BIOMEDICAL ENGINEERING, PH.D.

Biomedical engineering is the application of engineering tools for solving problems in biology and medicine. It is an engineering discipline that is practiced by professionals trained primarily as engineers, who specialize in medical and biological applications. This area of study combines fundamentals of the biomedical sciences with advanced engineering methods of analysis and design, and brings together these two fields in order to contribute to the design of new medical instruments and devices, apply engineering principles for understanding and repairing the human body and other biological systems, and use engineering tools for decision making and cost containment.

The interdisciplinary degree program offers a course of graduate study leading to the master of science or the doctor of philosophy degrees in biomedical engineering. The Department of Biomedical Engineering should be of interest to students who wish to practice engineering or engage in research in an engineering specialization in medicine and biology. An individualized course of study is planned with a faculty advisor. Biomedical engineering faculty and affiliated faculty come from the various colleges and professional schools throughout the university. They specialize in biomedical engineering areas as diverse as biomechanics, bioinstrumentation, biomedical imaging and biophotonics, micro and nanotechnology, systems biology, biomaterials, cellular engineering, tissue engineering, neuroengineering, and rehabilitation and human performance. A list of biomedical engineering faculty, affiliated faculty, and their respective areas of specialization is available from the department website.

ADMISSIONS

Please consult the table below for key information about this degree program’s admissions requirements. The program may have more detailed admissions requirements, which can be found below the table or on the program’s website. Graduate admissions is a two-step process between academic programs and the Graduate School. Applicants must meet the minimum requirements (https://grad.wisc.edu/apply/requirements/) of the Graduate School as well as the program(s).

Once you have researched the graduate program(s) you are interested in, apply online (https://grad.wisc.edu/apply/).

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall Deadline</td>
<td>December 1</td>
</tr>
<tr>
<td>Spring Deadline</td>
<td>October 1</td>
</tr>
<tr>
<td>Summer Deadline</td>
<td>December 1</td>
</tr>
<tr>
<td>GRE (Graduate Record Examinations)</td>
<td>Required.</td>
</tr>
<tr>
<td>English Proficiency Test</td>
<td>Every applicant whose native language is not English or whose undergraduate instruction was not in English must provide an English proficiency test score and meet the Graduate School minimum requirements (<a href="https://grad.wisc.edu/apply/requirements/#english-proficiency">https://grad.wisc.edu/apply/requirements/#english-proficiency</a>).</td>
</tr>
<tr>
<td>Other Test(s) (e.g., GMAT, MCAT)</td>
<td>The MCAT may be accepted as an alternate to the GRE.</td>
</tr>
</tbody>
</table>

Letters of Recommendation 3
Required

Applicants should have a bachelor’s degree in engineering (biomedical, chemical, electrical, industrial, mechanical, etc.) or science (biology, biochemistry, chemistry, genetics, immunology, physics, etc.). Each application is judged on the basis of:

- Official academic transcripts
- Graduate Record Examinations (http://www.ets.org/gre/) (GRE) scores or Medical College Admission Test (MCAT) scores for the general test
- Test of English as a Foreign Language (http://www.ets.org/toefl/) (TOEFL) examination for international students
- Three letters of recommendation
- Statement of purpose (https://grad.wisc.edu/apply/prepare/)
- Resume (for Ph.D. applicants only)

All applicants must satisfy requirements that are set forth by the Graduate School (https://grad.wisc.edu/). Students admitted to the program may be required to make up deficiency course requirements.

To apply to the BME program, complete applications (https://grad.wisc.edu/apply/), including supportive materials, must be submitted as described below and received by the following deadline dates:

- Fall Semester—December 1 (MS and Ph.D.)
- Spring Semester—October 1 (MS and Ph.D.)
- Summer Session1—December 1 (MS and Ph.D.)

1 Please note that summer admissions are generally limited to continuing BME students at UW–Madison or applicants who have research assistantships already arranged with UW faculty.

OFFICIAL ACADEMIC TRANSCRIPT

Electronically submit one copy of your transcript of all undergraduate and previous graduate work along with your online application to the Graduate School. Unofficial copies of transcripts will be accepted for review, but official copies are required for admitted students. Please do not send transcripts or any other application materials to the Graduate School or the BME department unless requested. If you have questions, please contact bmegradadmission@engr.wisc.edu.

GRADUATE RECORD EXAMINATION (GRE)

Applicants should request ETS to send their official GRE scores by using institution code 1846.

MCAT scores may be substituted for GRE. Domestic applicants who choose to substitute MCAT scores for the GRE should send their MCAT score report to bmegradadmission@engr.wisc.edu.

