BIOMEDICAL ENGINEERING, PHD

REQUIREMENTS

MINIMUM GRADUATE SCHOOL REQUIREMENTS

Review the Graduate School minimum academic progress and degree requirements (http://guide.wisc.edu/graduate/#policiesandrequirementstext), in addition to the program requirements listed below.

MAJOR REQUIREMENTS

MODE OF INSTRUCTION

Face to Face	Evening/ Weekend	Online	Hybrid	Accelerated
Yes	No	No	No	No

Mode of Instruction Definitions

Accelerated: Accelerated programs are offered at a fast pace that condenses the time to completion. Students typically take enough credits aimed at completing the program in a year or two.

Evening/Weekend: Courses meet on the UW–Madison campus only in evenings and/or on weekends to accommodate typical business schedules. Students have the advantages of face-to-face courses with the flexibility to keep work and other life commitments.

Face-to-Face: Courses typically meet during weekdays on the UW-Madison Campus.

Hybrid: These programs combine face-to-face and online learning formats. Contact the program for more specific information.

Online: These programs are offered 100% online. Some programs may require an on-campus orientation or residency experience, but the courses will be facilitated in an online format.

CURRICULAR REQUIREMENTS

Requirement	Detail
Minimum Credit Requirement	60 credits
Minimum Residence Credit Requirement	32 credits
Minimum Graduate Coursework Requirement	30 credits must be graduate-level coursework. Refer to the Graduate School: Minimum Graduate Coursework (50%) Requirement policy: https://policy.wisc.edu/library/UW-1244 (https://policy.wisc.edu/library/UW-1244/).
Overall Graduate GPA Requirement	3.00 GPA required. Refer to the Graduate School: Grade Point Average (GPA) Requirement policy: https://policy.wisc.edu/library/UW-1203 (https://policy.wisc.edu/library/UW-1203/).
Other Grade Requirements	n/a
Assessments and Examinations	PhD candidates are required to pass a comprehensive qualifying examination, preliminary examination, and final oral defense. Deposit of the doctoral dissertation to the Graduate School is required.
Language Requirements	No language requirements.
Graduate School Breadth Requirement	Breadth is provided via interdisciplinary training. The central aim of biomedical engineers is to unravel gaps in biological knowledge through the use of engineering principles. Thus, the doctoral program is inherently interdisciplinary. Prior to obtaining a PhD warrant, students will prepare a summary of their effort in interdisciplinary coursework and training. The purpose of the summary will be to document the effort to meet the spirit of the minor requirement. The summary must be approved by the student's thesis committee and filed with the department. Students may elect to pursue a doctoral minor or graduate/professional certificate.

REQUIRED COURSES

Code	Title	Credits
General Requirements		
Research Credits (B M E 790, 890, 990)		*at least 35*
Coursework, including:		*at least 25*
2 semesters of B M E 701		2
B M E 703	Responsible Conduct of Research for Biomedical Engineers	2
One set of PhD pathway requirements (credits vary; see below).		21
Total Credits		**60**

Students who follow the PhD coursework guidelines should fulfill the Biomedical Engineering: Research, MS (https://guide.wisc.edu/graduate/biomedical-engineering/biomedical-engineering-ms/biomedical-engineering-research-ms/) requirements. They may file for that degree prior to their preliminary examination.

Biomaterials & Tissue Engineering Pathway [1]

Biomaterials and tissue engineering employ a diverse range of approaches to develop methods to diagnose and treat diseases, create living tissue environments that may be used to restore the function of a damaged organ, and uncover biological mechanisms related to tissue development and disease. Graduate students trained in biomaterials and tissue engineering are expected to gain a detailed understanding of cellular and molecular biology, materials science, and engineering methods relevant to their research focus.

