wisconsin. May be taken by doctorate BIEN students at Marquette University.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2019 Fall Term, 2017 Fall Term, 2016 Fall Term, 2016 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206947>)

**BIEN 6953 Seminar in Biomedical Engineering (0 credits)**

Scholarly presentations on current topics in biomedical engineering and related areas by visiting professors, resident faculty and graduate students. Attendance is required of all full-time graduate students. SNC/UNC grade assessment. Mandatory for all full-time BIEN graduate students.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206953>)

**BIEN 6954 Seminar in Biomedical Computing (0 credits)**

Scholarly presentations on current topics in biomedical engineering and related areas by visiting professors, resident faculty and graduate students. Attendance is required of all full-time graduate students. SNC/UNC grade assessment. Mandatory for all full-time BIEN graduate students.

*Level of Study:* Graduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206954>)

**BIEN 6960 Seminar: Journal Club (0-3 credits)**

0 credit will be SNC/UNC grade assessment; 1-3 credits will be graded.

*Level of Study:* Graduate

*Last four terms offered:* 2022 Spring Term, 2007 Fall Term, 2005 Fall Term, 1996 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206960>)

**BIEN 6995 Independent Study in Biomedical Engineering (1-3 credits)**

Faculty-supervised, independent study/research of a specific area or topic in Biomedical Engineering.

*Prerequisite:* Cons. of instr. and cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Fall Term, 2021 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206995>)

**BIEN 6999 Master's Thesis (1-6 credits)**

S/U grade assessment.

*Prerequisite:* Cons. of instr.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Summer Term, 2022 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%206999>)

**BIEN 8110 Research Methodologies 1 (3 credits)**

Development of research aims and hypotheses, identification of relevant scientific literature, experimental approaches, statistical design, and pilot work to obtain preliminary results. Emphasizes written communication of research theme. The course project consists of the development of a research proposal including research aims, background, pilot experiments, and experimental design and methodology.

*Prerequisite:* Accepted Ph.D. student in biomedical engineering.

*Level of Study:* Graduate

*Last four terms offered:* 2021 Spring Term, 2020 Fall Term, 2020 Spring Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%208110>)

**BIEN 8120 Research Methodologies 2 (3 credits)**

Oral and written communication of research results including graphics and text. Addresses graphical presentation of data and conceptual development of a scientific presentation and a manuscript. Emphasizes the basics of clear and effective scientific communication. Work culminates in the development of a scientific manuscript for peer review.

*Prerequisite:* Accepted Ph.D. student in biomedical engineering.

*Level of Study:* Graduate

*Last four terms offered:* 2020 Fall Term, 2019 Spring Term, 2017 Fall Term, 2016 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%208120>)

**BIEN 8210 Teaching Methodologies (3 credits)**

Seminar aimed at issues important for teaching in a university setting. Topics include: development of teaching philosophy, planning a class, designing a syllabus, assessing student learning and using technology in the classroom. Taught in conjunction with the Preparing Future Faculty (PFF) program.

*Prerequisite:* Accepted Ph.D. student in biomedical engineering.

*Level of Study:* Graduate

*Last four terms offered:* 2017 Spring Term, 2016 Spring Term, 2015 Spring Term, 2014 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%208210>)



**BIEN 8995 Independent Study in Biomedical Engineering (1-3 credits)**

In-depth research on a topic or subject matter usually not offered in the established curriculum with faculty and independent of the classroom setting.

*Prerequisite:* Cons. of instr. and cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2022 Spring Term, 2021 Fall Term, 2020 Fall Term, 2020 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%208995>)

**BIEN 8999 Doctoral Dissertation (1-12 credits)**

S/U grade assessment.

*Prerequisite:* Cons. of instr.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Spring Term, 2021 Spring Term, 2020 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%208999>)

**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. SNC/UNC grade assessment.

*Prerequisite:* cons. of dpt. ch.

*Level of Study:* Undergraduate

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209002>)

**BIEN 9970 Graduate Standing Continuation: Less than Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Designated as less than half-time status only, cannot be used in conjunction with other courses, and does not qualify students for financial aid or loan deferment.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2021 Fall Term, 2021 Spring Term, 2020 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209970>)

**BIEN 9974 Graduate Fellowship: Full-Time (0 credits)**

Fee. SNC/UNC grade assessment. Designated as full-time status. If a student is already registered in other courses full time, this continuation course is not needed.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2019 Spring Term, 2018 Fall Term, 2018 Spring Term, 2016 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209974>)

**BIEN 9975 Graduate Assistant Teaching: Full-Time (0 credits)**

Fee. SNC/UNC grade assessment. Designated as full-time status. If a student is already registered in other courses full time, this continuation course is not needed.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2021 Spring Term, 2020 Fall Term, 2020 Spring Term, 2019 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209975>)