TEST OF ENGLISH AS A FOREIGN LANGUAGE (TOEFL)

The TOEFL is required for international students unless a degree from a U.S. educational institution is held. Scores should be sent using institution code 1846.

An applicant whose TOEFL (paper-based) test score is below 580; TOEFL computer-based test (CBT) score below 237; (TOEFL internet-based iBT) test score below 92; IELTS score below 7; or MELAB below 82 must take an English assessment test upon arrival. Depending on your score,
you may need to register for any recommended English as a Second Language (ESL) courses in the first semester you are enrolled.

Any international applicant who will hold a teaching assistantship (TA), and whose native language is not English must take the SPEAK test (https://esl.wisc.edu/ita-training/speak/) when arriving on campus.

THREE LETTERS OF RECOMMENDATIONS
These letters are required from people who can accurately judge the applicant’s academic or research performance. Letters of recommendation are submitted electronically to graduate programs through the online application. Applicants should not send any more than three letters (if more than three are sent, only the first three will be considered). See the Graduate School for FAQs (https://grad.wisc.edu/apply/) regarding letters of recommendation.

STATEMENT OF PURPOSE
In this document, applicants should explain why they want to pursue further education in BME and discuss which UW faculty members they would be interested in doing research with during their graduate study (see the Graduate School for more advice on how to structure a personal statement (https://grad.wisc.edu/apply/prepare/)).

RESUME (FOR PH.D. APPLICATIONS ONLY)
Include your resume ONLY if applying for the Ph.D. program.

APPLICATION FEE
Submission must be accompanied by the one-time application fee. It is non-refundable and can be paid by credit card (Master Card or Visa) or debit/ATM. By state law, this fee can only be waived or deferred through the conditions outlined here by the Graduate School (https://grad.wisc.edu/apply/fee-grant/).

FUNDING
GRADUATE SCHOOL RESOURCES
Resources to help you afford graduate study might include assistantships, fellowships, traineeships, and financial aid. Further funding information (https://grad.wisc.edu/funding/) is available from the Graduate School. Be sure to check with your program for individual policies and restrictions related to funding.

PROGRAM RESOURCES
It is our experience that nearly all doctoral students in the BME department obtain funding, but there are no guarantees. A limited number receive fellowships. A few students enrolled in M.S. coursework program are self-funded.

Research assistantships are available from individual faculty based on their research funding and awarded when grants are funded and after applications for BME admission are accepted. Sometimes there are project assistantships, teaching assistantships, and traineeships also available. A few students enrolled in M.S. coursework program are self-funded.

ADMITTED WITH FUNDING
We have a limited number of university or departmental fellowships to offer each year. In addition, there are research assistantships that are offered to grad applicants from individual faculty members. Teaching assistantships (TA) are possible through specific departments with more opportunity in lower-level courses, such as calculus, chemistry, and physics. Often, funding matches with specific faculty occur during the Visit Wisconsin Weekend in the spring.

ADMITTED WITHOUT FUNDING
If you are admitted without funding, please know that you will be considered by BME faculty for potential support. You are also encouraged to contact faculty in BME (http://www.engr.wisc.edu/bme/faculty/) whose research is of particular interest. Please wait to hear from us about your admission without aid before contacting faculty for support. You may also apply to BME specific TA positions after being admitted or other TA positions on campus.

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

<table>
<thead>
<tr>
<th>Face to Face</th>
<th>Evening/Weekend</th>
<th>Online</th>
<th>Hybrid</th>
<th>Accelerated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Mode of Instruction Definitions

- **Evening/Weekend**: These programs are offered in an evening and/or weekend format to accommodate working schedules. Enjoy the advantages of on-campus courses and personal connections, while keeping your day job. For more information about the meeting schedule of a specific program, contact the program.

- **Online**: These programs are offered primarily online. Many available online programs can be completed almost entirely online with all online programs offering at least 50 percent or more of the program work online. Some online programs have an on-campus component that is often designed to accommodate working schedules. Take advantage of the convenience of online learning while participating in a rich, interactive learning environment. For more information about the online nature of a specific program, contact the program.

- **Hybrid**: These programs have innovative curricula that combine on-campus and online formats. Most hybrid programs are completed on-campus with a partial or completely online semester. For more information about the hybrid schedule of a specific program, contact the program.

- **Accelerated**: These on-campus programs are offered in an accelerated format that allows you to complete your program in a condensed time-frame. Enjoy the advantages of on-campus courses with minimal disruption to your career. For more information about the accelerated nature of a specific program, contact the program.