Code	Title	Credits
Biology Requirement		**3**
CRB 640	Fundamentals of Stem Cell and Regenerative Biology	
CRB 650	Molecular and Cellular Organogenesis	
M M & I/PATH-BIO 528	Immunology	
ZOOLOGY 570	Cell Biology	
Data Analysis Requirement		**3-4**

B M I/STAT 541	Introduction to Biostatistics	
B M I/ COMP SCI 776	Advanced Bioinformatics	
COMP SCI 765	Data Visualization	
STAT/ F&W ECOL 571	Statistical Methods for Bioscience I	
STAT/B M I 877	Statistical Methods for Molecular Biology	
Engineering Requirement		**9**
B M E/ PHM SCI 430	Biological Interactions with Materials	
B M E 510	Introduction to Tissue Engineering	
B M E 511	Tissue Engineering Laboratory	
B M E 520	Stem Cell Bioengineering	
B M E 545	Engineering Extracellular Matrices	
B M E 550	Introduction to Biological and Medical Microsystems	
B M E 602	Special Topics in Biomedical Engineering (CRISPR Genome Editing and Engineering Laboratory)	
CBE 540	Polymer Science and Technology	
CBE 562	Special Topics in Chemical Engineering (Cellular Biomanufacturing)	
CBE 648	Synthetic Organic Materials in Biology and Medicine	
CBE 781	Biological Engineering: Molecules, Cells & Systems	
M S & E 521	Advanced Polymeric Materials	
Elective credits chosen in consultation with your advisor		**6**
Total Credits		**21-22**

Biomedical Imaging & Optics Pathway [1]

Biomedical imaging and optics research develops and utilizes new experimental and computational tools to characterize tissue structure across multiple size scales. A particular focus is on human health, especially with respect to achieving superior diagnostic/prognostic tools for a spectrum of diseased states. Graduate students trained in this pathway are expected to gain a detailed understanding of mathematics, biology and engineering both optical and/or physical methods relevant to their research focus.

Code	Title	Credits
Mathematics Requirement [2]		**3**
MATH 443	Applied Linear Algebra	
Biology Requirement		**3-5**
ANAT&PHY 335	Physiology	
BIOCHEM 501	Introduction to Biochemistry	
ZOOLOGY 570	Cell Biology	
Data Analysis Requirement		**3**
B M E/ MED PHYS 574	Data Science in Medical Physics	
COMP SCI 319	Data Science Programming I for Research	
COMP SCI/E C E/ M E 532	Matrix Methods in Machine Learning	
COMP SCI/ E C E 766	Computer Vision	
COMP SCI/ B M I 767	Computational Methods for Medical Image Analysis	
Engineering Requirement		**9**
B M E/ MED PHYS 573	Mathematical Methods in Medical Physics	
B M E/ MED PHYS 578	Non-Ionizing Diagnostic Imaging	
B M E 651	Biophotonics Laboratory	
B M E/ MED PHYS/ PHMCOL-M/PHYSICS/ RADIOL 619	Microscopy of Life	
B M E/ MED PHYS 710	Advances in Medical Magnetic Resonance	
B M E/CHEM/ MED PHYS 750	Biological Optical Microscopy	
B M E 751	Biomedical Optics and Biophotonics	
B M E 780	Methods in Quantitative Biology	
MED PHYS/ B M E/H ONCOL/ PHYSICS 501	Radiation Physics and Dosimetry	
MED PHYS/ B M E 580	The Physics of Medical Imaging with Ionizing Radiation	
MED PHYS 777	Principles of X-ray Computed Tomography	
Elective credits chosen in consultation with your advisor		**3**
Total Credits		**21-23**

Biomechanics Pathway [1]

Biomechanists use experiments and computational tools to investigate the mechanical aspects of biological systems at levels ranging from whole organisms to organs, tissues, and cells. Graduate students trained in biomechanics are expected to gain a detailed understanding of mechanics, mathematics, biology, and engineering relevant to their research focus.

Code	Title	Credits
Mechanics		**12**
To provide depth, 6 credits of Biomechanics courses are required. The remaining 6 credits may be selected from either the Advanced Mechanics or Biomechanics lists.		
Biomechanics		
B M E/M E 414	Orthopaedic Biomechanics - Design of Orthopaedic Implants	
B M E/M E 415	Biomechanics of Human Movement	
B M E/M E 505	Biofluidics	
B M E/M E 516	Finite Elements for Biological and Other Soft Materials	
B M E 603	Special Topics in Bioinstrumentation and Medical Devices (Image-Based Biomechanics)	

