Biomedical Engineering

M.S. in Biomedical Engineering (https://catalog.und.edu/graduateacademicinformation/departmentalcoursesprograms/engineering/biomedicalengineering/ms/)

Ph.D. in Biomedical Engineering (https://catalog.und.edu/graduateacademicinformation/departmentalcoursesprograms/engineering/biomedicalengineering/phd/)

Graduate Certificate in Biomedical IoT Devices

BME 510. Graduate Internship. 1-6 Credits.
A practical research experience with an employer or another research laboratory closely associated with the student's academic research area. A written report and an oral presentation are required. Prerequisite: Advisor approval is required; must be eligible to legally work at the site. Repeatable to 6.00 credits. S/U grading. F,S,SS.

BME 599. Doctoral Research. 1-15 Credits.
Doctoral research for Ph.D. students in BME. Repeatable to 15.00 credits. F,S,SS.

BME 621. Software for Biomedical Engineering. 3 Credits.
This course is designed to develop the student in; 1) the exposure at a high-level to various biomedical engineering software tools, 2) applying one software tool applied to the team innovation project chosen by the student, 3) the software engineering perspectives of biomedical concepts, 4) professionalism, and 5) ethical and regulatory issues. Prerequisite: Knowledge of computer programming. On demand.

BME 622. Introduction to NeuroEngineering. 3 Credits.
This course is designed to develop the student in; 1) the understanding and application of fundamental neural engineering concepts, 2) understanding and analysis of the nervous system and neurological disorders 3) the design, analysis, and evaluation of current neural engineering challenges, 4) professionalism, and 5) ethical and regulatory issues. Prerequisite or Corequisite: BME 632 or BME 630 or by instructor approval. On demand.

BME 624. Computational neuroengineering of innovation. 3 Credits.
This course is designed to develop the student in: 1) navigating the balance between reductive science and complexity, 2) applying inductive, deductive, and abductive reasoning, 3) exploring the integration of wetware with computational models, 4) understanding and analyzing learning models, including artificial neural networks (ANN) and reinforcement learning (RL), 5) addressing professionalism, and ethical and regulatory issues. Prerequisite or Corequisite: BME 631 or BME 630 or by instructor approval. On demand.

BME 625. Biomedical Applications of RF/Microwaves. 3 Credits.
This course is designed to develop the student in: 1) microwave radiation and its applications to biological systems for communications, power, sensing, and therapy, 2) the practice of medical device and process innovation, 3) professionalism, and 4) ethical and regulatory issues. Prerequisite: Knowledge of electromagnetics. On demand.

BME 630. Anatomy and Physiology for Biomedical Engineers. 6 Credits.
Biomedical engineering is a growing field of engineering that requires a fundamental understanding of human anatomy and physiology. This course is intended to provide a foundation for biomedical engineers with a focus on learning necessary terminologies, concepts, and functions essential to human anatomy and physiology. Prerequisite: Consent of instructor. F.

BME 631. Anatomy and Physiology for Biomedical Engineers I. 4 Credits.
This course is designed to develop the student in; 1) the practice of medical device and process innovation, 2) the engineering perspective of physiological concepts, 3) professionalism, and 4) ethical and regulatory issues. The course uses an established experiential learning model termed Innovation-Based learning. In innovation-based learning, students select an innovation project, form teams, and throughout the semester, learn to integrate physiological knowledge with ethical and regulatory constraints to produce an innovation in the biomedical engineering space while gaining professional skills. Student assessment of learning is accomplished through mastery of pillar concepts, generation of project tokens, and communicating the innovation to society. Prerequisite: Background knowledge in differential equations, physics of electric and magnetic fields, introductory chemistry, or by instructor approval. F.

BME 632. Anatomy and Physiology for Biomedical Engineers II. 4 Credits.
This course is designed to develop the student in; 1) the practice of medical device and process innovation, 2) the engineering perspective of physiological concepts, 3) professionalism, and 4) ethical and regulatory issues. The course uses an established experiential learning model termed Innovation-Based learning. In innovation-based learning, students select an innovation project, form teams, and throughout the semester, learn to integrate physiological knowledge with ethical and regulatory constraints to produce an innovation in the biomedical engineering space while gaining professional skills. Student assessment of learning is accomplished through mastery of pillar concepts, generation of project tokens, and communicating the innovation to society. Prerequisite: BME 631 with a "C" or better, or by instructor approval. S.