CURRICULAR REQUIREMENTS

<table>
<thead>
<tr>
<th>Requirements Detail</th>
<th>Minimum</th>
<th>Credit</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Biomedical Engineering, Ph.D.

Minimum Residence Credit Requirement
32 credits

Minimum Graduate Coursework Requirement
Half of degree coursework (30 credits out of 60 total credits) must be completed graduate-level coursework; courses with the Graduate Level Coursework attribute are identified and searchable in the university’s Course Guide.

Overall Graduate GPA Requirement
3.00 GPA required.

Other Grade Requirements
The Graduate School requires an average grade of B or better in all coursework (300 or above, not including research credits) taken as a graduate student unless conditions for probationary status require higher grades. Grades of Incomplete are considered to be unsatisfactory if they are not removed during the next enrolled semester.

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.

Doctoral Minor/Breadth Requirements
Breadth is provided via interdisciplinary training (minor requirement waived). 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 Ph.D. 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.

REQUERED COURSES

M.S. Requirements
To receive a Ph.D., students must first complete the requirements for an M.S. degree in biomedical engineering (https://guide.wisc.edu/graduate/biomedical-engineering/biomedical-engineering-ms/#requirementstext):

- Two semesters of B M E 701 Seminar in Biomedical Engineering
- At least one course in bioscience (if not from a bioscience or BME background)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ANAT&amp;PHY 335</td>
<td>Physiology</td>
<td>5</td>
</tr>
<tr>
<td>ANAT&amp;PHY 435</td>
<td>Fundamentals of Human Physiology</td>
<td>5</td>
</tr>
<tr>
<td>ANATOMY 622</td>
<td>Human Anatomy-Physical Therapy, Occupational Therapy</td>
<td>6</td>
</tr>
<tr>
<td>BIOCHEM 501</td>
<td>Introduction to Biochemistry</td>
<td>3</td>
</tr>
<tr>
<td>B M E 601</td>
<td>Special Topics in Biomedical Engineering (Topic in Physiology for Biomedical Engineering Students)</td>
<td>3</td>
</tr>
<tr>
<td>CRB 640</td>
<td>Fundamentals of Stem Cell and Regenerative Biology</td>
<td>3</td>
</tr>
<tr>
<td>CRB 650</td>
<td>Molecular and Cellular Organogenesis</td>
<td>3</td>
</tr>
<tr>
<td>KINES 350</td>
<td>Introduction to Exercise Psychology</td>
<td>3</td>
</tr>
<tr>
<td>KINES 531</td>
<td>Neural Control of Movement</td>
<td>3</td>
</tr>
<tr>
<td>KINES 773</td>
<td>Cardiorespiratory Adapts to Environment and Exercise</td>
<td>3</td>
</tr>
<tr>
<td>NTP/NEURODPT 610</td>
<td>Neuroscience</td>
<td>4</td>
</tr>
<tr>
<td>NTP/NEURODPT/PSYCH 611</td>
<td>Systems Neuroscience</td>
<td>4</td>
</tr>
<tr>
<td>NTP/NEUROL 735</td>
<td>Neuropathology of Disease</td>
<td>2</td>
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<tr>
<td>ONCOLOGY 401</td>
<td>Introduction to Experimental Oncology</td>
<td>2</td>
</tr>
<tr>
<td>PHMCOL-M/BIOCHEM/ZOOLOGY 630</td>
<td>Cellular Signal Transduction Mechanisms</td>
<td>3</td>
</tr>
<tr>
<td>ZOOLOGY/PSYCH 523</td>
<td>Neurobiology</td>
<td>3</td>
</tr>
<tr>
<td>ZOOLOGY 570</td>
<td>Cell Biology</td>
<td>3</td>
</tr>
</tbody>
</table>

- At least 12 credits of engineering courses, 400-level or above
- At least 15 credits in one track, 400-level or above
- At least 15 credits that are graduate level (700 or above or courses with the Graduate Level Coursework attribute)
- Optional, but recommended: 3-6 credits of independent study project experience (B M E 799 Advanced Independent Study) or master’s thesis research (B M E 790 Master’s Research and Thesis) in the student’s track (a maximum of 6 credits can be applied to the M.S. although students may take more). These credits may count towards your track credits.

Specific course selection is very flexible and draws upon a variety of courses. The required coursework is designed to complement each student’s interests and background in biomedical engineering and meet the spirit of a BME degree; deviations from the requirements should be discussed with the associate chair of graduate advising and will be decided on a case-by-case basis.

Ph.D. Requirements
In addition to the M.S. requirements listed above, Ph.D. students must complete one the following six Ph.D. tracks. Credits used toward the M.S. requirements may also be used toward the Ph.D. track requirements.

