Biomedical Engineering, PHD

Chairperson: Frank A. Pintar, Ph.D.
Biomedical Engineering Graduate Programs website (https://www.marquette.edu/grad/programs-biomedical-engineering.php)

Degree Offered
Doctor of Philosophy

Mission Statement
The Marquette University (MU) and Medical College of Wisconsin (MCW) Department of Biomedical Engineering is dedicated to delivering an extraordinary educational experience designed to empower the next generation of biomedical engineers, scientists and physicians. If you have a passion for learning and a desire to translate ideas into action — particularly those involving medical devices and health care technologies — let our faculty, staff and industry partners guide you on your journey. 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;
• Promoting critical thinking and lifelong learning;
• 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; and
• Inspiring faculty and students to serve others.

Program Descriptions
The MU-MCW biomedical engineering program (https://mcw.marquette.edu/biomedical-engineering/) is interdisciplinary in nature, involving the application of engineering and mathematics to the solution of problems related to medicine and biology. The faculty reflect this interdisciplinary nature in their courses and research. MU faculty are synergistically complemented by faculty from the MCW. The Department of Biomedical Engineering fosters collaborative interactions between the two institutions. Research can be characterized by the general areas of bioinstrumentation, biomechanics, biomedical imaging, cellular and molecular engineering, computational biology and bioinformatics, and rehabilitation bioengineering.

General Information
All admitted students are required to obtain and read the department’s Graduate Student Handbooks for each of the degree programs, which contains complete details about the biomedical engineering programs. The handbook for each degree is available through the Department of Biomedical Engineering website (https://mcw.marquette.edu/biomedical-engineering/graduate-studies.php).

CAREER SKILLS REQUIREMENT FOR PH.D. STUDENTS
Marquette University is committed to preparing our students to become exemplary leaders in their chosen academic and professional fields by preparing them for careers in which they find purpose and value by engaging in Ignatian pedagogical reflection and practice. The purpose of the career skills requirement is to ensure all doctoral students have the opportunity to reflect on their desired career and to acquire essential career-related skills needed for them to pursue their chosen path.

Students enrolled in Ph.D. programs in Fall 2024 and beyond at Marquette must complete three career skills requirements. Requirements are satisfied by one or more of approved courses, workshops, or practical experiences in each category, as approved by the Graduate School. Completion of each skill will be noted on the student’s transcript.

CAREER DISCERNMENT
Students will be able to identify and prepare for career pathways that are consistent with their values.

Objectives:
1. Understand realities of academic job market for your discipline, creating space for career imagination and understand potential career paths.
2. Exploration of, and defining student’s own identity/experiences/values/strengths/gifts and how the career pathway fits with those values.
3. Students will learn to identify and attain the skills and experiences necessary to obtain the career pathway they desire.

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<tr>
<td>GRAD 8097</td>
<td>Career Discernment/Career Diversity Skills (Career Development Bootcamp)</td>
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<tr>
<td>GRAD 8097</td>
<td>Career Discernment/Career Diversity Skills (Seminar Series)</td>
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Communications

Students will be able to communicate their ideas and scholarship effectively to audiences beyond those in their discipline.

Objectives:

1. Demonstrate the ability to communicate (e.g., research, expertise, experiences) effectively and ethically with disciplinary, cross-disciplinary, and nonacademic audiences.
2. Demonstrate the ability to communicate effectively and ethically within various contexts, formats, and media.
3. Demonstrate the ability to effectively deliver a presentation and facilitate discussion.

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<td>GRAD 8098</td>
<td>Communication Skills (Seminar Series)</td>
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<td>GRAD 8098</td>
<td>Communication Skills (Three Minute Thesis)</td>
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<tr>
<td>GRAD 8961</td>
<td>Science Storytelling</td>
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Understanding Diversity, Equity and Inclusion

Students will understand the importance of diversity, equity and inclusion and how issues of DEI are relevant to their career pathways.

Objectives:

1. Be aware of and able to identify how explicit and implicit bias impacts work life and understand possible strategies to address this bias.
2. Be able to articulate the value of universal design principles and ethical application to area of study.
3. Be able to work and interact effectively with persons from diverse backgrounds with varied values, ideas, and opinions.

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<td>Diversity, Equity and Inclusion Skills</td>
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Biomedical Engineering Doctorate

The doctor of philosophy (Ph.D.) degree in biomedical engineering is a joint degree between the Medical College of Wisconsin (MCW) and Marquette University. This research degree is intended to provide the graduate with the breadth and depth of knowledge in one area of specialization within biomedical engineering, as well as the scientific research training needed for successful careers in academia, biomedical industry, or government. Students choose one of the following specializations: bioinstrumentation, biomechanics, biomedical imaging, cellular and molecular engineering, computational biology and bioinformatics, and rehabilitation bioengineering.