BME 643. BioPhotonics. 3 Credits.
This course introduces the fundamentals of Biophotonics, exploring how light interacts with biological tissues for imaging, and diagnostics. Designed for students in Biomedical and Electrical Engineering, the course combines theory with hands-on experience using experimental kits for absorption, scattering, spectroscopy, and fluorescence with the focus on tissue optics. Kits include a Raspberry Pi, camera, and custom 3D-printed components for building optical setups, with data analysis performed using Matlab and ImageJ. Students work in teams, supported by a lab assistant and interactive office hours, applying photonic technologies to real-world clinical and research problems. Prerequisite: BME 450 or BME 650. S.

BME 644. Advanced Imaging Systems in Biomedicine. 3 Credits.
This course covers foundational and advanced concepts in biomedical imaging, including X-ray, MRI, ultrasound, spectroscopy, and emerging optical methods like OCT and hyperspectral imaging. Aimed at engineering students interested in medical imaging, it emphasizes the principles, advantages, limitations, and clinical applications of each modality. Students gain a solid understanding of image quality, resolution, contrast, and the effects of tissue properties on imaging, while also exploring the application of these technologies. Prerequisite: Knowledge of Linear system and Fourier transform and Differential equations. F, odd years.

BME 650. Medical IoT Innovation I: Biomedical Instrumentation. 3 Credits.
The course focuses on both theoretical and practical aspects of biomedical instruments. The course includes a special emphasis on laboratory activities. There is also a strong innovation component to the course expecting the students to produce an innovation at the end of their semester using principles learned in the course and present their results to the class. This is a graduate level class. Thus, graduate students are expected to work on a project of greater scope/complexity than undergraduates. Students in this course often demonstrate their learning through project outputs such as a conference or journal publication. Publications by graduate students will demonstrate higher-levels of critical thinking and data analysis. Prerequisite: Background knowledge of electrical circuit theory. Prerequisite or Corequisite: BME 631. F.

BME 651. Medical IoT Innovation II: Digital Data Use. 3 Credits.
The course covers both theoretical and practical aspects of uploading, processing, managing, and interpreting data from biomedical instruments. The course includes a special emphasis on laboratory activities. There is also a strong innovation component to the course expecting the students to produce an innovation at the end of their semester using principles learned in the course and present their results to the class. This is a graduate level class. Thus, graduate students are expected to work on a project of greater scope/complexity than undergraduates. Students in this course often demonstrate their learning through project outputs such as a conference or journal publication. Publications by graduate students will demonstrate higher-levels of critical thinking and data analysis. Prerequisite: BME 650, and background knowledge in software programming and statistics. S.

BME 670. Seminar for Biomedical Engineers. 1-3 Credits.
The purpose of the course is to practice communication skills in writing papers and preparing presentations. Prerequisite: Consent of instructor. Repeatable to 3.00 credits. F,S.

BME 671. Medical Device Regulatory and Commercialization. 3 Credits.
This course is to provide a roadmap for medical device commercialization and to address various requirements of regulatory considerations for inventors. There is an emphasis on verifying an Idea has the potential to be developed into a Product and can be viable in the Marketplace. A commercialization plan for a medical device typically includes the successful implementation of several key elements and strategies to achieve commercial success. On demand.

BME 672. Quality Engineering. 3 Credits.
This course is designed to develop the student in; 1) the practice of medical device and process innovation, 2) best practices in quality engineering, 3) professionalism, and 4) ethical and regulatory issues. Prerequisite: BME 671 with a grade of C or higher. On demand.

BME 673. Risk Management. 3 Credits.
This course is designed to develop the student in; 1) the practice of medical device and process innovation, 2) best practices in risk management, 3) professionalism, and 4) ethical and regulatory issues. Prerequisite: BME 671 with a grade of C or higher. On demand.

BME 674. Good Manufacturing Practice. 3 Credits.
This course is designed to develop the student in; 1) the practice of medical device and process innovation, 2) FDA CGMP (Current Good Manufacturing Practice) requirements and processes, 3) professionalism, and 4) ethical and regulatory issues. Prerequisite: BME 671 with a grade of C or higher. On demand.