Students must complete a minimum of 60 credits total to earn the Ph.D. degree. Beyond the 30 credits used to satisfy the M.S. degree requirements, students typically take 30 credits of research (B M E 790 Master’s Research and Thesis, B M E 890 Pre-dissertation Research, and B M E 990 Research and Thesis).

Biomaterials & Tissue Engineering Track

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.
Biomedical Engineering, Ph.D.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biology Requirement</strong></td>
<td></td>
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<tr>
<td>ZOOLOGY 570</td>
<td>Cell Biology</td>
<td>2-5</td>
</tr>
<tr>
<td>ZOOLOGY/ BIOCHEM/ PHMCOL-M 630</td>
<td>Cellular Signal Transduction Mechanisms</td>
<td></td>
</tr>
<tr>
<td>CRB 650</td>
<td>Molecular and Cellular Organogenesis</td>
<td></td>
</tr>
<tr>
<td>ONCOLOGY 401</td>
<td>Introduction to Experimental Oncology</td>
<td></td>
</tr>
<tr>
<td>ANAT&amp;PHY 335</td>
<td>Physiology</td>
<td></td>
</tr>
<tr>
<td><strong>Data Analysis Requirement</strong></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>B M I/STAT 541</td>
<td>Introduction to Biostatistics</td>
<td></td>
</tr>
<tr>
<td>COMP SCI 765</td>
<td>Data Visualization</td>
<td></td>
</tr>
<tr>
<td>B M E 601</td>
<td>Special Topics in Biomedical Engineering (Topic in Matlab Skills )</td>
<td></td>
</tr>
<tr>
<td><strong>Biomaterials &amp; Tissue Engineering Requirement</strong></td>
<td></td>
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</tr>
<tr>
<td>B M E/ PHM SCI 430</td>
<td>Biological Interactions with Materials</td>
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<tr>
<td>B M E/CBE 510</td>
<td>Introduction to Tissue Engineering</td>
<td></td>
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<tr>
<td>B M E 511</td>
<td>Tissue Engineering Laboratory</td>
<td></td>
</tr>
<tr>
<td>B M E/CBE 520</td>
<td>Stem Cell Bioengineering</td>
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<tr>
<td>B M E 545</td>
<td>Engineering Extracellular Matrices</td>
<td></td>
</tr>
<tr>
<td>B M E 550</td>
<td>Introduction to Biological and Medical Microsystems</td>
<td></td>
</tr>
<tr>
<td>B M E 601</td>
<td>Special Topics in Biomedical Engineering</td>
<td></td>
</tr>
<tr>
<td>CBE 540</td>
<td>Polymer Science and Technology</td>
<td></td>
</tr>
<tr>
<td>M S &amp; E 521</td>
<td>Advanced Polymeric Materials</td>
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<tr>
<td><strong>Elective Requirement</strong></td>
<td>To provide breadth, at least 6 credits of electives must be chosen from courses that are not listed above.</td>
<td>6</td>
</tr>
</tbody>
</table>

| **Total Credits** | 17-20 |

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

**Biomedical Imaging & Optics Track**

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 diseases states. Graduate students trained in this track are expected to gain a detailed understanding of mathematics, biology, and engineering methods relevant to their research focus.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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<tr>
<td><strong>Mathematics Requirement (from courses listed OR previous undergraduate course with grade B- or better)</strong></td>
<td>0-3</td>
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<tr>
<td>MATH 443</td>
<td>Applied Linear Algebra</td>
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<tr>
<td><strong>Biology Requirement</strong></td>
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<td>3-5</td>
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<tr>
<td>ANAT&amp;PHY 335</td>
<td>Physiology</td>
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<tr>
<td>ZOOLOGY 570</td>
<td>Cell Biology</td>
<td></td>
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<tr>
<td><strong>Data Analysis</strong></td>
<td>ZOOLOGY/ BIOCHEM/ PHMCOL-M 630</td>
<td></td>
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<tr>
<td>B M E 601</td>
<td>Special Topics in Biomedical Engineering (Topic in Matlab Image Analysis)</td>
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<tr>
<td>COMP SCI 766</td>
<td>Computer Vision</td>
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<tr>
<td>COMP SCI/ B M I 767</td>
<td>Computational Methods for Medical Image Analysis</td>
<td></td>
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<tr>
<td>E C E 431</td>
<td>Digital Signal Processing</td>
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</table>