B M E/M E 615	Tissue Mechanics
B M E/M E 715	Advanced Tissue Mechanics
Advanced Mechanics	
M E 440	Intermediate Vibrations
M E/CIV ENGR/ E M A 508	Composite Materials
M E/E M A 540	Experimental Vibration and Dynamic System Analysis
M E 563	Intermediate Fluid Dynamics
M E/E M A 570	Experimental Mechanics
M E 573	Computational Fluid Dynamics
E M A 506	Advanced Mechanics of Materials I
E M A 519	Fracture Mechanics
E M A/ M S & E 541	Heterogeneous and Multiphase Materials
E M A 545	Mechanical Vibrations
E M A 605	Introduction to Finite Elements
E M A/E P 615	Micro- and Nanoscale Mechanics
E M A 630	Viscoelastic Solids
E M A 700	Theory of Elasticity
E M A 710	Mechanics of Continua
Biosciences	**3-5**
ANAT&PHY 335	Physiology
ANAT&PHY 435	Fundamentals of Human Physiology
BIOCHEM/ GENETICS/ MD GENET 620	Eukaryotic Molecular Biology
CRB/B M E 670	Biology of Heart Disease and Regeneration
KINES 773	Cardiorespiratory Adaptions to Environment and Exercise
ZOOLOGY 570	Cell Biology
Elective credits chosen in consultation with your advisor	**6**
Total Credits	**21-23**

Medical & Microdevices Pathway [1]

Medical and mircodevices involve the use of electronic and computational tools to develop devices used in diagnosis and treatment of disease ranging from the systemic to the cellular and molecular levels.

Code	Title	Credits
Mathematics Requirement [2]		**3**
MATH 443	Applied Linear Algebra	
MATH 519	Ordinary Differential Equations	
MATH 619	Analysis of Partial Differential Equations	
Biology Requirement		**3-5**
ANAT&PHY 335	Physiology	
BIOCHEM 501	Introduction to Biochemistry	
BIOCHEM/ GENETICS/ MICROBIO 612	Prokaryotic Molecular Biology	
BIOCHEM/ GENETICS/ MD GENET 620	Eukaryotic Molecular Biology	
PATH 750	Cellular and Molecular Biology/ Pathology	
PATH 752	Cellular and Molecular Biology/ Pathology Seminar	
ZOOLOGY/ PSYCH 523	Neurobiology	
ZOOLOGY 570	Cell Biology	
Data Analysis Requirement		**3-4**
B M I/STAT 541	Introduction to Biostatistics	
B M I/STAT 542	Introduction to Clinical Trials I	
B M I/ COMP SCI 576	Introduction to Bioinformatics	
B M I/ COMP SCI 776	Advanced Bioinformatics	
Engineering Requirement		**9**
B M E/E C E 462	Medical Instrumentation	
B M E/ MED PHYS 535	Introduction to Energy-Tissue Interactions	
B M E 550	Introduction to Biological and Medical Microsystems	
B M E 602	Special Topics in Biomedical Engineering (Introduction to Neuroengineering)	
B M E 640	Medical Devices Ecosystem: The Path to Product	
B M E 651	Biophotonics Laboratory	
B M E/CHEM/ MED PHYS 750	Biological Optical Microscopy	
Elective credits chosen in consultation with your advisor		**3**
Total Credits		**21-24**

Neuroengineering Pathway [1]

Neuroengineering is the convergence of neuroscience, computation, device development, and mathematics to improve human health. Neuroengineering brings together state-of-the-art technologies for the development of devices and algorithms to assist those with neural disorders. It is also used to reverse engineer living neural systems via new algorithms, technologies and robotics. Students pursing this pathway are involved in all of these endeavors so as the next generation of engineers, they will transcend the traditional boundaries of neuroscience, technology, engineering and mathematics.