BME 675. Medical Device Commercialization. 3 Credits.
This course is designed to develop the student in; 1) the practice of medical device and process innovation, 2) commercialization, reimbursement, supply chain, patenting, fundraising, product pipeline, and exit strategy, 3) professionalism, and 4) ethical and regulatory issues. Prerequisite: BME 671 with a grade of C or higher. On demand.

BME 676. Product Safety. 3 Credits.
This course is designed to develop the student in; 1) the practice of medical device and process innovation, 2) product safety design and testing requirements, 3) professionalism, and 4) ethical and regulatory issues. On demand.

BME 677. FDA Regulatory Approval Pathways. 3 Credits.
This course is designed to develop the student in; 1) the practice of medical device and process innovation, 2) different FDA Regulatory Approval Pathways, 3) professionalism, and 4) ethical and regulatory issues. Prerequisite: BME 671 with a grade of C or higher. On demand.

BME 678. Verification & Validation. 3 Credits.
This course is designed to develop the student in; 1) the practice of medical device and process innovation, 2) industry best practices related to formal verification and validation of products and processes, 3) professionalism, and 4) ethical and regulatory issues. Prerequisite: BME 671 with a grade of C or higher. On demand.

BME 690. Special Topics in Biomedical Engineering. 1-9 Credits.
Special topics for graduate students in BME. Repeatable to 9.00 credits. F,S,SS.

BME 996. Continuing Enrollment. 1-12 Credits.
Continuing enrollment for graduate students in BME. Repeatable to 12.00 credits. S/U grading. F,S,SS.

BME 997. MS Project. 1-3 Credits.
This is the course required for the students in non-thesis based MS program in BME. Prerequisite: Consent of advisor. Repeatable to 3.00 credits. F,S,SS.

BME 998. MS Thesis. 1-9 Credits.
Thesis for students in the thesis-based MS program in BME. Repeatable to 9.00 credits. F,S,SS.

BME 999. PhD Dissertation. 1-15 Credits.
Dissertation for Ph.D. students in BME. Repeatable to 15.00 credits. F,S,SS.

Undergraduate Courses for Graduate Credit

BME 421. Software for Biomedical Engineering. 3 Credits.
This course is designed to develop the student in; 1) the exposure at a high-level to various biomedical engineering software tools, 2) applying one software tool applied to the team innovation project chosen by the student, 3) the software engineering perspectives of biomedical concepts, 4) professionalism, and 5) ethical and regulatory issues. The course is delivered via in-person, synchronous, and asynchronous modes using an established experiential learning model termed Innovation-Based learning. In innovation-based learning, students select an innovation project, form teams, and throughout the semester, learn to integrate engineering knowledge with ethical and regulatory constraints to produce an innovation in the biomedical engineering space while gaining professional skills. Students in this class must show mastery in the use of at least one software in the innovation projects. Student assessment of learning is accomplished through mastery of pillar concepts, generation of project tokens, and communicating the innovation to society. Prerequisite: Programming course - ENGR 200 or CSCI 130 or EE 304; or by instructor approval. Prerequisite or Corequisite: BME 380 or BME 631 or BME 630 or by instructor approval. F.

BME 422. Introduction to NeuroEngineering. 3 Credits.
This course is designed to develop the student in; 1) the understanding and application of fundamental neural engineering concepts, 2) understanding and analysis of the nervous system and neurological disorders 3) the design, analysis, and evaluation of current neural engineering challenges, 4) professionalism, and 5) ethical and regulatory issues. The course is delivered via in-person, synchronous, and asynchronous modes using an established experiential learning model termed Innovation-Based learning. In innovation-based learning, students select an innovation project, form teams, and throughout the semester, learn to integrate physiological knowledge with ethical and regulatory constraints to produce an innovation in the biomedical engineering space while gaining professional skills. The role of the students in innovation projects must include the use of software. Student assessment of learning is accomplished through mastery of pillar concepts, generation of project tokens, and communicating the innovation to society. Prerequisite: Background knowledge in differential equations, physics of electric and magnetic fields, introductory chemistry, or by instructor approval. Corequisite: BME 381 or by instructor approval. On demand.