**Imaging Requirement**

<table>
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<tr>
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<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>B M E/ MED PHYS 530</td>
<td>Medical Imaging Systems</td>
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<tr>
<td>B M E/ MED PHYS 573</td>
<td>Medical Image Science: Mathematical and Conceptual Foundations</td>
<td></td>
</tr>
<tr>
<td>B M E/ MED PHYS 574</td>
<td>Imaging in Medicine: Applications</td>
<td></td>
</tr>
<tr>
<td>B M E/ MED PHYS 578</td>
<td>Non-Ionizing Diagnostic Imaging</td>
<td></td>
</tr>
<tr>
<td>B M E 601</td>
<td>Special Topics in Biomedical Engineering</td>
<td></td>
</tr>
<tr>
<td>B M E/CHEM/ MED PHYS 750</td>
<td>Biological Optical Microscopy</td>
<td></td>
</tr>
<tr>
<td>MED PHYS/ B M E 710</td>
<td>Advances in Medical Magnetic Resonance</td>
<td></td>
</tr>
</tbody>
</table>

**Elective Requirement** | To provide breadth, at least 6 credits of electives must be chosen from courses that are not listed above. | 6       |

| **Total Credits** | 21-26 |

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

**Biomechanics Track**

Biomechanics utilizes experimental and computational tools to analyze and develop novel biomechanical systems. Graduate students trained in biomechanics are expected to gain a detailed understanding of mathematics, biology, and engineering methods relevant to their research focus.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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<tr>
<td><strong>Mathematics Requirement (from courses listed OR previous undergraduate course with grade B- or better)</strong></td>
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<tr>
<td>MATH 443</td>
<td>Applied Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>MATH 519</td>
<td>Ordinary Differential Equations</td>
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<tr>
<td>MATH 619</td>
<td>Analysis of Partial Differential Equations</td>
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</table>

**Biomechanics of Solids & Fluids Requirement**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>B M E/M E 415</td>
<td>Biomechanics of Human Movement</td>
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<tr>
<td>B M E/M E 505</td>
<td>Biofluidics</td>
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<tr>
<td>B M E/M E 603</td>
<td>Topics in Bio-Medical Engineering (Topic in Finite Elements for Biomechanics)</td>
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<tr>
<td>B M E/M E 615</td>
<td>Tissue Mechanics</td>
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</table>
Biosciences 3-6

ANATOMY 622 Human Anatomy-Physical Therapy, Occupational Therapy
KINES 350 Introduction to Exercise Psychology
KINES 531 Neural Control of Movement
KINES 773 Cardiorespiratory Adapts to Environment and Exercise
ANAT&PHY 335 Physiology
ANAT&PHY 435 Fundamentals of Human Physiology
ZOOLOGY 570 Cell Biology
ZOOLOGY/ BIOCHEM/ PHMCOL-M 630 Cellular Signal Transduction Mechanisms

Elective Requirement 6
To provide breadth, electives must be courses that are not listed above. Some recommendations are below.

Data Analysis
B M I/STAT 541 Introduction to Biostatistics

Computational Methods
E M A 405 Practicum in Finite Elements
E M A 605 Introduction to Finite Elements
M E 460 Applied Thermal / Structural Finite Element Analysis

Solid & Fluid Mechanics
E M A 622 Mechanics of Continua
E M A 630 Viscoelastic Solids
E M A 700 Theory of Elasticity
M E 563 Intermediate Fluid Dynamics
M E/E M A 570 Experimental Mechanics
M E 573 Computational Fluid Dynamics

Other
B M E/E C E 462 Medical Instrumentation
B M E/ MED PHYS 530 Medical Imaging Systems
B M E/MED PHYS/ MICROSCOPY OF LIFE PHMCOL-M/ PHYSICS/ RADIOL 619
M E/STAT 424 Statistical Experimental Design

Total Credits 21-24

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

Medical & Microdevices Track
Medical and microdevices 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.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 443</td>
<td>Applied Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>MATH 519</td>
<td>Ordinary Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MATH 619</td>
<td>Analysis of Partial Differential Equations</td>
<td></td>
</tr>
</tbody>
</table>

Biology Requirement 3-5

B M E 601 Special Topics in Biomedical Engineering (Topic in Physiology for Biomedical Engineering Students)
ANAT&PHY 335 Physiology
ZOOLOGY 570 Cell Biology
ZOOLOGY/ BIOCHEM/ PHMCOL-M 630 Cellular Signal Transduction Mechanisms

Data Analysis 3

COMP SCI 300 Programming II
COMP SCI 368 Learning a Programming Language

Biology and Medical Informatics Course (relevant options below):
B M I/STAT 541 Introduction to Biostatistics
B M I/ COMP SCI 567 Medical Image Analysis
B M I/ COMP SCI 767 Image Analysis

Signal Processing Course (relevant options below):
E C E 431 Digital Signal Processing
E C E 730 Probability and Random Processes

Medical & Microdevices 6

B M E 515 Therapeutic Medical Devices
B M E/ MED PHYS 535 Introduction to Energy-Tissue Interactions
B M E 550 Introduction to Biological and Medical Microsystems

Elective Requirement 6
To provide breadth, 6 credits of electives must be from courses that are not listed above. An example of a possible course is listed below.