**BIEN 9976 Graduate Assistant Research: Full-Time (0 credits)**

Fee. SNC/UNC grade assessment. Designated as full-time status. If a student is already registered in other courses full time, this continuation course is not needed.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209976>)

**BIEN 9984 Master's Comprehensive Examination Preparation: Less than Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week toward their master's comprehensive exam.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2009 Fall Term, 2008 Fall Term, 2008 Spring Term, 2007 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209984>)

**BIEN 9985 Master's Comprehensive Examination Preparation: Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week toward their master's comprehensive exam. May be taken in conjunction with credit-bearing or other non-credit courses to result in the status indicated, as deemed appropriate by the department.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2009 Fall Term, 2008 Fall Term, 2008 Spring Term, 2007 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209985>)

**BIEN 9986 Master's Comprehensive Examination Preparation: Full-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week toward their master's comprehensive exam. May be taken in conjunction with credit-bearing or other non-credit courses to result in the status indicated, as deemed appropriate by the department.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2009 Fall Term, 2008 Fall Term, 2008 Spring Term, 2007 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209986>)

**BIEN 9987 Doctoral Qualifying Examination Preparation: Less than Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week toward their doctoral qualifying exam.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2008 Spring Term, 2007 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209987>)

**BIEN 9988 Doctoral Qualifying Examination Preparation: Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week toward their doctoral qualifying exam. May be taken in conjunction with credit-bearing or other non-credit courses to result in the status indicated, as deemed appropriate by the department.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2008 Spring Term, 2007 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209988>)

**BIEN 9989 Doctoral Qualifying Examination Preparation: Full-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week toward their doctoral qualifying exam. May be taken in conjunction with credit-bearing or other non-credit courses to result in the status indicated, as deemed appropriate by the department.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2018 Spring Term, 2008 Spring Term, 2007 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209989>)

**BIEN 9991 Professional Project Continuation: Less than Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week on their professional project. Any professional project credits required for the degree should be completed before registering for non-credit Professional Project Continuation.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2012 Summer Term, 2011 Summer Term, 2010 Summer Term, 2009 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209991>)

**BIEN 9992 Professional Project Continuation: Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week on their professional project. Any project credits required for the degree should be completed before registering for non-credit Professional Project Continuation.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2012 Summer Term, 2011 Summer Term, 2010 Summer Term, 2009 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209992>)

**BIEN 9993 Professional Project Continuation: Full-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week on their professional project. Any professional project credits required for the degree should be completed before registering for non-credit Professional Project Continuation.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2012 Summer Term, 2011 Summer Term, 2010 Summer Term, 2009 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209993>)

**BIEN 9994 Master's Thesis Continuation: Less than Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week on their master's thesis. All six thesis credits required for the degree should be completed before registering for non-credit Master's Thesis Continuation.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209994>)

**BIEN 9995 Master's Thesis Continuation: Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week on their master's thesis. All six thesis credits required for the degree should be completed before registering for non-credit Master's Thesis Continuation.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Summer Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209995>)

**BIEN 9996 Master's Thesis Continuation: Full-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week on their master's thesis. All six thesis credits required for the degree should be completed before registering for non-credit Master's Thesis Continuation.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Summer Term, 2023 Spring Term, 2022 Fall Term, 2022 Summer Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209996>)

**BIEN 9997 Doctoral Dissertation Continuation: Less than Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of less than half-time status. Requires that the student is working less than 12 hours per week on their doctoral dissertation. All 12 dissertation credits required for the degree should be completed before registering for non-credit Doctoral Dissertation Continuation.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2016 Summer Term, 2016 Spring Term, 2013 Fall Term, 2012 Spring Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209997>)

**BIEN 9998 Doctoral Dissertation Continuation: Half-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of half-time status. Requires that the student is working more than 12 to less than 20 hours per week on their doctoral dissertation. All 12 dissertation credits required for the degree should be completed before registering for non-credit Doctoral Dissertation Continuation.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209998>)

**BIEN 9999 Doctoral Dissertation Continuation: Full-Time (0 credits)**

Fee. SNC/UNC grade assessment. Allows a student to be considered the equivalent of full-time status. Requires that the student is working 20 hours or more per week on their doctoral dissertation. All 12 dissertation credits required for the degree should be completed before registering for non-credit Doctoral Dissertation Continuation.

*Prerequisite:* Cons. of dept. ch.

*Level of Study:* Graduate

*Last four terms offered:* 2023 Spring Term, 2022 Fall Term, 2022 Spring Term, 2021 Fall Term

Schedule of Classes (<https://bulletin.marquette.edu/class-search/?details&code=BIEN%209999>)