BME 425. Biomedical Applications of RF/Microwaves. 3 Credits.
This course is designed to develop the student in: 1) microwave radiation and its applications to biological systems for communications, power, sensing, and therapy, 2) the practice of medical device and process innovation, 3) professionalism, and 4) ethical and regulatory issues. The course is delivered via in-person, synchronous and asynchronous modes using an established experiential learning model termed Innovation-Based learning. In innovation-based learning, students select an innovation project, form teams, and throughout the semester, learn to integrate physiological knowledge with ethical and regulatory constraints to produce an innovation in the biomedical engineering space while gaining professional skills. Student assessment of learning is accomplished through mastery of pillar concepts, generation of project tokens, and communicating the innovation to society. Prerequisite: BME 180 and EE 316 both with a C or better; or Instructor Approval. F.

BME 430. Fundamentals of Biomedical Imaging. 3 Credits.
This course will discuss the physics, instrumentation, and data processing methods used in common medical imaging modalities including X-ray radiography, X-ray computed tomography, ultrasound imaging, nuclear medicine, magnetic resonance imaging. The course will also introduce emerging optical imaging techniques in medical diagnosis, including optical coherence tomography and photoacoustic imaging. The course is suitable for graduate and advanced undergraduate students. There is a strong research component to the course expecting the students to produce a written report at the end and present their results to the class. This course is also designed to bring together students with various backgrounds in physics, math and programming. Prerequisite: EE 314 or consent of instructor. F.

BME 432. Fundamentals of Biomedical Optics. 3 Credits.
Biomedical optics is an emerging interdisciplinary field where optical methods are utilized to reveal biological mechanisms, diagnose and treat diseases. This course will cover the fundamental principle of optical instruments and their applications in biology and medicine. Topics of the course include modern optical devices, optical system design, tissue optical properties, light-tissue interactions, and applications of optical instruments in biomedicine. This course is interdisciplinary and is suitable for graduate and advanced undergraduate students. There is a strong research component to the course expecting the students to produce a written report at the end and present their results to the class. This course is also designed to bring together students with various backgrounds in physics, math and programming. Prerequisite: PHYS 252 and EE 314. S.

BME 450. Biomedical Instrumentation (Medical IoT Innovation I). 3 Credits.
The goal of this course is to introduce students to engineering principles of biomedical devices. The particular emphasis is on electrical devices but an introduction to biomedical imaging modalities, biomechanics and biomaterials is also provided. The course focuses on both theoretical and practical aspects of biomedical instruments. The course includes a special emphasis on campus laboratory activities. There is also a strong research component to the course expecting the students to produce a written report at the end and present their results to the class. A student with a strong background in physics, math and also programming will be able to benefit from this course. Familiarity with electrical circuits is an asset. Prerequisite: EE 314 and EE 321. S.

BME 451. Medical IoT Innovation II: Digital Data Use. 3 Credits.
This course is designed to develop the student in; 1) the practice of medical device and process innovation, 2) the engineering perspective of physiological concepts, 3) professionalism, and 4) ethical and regulatory issues. The course utilizes innovation-based learning where the students select an innovation project, form teams, learn to integrate physiological knowledge with ethical and regulatory constraints to produce an innovation in the biomedical engineering space while gaining professional skills. Student assessment of learning is accomplished through mastery of pillar concepts, generation of project tokens, and communicating the innovation to society. Prerequisite: BME 180; CEM Core Programming Course - ENGR 200, CSCI 130, or EE 304; CEM Core Statistics Course - CHE 315, EE 318, or MATH 321; all with a grade of C or better, or Instructor Approval. On demand.

BME 460. Computational Biology. 3 Credits.
Students will be introduced to the fundamentals of molecular biology and recent advance in genomics technology. The students will be shown how to use basic computational approaches in the field. This course also aims to provide students with a practical and hands-on experience with common bioinformatics tools and databases. Students will be trained in the basic theory and application of programs used for database searching, genomic/protein sequence analysis, and prediction of genomic/protein functions. Students will also discuss the social impact of this emerging technology and overwhelming information. Hence, bioinformatics can be considered as a field of data science for solving problems in biology and human health. This course is geared toward biologists who routinely work with data and need to analyze it in a novel way, above and beyond statistical analysis, using the "machine learning" paradigm. This course teaches students how to identify variables (that explain outcomes) in an experiment and use techniques to filter, manipulate and act upon the data. Prerequisite: EE 304 and BIMD 221. F.