B M E/ MED PHYS 574 Imaging in Medicine: Applications

Total Credits 18-23

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Neuroengineering Track
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 track 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.
Biomedical Engineering, Ph.D.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
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<td><strong>Mathematics Requirement (from courses listed OR</strong></td>
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<td>previous undergraduate course with grade B- or better)**</td>
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<td>MATH 443</td>
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<td><strong>Biology</strong></td>
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<td>ANAT&amp;PHY 335</td>
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<tr>
<td>ZOOLOGY 570</td>
<td>Cell Biology</td>
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<tr>
<td>ZOOLOGY/BIOCHEM/PHMCOL-M 630</td>
<td>Cellular Signal Transduction Mechanisms</td>
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<td><strong>Ethics</strong></td>
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<td>MED HIST 545</td>
<td>Ethical and Regulatory Issues in Clinical Investigation</td>
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<td>MED PHYS 701</td>
<td>Ethics and the responsible conduct of research and practice of Medical Physics</td>
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<td><strong>Data Analysis</strong></td>
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<td>Medical Image Analysis</td>
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<td>COMP SCI 766</td>
<td>Computer Vision</td>
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<td>COMP SCI/ B M I 767</td>
<td>Computational Methods for Medical Image Analysis</td>
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<td>B M E 515</td>
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<td>B M E 601</td>
<td>Special Topics in Biomedical Engineering (Topic in BioMEMs)</td>
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<td><strong>Neurobiology Requirement</strong></td>
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<td>B M E/CBE 520</td>
<td>Stem Cell Bioengineering</td>
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<td>KINES 721</td>
<td>Neural Basis for Movement</td>
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<td>KINES 861</td>
<td>Principles of Motor Control and Learning</td>
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<td>NTP/NEURODPT 610</td>
<td>Cellular and Molecular Neuroscience</td>
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<td>NTP/NEURODPT/PSYCH 611</td>
<td>Systems Neuroscience</td>
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<tr>
<td>NTP/NEURODPT 630</td>
<td>Neuronal Mechanisms for Sensation and Memory in Cerebral Cortex</td>
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<td>NTP/NEUROL 735</td>
<td>Neurobiology of Disease</td>
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<td>PSYCH 610</td>
<td>Design and Analysis of Psychological Experiments I</td>
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<td><strong>PSYCH/NEURODPT/ NTP 611</strong></td>
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<td>PSYCH 733</td>
<td>Perceptual and Cognitive Sciences</td>
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<tr>
<td>ZOOLOGY 625</td>
<td>Development of the Nervous System</td>
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<td><strong>Electives</strong></td>
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<td>To provide breadth, 6 credits of electives must be from courses that are not listed above.</td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

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**Systems & Synthetic Biology Track**

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/](http://guide.wisc.edu/graduate/biomedical-engineering/quantitative-biology-doctoral-minor/)) enrollment in B M E 601 Special Topics in Biomedical Engineering (Topic in 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 track).
The Graduate School regularly reviews the record of any student who
earned grades of BC, C, D, F, or Incomplete in a graduate course (300
or above), or grade of U in research credits. This review could result
in academic probation with a hold on future enrollment or in being
suspended from the Graduate School.

**POLICIES**

**GRADUATE SCHOOL POLICIES**

The Graduate School’s Academic Policies and Procedures (https://
grad.wisc.edu/acadpolicy/) provide essential information regarding
general university policies. Program authority to set degree policies
beyond the minimum required by the Graduate School lies with the
degree program faculty. Policies set by the academic degree program can
be found below.

**MAJOR-SPECIFIC POLICIES**

**PRIOR COURSEWORK**

**Graduate Work from Other Institutions**

A student may transfer graduate coursework from other institutions
with program approval. These courses may not be used toward the Graduate
School’s Minimum Graduate Residence Credit. Reach out to the BME
Graduate Coordinator for more information.

**UW-Madison Undergraduate**

A student who has completed their bachelor’s degree in Biomedical
Engineering at UW-Madison may transfer 6 credits of coursework with
program approval. These courses must be biomedical engineering
department coursework numbered 300 level or above. These courses may
not be used toward the Graduate School’s Minimum Graduate Residence
Credit.