The research training process begins with the student working closely with their dissertation director and participating in their research program. Building on these experiences, the student begins to conduct independent research that eventually leads to an original contribution to the field of biomedical engineering. The strength and efficacy of the training process depend to a large extent on the direct interactions of the student with their dissertation director and on the time the student spends in the laboratory working on their research. The importance of this research training to a Ph.D. degree in biomedical engineering is underscored in the following learning objectives:

- Conduct independent research that reflects an original contribution to biomedical engineering.
- Demonstrate technical proficiency in at least one area of biomedical engineering.
- Recognize the need to apply ethical principles in conducting research.
- Demonstrate a commitment to life-long learning by participating in local and national professional development activities on a continuing basis.

Medical College of Wisconsin (MCW) students in the combined M.D./Ph.D. Medical Scientist Training Program (MSTP) are eligible to choose the Ph.D. program of the Joint Department of Biomedical Engineering for the Ph.D. requirements of the M.D./Ph.D. degree program.

Visit the Joint Biomedical Engineering Department website (https://mcw.marquette.edu/biomedical-engineering/graduate-studies/handbooks.php) for detailed program requirements.

University Policies

- Academic Censure - Graduate School (https://bulletin.marquette.edu/policies/academic-censure/graduate/)
- Academic Integrity (https://bulletin.marquette.edu/policies/academic-integrity/)
• Academic Misconduct (https://bulletin.marquette.edu/policies/academic-misconduct-policy/)
• Academic Program Definitions (https://bulletin.marquette.edu/policies/academic-programs-defined/)
• Accelerated Degree Programs (https://bulletin.marquette.edu/policies/accelerated-degree-programs/)
• Attendance - Graduate School (https://bulletin.marquette.edu/policies/attendance/graduate/)
• Awarding Diplomas and Certificates (https://bulletin.marquette.edu/policies/awarding-diplomas-certificates/)
• Background Checks, Drug Testing (https://bulletin.marquette.edu/policies/background-checks-drug-testing/)
• Class Rank (https://bulletin.marquette.edu/policies/class-rank/)
• Commencement (https://bulletin.marquette.edu/policies/commencement/)
• Course Levels (https://bulletin.marquette.edu/policies/course-levels/)
• Credit Hour (https://bulletin.marquette.edu/policies/credit/)
• Credit Load - Graduate School (https://bulletin.marquette.edu/policies/credit-load/graduate/)
• Faculty Grading (https://bulletin.marquette.edu/policies/faculty-grading/)
• Family Education Rights and Privacy Act-FERPA (https://bulletin.marquette.edu/policies/ferpa/)
• Grade Appeals (https://bulletin.marquette.edu/policies/grade-appeals/)
• Grading System - Graduate School and Graduate School of Management (https://bulletin.marquette.edu/policies/grading-system/graduate-management/)
• Graduation - Graduate School (https://bulletin.marquette.edu/policies/graduation/graduate/)
• Immunization and Tuberculosis Screening Requirements (https://bulletin.marquette.edu/policies/immunization-and-tuberculosis-screening/)
• Last Date of Attendance/Activity (https://bulletin.marquette.edu/policies/last-dateof-attendance-activity/)
• Military Call to Active Duty or Training (https://bulletin.marquette.edu/policies/militarycall-active-duty-training/)
• Registration - Graduate School (https://bulletin.marquette.edu/policies/registration/graduate/)
• Repeated Courses - Graduate School (https://bulletin.marquette.edu/policies/repeated-courses/graduate/)
• Student Data Use and Privacy (https://bulletin.marquette.edu/policies/student-data-use-privacy/)
• Transcripts-Official (https://bulletin.marquette.edu/policies/transcripts-official/)
• Transfer Course Credit - Graduate School (https://bulletin.marquette.edu/policies/transfer-course-credit-policy/graduate/)
• Withdrawal - Graduate School (https://bulletin.marquette.edu/policies/withdrawals/graduate/)