Code	Title	Credits
Data Analysis Requirement		**3**
COMP SCI 319	Data Science Programming I for Research	
COMP SCI/E C E/ M E 532	Matrix Methods in Machine Learning	
COMP SCI/ E C E 533	Image Processing	
COMP SCI/ B M I 567	Medical Image Analysis	
Engineering Requirement		**9**

B M E 520	Stem Cell Bioengineering	
B M E 550	Introduction to Biological and Medical Microsystems	
B M E 602	Special Topics in Biomedical Engineering (Introduction to Neuroengineering)	
B M E 640	Medical Devices Ecosystem: The Path to Product	
E C E/B M E 462	Medical Instrumentation	
E C E/B M E 463	Computers in Medicine	
Biology Requirement		**3**
KINES 721	Neural Basis for Movement	
KINES 861	Principles of Motor Control and Learning	
NTP/ NEURODPT 610	Cellular and Molecular Neuroscience	
NTP/NEURODPT/ PSYCH 611	Systems Neuroscience	
NTP 735		
PSYCH 610	Design and Analysis of Psychological Experiments I	
PSYCH 733	Perceptual and Cognitive Sciences	
ZOOLOGY 625	Development of the Nervous System	
Elective credits chosen in consultation with your advisor		**6**
Total Credits		**21**

Systems & Synthetic Biology Pathway [1]

Systems and synthetic biology utilizes experimental and computational tools in an iterative fashion to analyze and regulate biological systems.

Students interested in earning a doctoral minor in Quantitative Biology (http://guide.wisc.edu/graduate/biomedical-engineering/quantitative-biology-doctoral-minor/): enrollment in B M E 780 Methods in Quantitative Biology is a requirement. Additionally, students will need to take one additional 3-credit course in quantitative science, biology, or integrated biology/quantitative science from the approved list of courses in the doctoral minor (this course counts toward the elective credits for this pathway).

Code	Title	Credits
Mathematics Requirement [2]		**3**
MATH 443	Applied Linear Algebra	
MATH 519	Ordinary Differential Equations	
MATH 619	Analysis of Partial Differential Equations	
Biology Requirement		**3**
BIOCHEM 501	Introduction to Biochemistry	
BIOCHEM/ GENETICS/ MICROBIO 612	Prokaryotic Molecular Biology	
BIOCHEM/ GENETICS/ MD GENET 620	Eukaryotic Molecular Biology	
M M & I/PATH-BIO 528	Immunology	
ZOOLOGY 570	Cell Biology	
Data Analysis Requirement		**3**
B M I/STAT 541	Introduction to Biostatistics	
B M I/ COMP SCI 576	Introduction to Bioinformatics	
COMP SCI 319	Data Science Programming I for Research	
COMP SCI/E C E/ M E 532	Matrix Methods in Machine Learning	
Engineering Requirement		**9**
B M E 550	Introduction to Biological and Medical Microsystems	
B M E 556	Systems Biology: Mammalian Signaling Networks	
B M E 602	Special Topics in Biomedical Engineering (CRISPR Genome Editing and Engineering Laboratory)	
B M E 780	Methods in Quantitative Biology	
CBE/B M E 560	Biochemical Engineering	
CBE 660	Intermediate Problems in Chemical Engineering	
CBE 781	Biological Engineering: Molecules, Cells & Systems	
CBE/B M E 782	Modeling Biological Systems	
Elective credits chosen in consultation with your advisor		**3**
Total Credits		**21**

Guidelines for students who earned a master's degree in another field at UW-Madison

1. Students who have earned a master's degree in another field at UW-Madison should contact the Associate Chair of the PhD Degree to understand remaining course requirements. A maximum of 7 credits can be counted from a separate MS degree, in compliance with the Graduate School's Double Degrees policy (https://grad.wisc.edu/documents/double-degrees/).
2. Master's degree students who have been absent for five or more years lose all degree credits earned before their absence.
3. All students with a prior master's degree will need to complete the Qualifying Exams and Preliminary Exam requirements even if coursework requirements have been met. Please discuss your specific plan with the Associate Chair of the PhD Degree.

Footnotes

[1] These pathways are internal to the program and represent different curricular paths a student can follow to earn this degree. Pathway names do not appear in the Graduate School admissions application, and they will not appear on the transcript.

[2] The math requirement can be satisfied with a B- or better in the equivalent course in undergraduate. For approval, please e-mail the Associate Chair of the PhD Degree a copy of your unofficial transcript and indicate the course you are proposing to use. The credits do not transfer; you will instead be able to take an additional 3 credits of electives.