**UW-Madison University Special**

A maximum of 15 credits from the UW–Madison University Special
student career may count toward program requirements. Minimum
graduate resident credits requirement and minimum graduate degree
credit requirement: allowed up to 15 credits numbered 300 or above.
Minimum graduate coursework (50%) requirement: allowed up to
15 credits numbered 700 or above. Coursework earned five or more
years prior to admission to a Ph.D. program is not allowed to satisfy
requirements.

**PROBATION**

The Graduate School regularly reviews the record of any student who
earned grades of BC, C, D, F, or Incomplete in a graduate course (300
or above), or grade of U in research credits. This review could result
in academic probation with a hold on future enrollment or in being
suspended from the Graduate School.

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1. Good standing (progressing according to standards; any funding
   guarantee remains in place).
2. Probation (not progressing according to standards but permitted
to enroll; loss of funding guarantee; specific plan with dates and
deadlines in place in regard to removal of probationary status).
3. Unsatisfactory progress (not progressing according to standards; not
   permitted to enroll, dismissal, leave of absence or change of advisor
   or program).

**ADVISOR / COMMITTEE**

Advisor: Every BME graduate student must have a faculty advisor. A
faculty advisor provides the graduate student with academic guidance
in their course program and research oversight in their thesis, project, or
engineering report. Graduate students should always seek advice from
their advisor and other faculty in their interest area prior to enrolling for
courses.

Doctoral Committee: In addition to the committee requirements put forth
by the Graduate School, BME has department-specific criteria that Ph.D.
students must meet when forming their committees:

- Committees should consist of 5 members (one more than the
  Graduate School’s requirement of four).
- The chair should be a faculty member in BME (primary or affiliate).
- At least one member must be from outside of the primary BME
  faculty.
- At least one member must be a primary BME faculty.
- The Ph.D. committee chair should approve the other members of the
  committee.
- Students must have a yearly committee meeting after passing the
  preliminary exam.

**CREDITS PER TERM ALLOWED**

15 credits

**TIME CONSTRAINTS**

Students typically complete their degree within seven years of entering
the program.

Within two years of entering their program, students are required to pass
a comprehensive qualifying examination.

Within one year of completion of their qualifying examination, students
are required to prepare for a preliminary examination.

**GRIEVANCES AND APPEALS**

These resources may be helpful in addressing your concerns:

- Bias or Hate Reporting (https://doso.students.wisc.edu/bias-or-hate-
  reporting/)
- Graduate Assistantship Policies and Procedures (https://hr.wisc.edu/
policies/gapp/#grievance-procedure)
- Hostile and Intimidating Behavior Policies and Procedures (https://
hr.wisc.edu/hib/)
  - Office of the Provost for Faculty and Staff Affairs (https://
    facstaff.provost.wisc.edu/)
  - Dean of Students Office (https://doso.students.wisc.edu/) (for all
    students to seek grievance assistance and support)
- Employee Assistance (http://www.eao.wisc.edu/) (for personal
counseling and workplace consultation around communication and
conflict involving graduate assistants and other employees, post-doctoral students, faculty and staff)

- Employee Disability Resource Office (https://employeedisabilities.wisc.edu/) (for qualified employees or applicants with disabilities to have equal employment opportunities)
- Graduate School (https://grad.wisc.edu/) (for informal advice at any level of review and for official appeals of program/departmental or school/college grievance decisions)
- Office of Compliance (https://compliance.wisc.edu/) (for class harassment and discrimination, including sexual harassment and sexual violence)
- Office of Student Conduct and Community Standards (https://conduct.students.wisc.edu/) (for conflicts involving students)
- Ombuds Office for Faculty and Staff (http://www.ombuds.wisc.edu/) (for employed graduate students and post-docs, as well as faculty and staff)
- Title IX (https://compliance.wisc.edu/titleix/) (for concerns about discrimination)

**BME Grievance Procedures**

If a student feels unfairly treated or aggrieved by faculty, staff, or another student, the University offers several avenues to resolve the grievance. Students’ concerns about unfair treatment are best handled directly with the person responsible for the objectionable action. Options for grievance reporting beyond the research advisor include seeking out the graduate program coordinator, BME grievance committee (details below), CoE Assistant Dean for Graduate Affairs, and UW-Madison Ombuds.

These are presented at increasing level of administration; the department encourages students to report at the lowest level they feel comfortable with and seek out higher levels if needed. For more information, students should consult the College of Engineering.