Graduate School Policies

• Academic Performance (https://bulletin.marquette.edu/graduate/policies/academic-performance/)
• Advising (https://bulletin.marquette.edu/graduate/policies/advising/)
• Certificate Concurrent Enrollment (https://bulletin.marquette.edu/graduate/policies/certificate-concurrent-enrollment/)
• Conduct (https://bulletin.marquette.edu/graduate/policies/conduct/)
• Confidentiality of Proprietary Information (https://bulletin.marquette.edu/graduate/policies/confidentiality-proprietary-information/)
• Continuous Enrollment (https://bulletin.marquette.edu/graduate/policies/continuous-enrollment/)
• Courses and Prerequisites (https://bulletin.marquette.edu/graduate/policies/courses-prerequisites/)
• Cross-listed Courses (https://bulletin.marquette.edu/graduate/policies/cross-listed-courses/)
• Deadlines (https://bulletin.marquette.edu/graduate/policies/deadlines/)
• Doctoral Degree Academic Program Overview (https://bulletin.marquette.edu/graduate/policies/doctoral-program-overview/)
• Graduate Credit (https://bulletin.marquette.edu/graduate/policies/graduate-credit/)
• Graduate School Policies (https://bulletin.marquette.edu/graduate/policies/)
• Independent Study (https://bulletin.marquette.edu/graduate/policies/independent-study/)
• Intellectual Property (https://bulletin.marquette.edu/graduate/policies/intellectual-property/)
• Master's Degree Academic Program Overview (https://bulletin.marquette.edu/graduate/policies/master-program-overview/)
• Merit-Based Aid Registration Requirements (https://bulletin.marquette.edu/graduate/policies/merit-based-aid-registration-requirements/)
• Research Involving Humans, Animals, Radioisotopes or Recombinant DNA/Transgenic Organisms (https://bulletin.marquette.edu/graduate/policies/research-involving-humans-animals-radioisotopes-recombinant-dnatriangenic-organisms/)
• Temporary Withdrawal from Graduate Program (https://bulletin.marquette.edu/graduate/policies/temporary-withdrawal-graduate-program/)
• Time Limitations (https://bulletin.marquette.edu/graduate/policies/time-limitations/)
• Working with Minors (https://bulletin.marquette.edu/graduate/policies/working-minors/)
Biomedical Engineering 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 (p. 1)

**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: 2024 Spring Term, 2023 Spring Term, 2022 Spring Term, 2021 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: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 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: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 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: 2024 Spring Term, 2022 Spring Term, 2020 Spring Term, 2019 Spring Term*

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

**BIEN 5430 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.

*Level of Study: Graduate*

*Schedule of Classes* (https://bulletin.marquette.edu/class-search/?details&code=BIEN%205430)
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: 2023 Fall Term, 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: 2024 Spring Term, 2023 Spring Term, 2022 Spring Term, 2019 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 neuropsychiatric 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: 2023 Fall Term, 2013 Spring Term, 2012 Spring Term, 2011 Spring Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%205610)

BIEN 5620 Rehabilitation Engineering: Teleshabilitation 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: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 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 (compartamental) 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: 2023 Fall Term, 2020 Fall Term, 2016 Fall Term, 2015 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: 2024 Spring Term, 2022 Fall Term, 2021 Fall Term, 2019 Spring 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: 2024 Spring Term, 2022 Fall Term, 2021 Fall Term, 2019 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. 
Prerequisite: BIEN 6200 or equiv.; knowledge of C or FORTRAN.
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: 2024 Spring Term, 2023 Fall Term, 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
Last four terms offered: 2024 Spring Term, 2023 Fall Term
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.
Prerequisite: BIEN 4400 or equiv.; or MEEN 3320 or CEEN 3150.
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 6430 Advanced Tissue Engineering (3 credits)
Explores advanced topics in 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. Students select applications of tissue engineering, review recent academic research as reported in the scientific literature, and present their findings to the class. Example tissue applications to be covered include: skin, blood vessels, nervous tissue, heart tissue, heart valves, tendons, ligaments, bone, muscle, pancreas, bladder and whole organs.
Prerequisite: BIEN 5430 recommended.
Level of Study: Graduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%206430)

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: 2023 Fall Term, 2012 Fall Term, 2006 Fall Term, 2002 Fall 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.

*Prerequisite:* BIEN 3300 which may be taken concurrently or equiv.; or cons. of instr.

*Level of Study: Graduate*

*Last four terms offered:* 2024 Spring Term, 2022 Fall Term, 2016 Fall Term, 2015 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 vary), 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 Fall Term, 2023 Spring Term, 2022 Spring Term, 2021 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: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 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: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 Spring 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: 2024 Summer Term, 2024 Spring Term, 2023 Fall Term, 2023 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](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](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:* 2023 Fall Term, 2022 Spring Term, 2021 Fall Term, 2020 Fall Term

*Schedule of Classes* ([https://bulletin.marquette.edu/class-search/?details&code=BIEN%208995](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](https://bulletin.marquette.edu/class-search/?details&code=BIEN%208999))

**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](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](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](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 Fall Term, 2023 Spring Term, 2022 Fall Term, 2022 Spring Term

*Schedule of Classes* ([https://bulletin.marquette.edu/class-search/?details&code=BIEN%209976](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](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](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](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](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](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, 2007 Fall Term
- **Schedule of Classes** ([https://bulletin.marquette.edu/class-search/?details&code=BIEN%209989](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](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 Fall Term, 2023 Spring Term, 2022 Fall Term, 2022 Spring 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: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 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: 2024 Summer Term, 2024 Spring Term, 2023 Fall Term, 2023 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: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 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: 2024 Spring Term, 2023 Fall Term, 2023 Spring Term, 2022 Fall Term
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%209999)