**Step 1**

The student is encouraged to speak first with the person toward whom the grievance is directed to see if a situation can be resolved at this level.

**Step 2**

Should a satisfactory resolution not be achieved, the student should contact the program’s Grievance Advisor, Professor Beth Meyerand, to discuss the grievance. The Grievance Advisor will facilitate problem resolution through informal channels and facilitate any complaints or issues of students.

The first attempt is to help students informally address the grievance prior to any formal complaint. Students are also encouraged to talk with their faculty advisors regarding concerns or difficulties if necessary.

University resources for sexual harassment, discrimination, disability accommodations, and other related concerns can be found on the UW Office of Equity and Diversity website.

**Step 3**

Other campus resources besides those listed above include the Assistant Dean for Graduate Affairs in the College of Engineering

**Step 4**

If the issue is not resolved to the student’s satisfaction, the student can submit the grievance to the Grievance Advisor in writing, within 60 calendar days of the alleged unfair treatment.

**Step 5**

On receipt of a written complaint, a faculty committee will be convened by the Grievance Advisor to manage the grievance. The program faculty committee will obtain a written response from the person toward whom the complaint is directed. This response will be shared with the person filing the grievance.

**Step 6**

The faculty committee will determine a decision regarding the grievance. The Grievance Advisor will report on the action taken by the committee in writing to both the student and the party toward whom the complaint was directed within 15 working days from the date the complaint was received.

**Step 7**

At this point, if either party (the student or the person toward whom the grievance is directed) is unsatisfied with the decision of the faculty committee, the party may file a written appeal. Either party has 10 working days to file a written appeal to the School/College.

**Step 8**

Documentation of the grievance will be stored for at least 7 years. Significant grievances that set a precedent will be stored indefinitely. The Graduate School has procedures for students wishing to appeal a grievance decision made at the school/college level. These policies are described in the Graduate School’s Academic Policies and Procedures.

**OTHER**

n/a

**PROFESSIONAL DEVELOPMENT**

**GRADUATE SCHOOL RESOURCES**

Take advantage of the Graduate School’s professional development resources (https://grad.wisc.edu/pd/) to build skills, thrive academically, and launch your career.

**PROGRAM RESOURCES**

**THE INDIVIDUAL DEVELOPMENT PLAN (IDP)**

An Individual Development Plan (IDP) (https://grad.wisc.edu/pd/idp/) helps graduate students and postdoctoral researchers:

- assess current skills, interests, and strengths;
- make a plan for developing skills to meet academic and professional goals; and
- communicate with supervisors, advisors, and mentors about evolving goals and related skills.

The IDP is a document to be revisited again and again, to update and refine as goals change and/or come into focus, and to record progress and accomplishments.

The university recommends IDPs for all postdoctoral researchers and graduate students, and requires IDPs for all postdoctoral researchers and graduate students supported by National Institutes of Health (NIH) funding. See the Graduate School for more information and IDP resources (https://grad.wisc.edu/pd/idp/).
ENGINEERING CAREER SERVICES
The Engineering Career Services (https://ecs.wisc.edu/) staff offers assistance to students searching or preparing for internships, co-ops, and jobs with well-recognized organizations.

THE WRITING CENTER
The Writing Center (https://writing.wisc.edu/) is a campus-wide organization that provides free of charge, face-to-face and online consultations for students writing papers, reports, resumes, and applications.

LEARNING OUTCOMES
1. Demonstrate an ability to synthesize knowledge from a subset of the biological and physical sciences.
2. Conduct original research.
3. Demonstrate an ability to create new knowledge and communicate it to their peers.
4. Foster ethical and professional conduct.

PEOPLE

FACULTY
See also BME Faculty Directory (https://directory.engr.wisc.edu/bme/faculty/)

PROFESSORS
• David Beebe
• Walter Block
• Paul Campagnola
• Naomi Chesler
• Kevin Eliceiri
• Shaqini (Sarah) Gong
• Kristyn Masters
• Beth Meyerand
• William Murphy
• Darryl Thelen
• Justin Williams

ASSOCIATE PROFESSORS
• Randolph Ashton
• Christopher Brace
• Pamela Kreeger
• Wan-ju Li
• Kip Ludwig
• Krishanu Saha
• Melissa Skala

ASSISTANT PROFESSORS
• Aviad Hai
• Melissa Kinney
• Megan McClean
• Jeremy Rogers

FACULTY ASSOCIATES
• Amit Nimunkar
• John Puccinelli
• Tracy Jane Puccinelli
• Darlis Suarez-Gonzalez
• Aaron Suminski

EMERITUS
• Ed Bersu
• Willis Tompkins
• John Webster