BIOMEDICAL ENGINEERING, BSE

Biomedical engineering (BME) students at UWM will learn to translate engineering principles into clinical methods. Students will also engage in collaborative and interdisciplinary research projects with labs in the College of Engineering & Applied Science, College of Letters & Science, College of Health Sciences, School of Nursing, School of Public Health, and with local industry.

The BME undergraduate program emphasizes engineering design in preparation for employment in biomedical industries or launching startups in this fast-growing field. Freshmen and sophomores take a core curriculum that provides a foundation of engineering principles and tools, software application, anatomy and physiology, and communication skills. Juniors take courses on sensors and actuators, biomedical signal processing and medical devices. Seniors also work on capstone design projects and the Product Realization course in multidisciplinary teams. A wide variety of elective courses allow juniors and seniors to specialize in the area of their choice.

Current focus areas include:

- Assistive Technology
- Biomechanics
- Medical Imaging
- Medical Instrumentation
- Rehabilitation Engineering

Key aspects of the undergraduate program include:

- Design projects, throughout the curriculum
- Hands-on laboratories
- Flexibility in biomedical engineering with depth through specialization areas
- Industry cooperatives/internship opportunities
- Research opportunities in world-class labs that make UWM one of the nation’s top research universities (rated R1 by the Carnegie Classification of Institutions of Higher Education); the only one in southeastern Wisconsin

Career Paths

Biomedical engineers work with medical scientists, other medical researchers, and manufacturers to address a wide range of injuries and physical disabilities. Their ability to work on different activities with other professionals is enlarging the range of applications for biomedical products and services, particularly in healthcare.

- Clinical or Field Engineer
- Staff Engineer
- Manufacturing Engineer
- Researcher
- Quality Engineer
- Sales Engineer

New Freshmen

Admission to the College of Engineering and Applied Science is based on an overall assessment of both academic and non-academic qualifications. The primary review factors for admission are the strength and quality of the high school curriculum, high school class percentile, grade point average, and the result of the ACT or SAT. Well-prepared freshman applicants will have four years of mathematics (including one-and-a-half years of algebra, one year of geometry, and one-half year of trigonometry) and four years of natural science (including biology, chemistry, and physics). The College also will consider non-academic qualifications such as leadership skills, diversity in personal background, work experience, motivation, and maturity.

Freshmen applicants will be considered for admission directly to the major or to the First-Year Program. Admission directly to the major is selective.

Transfer Students

Transfer student admission is based on an overall assessment of both academic and non-academic qualifications. For transfer applicants, the primary factors considered for admission are the grade point average on transferable courses and the level of curriculum completion. The College also will consider non-academic qualifications such as leadership skills, diversity in personal background, work experience, motivation, and maturity.

Transfer applicants will be considered for admission directly to the major or the Transfer Transition Program based on the number of transfer credits and GPA.

Admission to the Major

Students admitted to the First-Year Program or Transfer Transition Program (Engineering-intended or Computer Science-intended) may apply for major status with their academic advisor at the time they believe they meet the requirements. The program may impose major status as a prerequisite for courses numbered 200 or above.

1. Complete first semester calculus with a C or better grade.
2. Complete GER Oral and Written Communication Part A.
3. Engineering majors must complete Chem 100 with a C or better grade (or satisfactory score on the placement test). Computer Science majors must complete CompSci 251 with a C or better grade.
4. Obtain a minimum grade point as set by the major department. A 3.00 GPA guarantees admission to any CEAS major.
5. Courses required by the major may be repeated only once. No more than two courses may be repeated.

First-Year students have a maximum of three semesters to complete the admission to major requirements. Part-time students may be granted an extension by their academic advisor.

Transfer Transition students have a maximum of two semesters to complete the admission to major requirements. Part-time students may be granted an extension by their academic advisor.

Placement Testing

Most new freshmen are required to take placement exams in English and mathematics. Engineering students also take a placement exam in chemistry, provided they have had previous coursework in chemistry. Students with previous college-level credits in chemistry, English, and math may not be required to take placement tests. Additional prerequisite coursework may be required as a result of these placement tests. Credit for prerequisite academic work may not count toward the degree program. Entering students are urged to take their placement exams when scheduled. All placement exams must be completed before beginning coursework in the subject area. Students who place into
precalculus math courses may be asked to participate in an online summer bridge program.

Questions on admission to CEAS or choosing a major should be directed to the Office of Student Services, (414) 229-4667.

**Biomedical Engineering Curriculum**

The minimum number of credits required to complete the Bachelor of Science in Biomedical Engineering is 120. Students who need background preparation courses in math, English, and foreign language may need additional credits. Students must maintain an average GPA of at least 2.0 on all work attempted at the University and in all courses offered by the College. Engineering students may apply for major status with their academic advisor at any time they believe they meet the requirements. Students majoring in Biomedical Engineering must maintain an average GPA of at least 2.0 in all 300-level required major courses. Transferable courses will be included as appropriate. Advancement to major status is required for graduation. Programs may impose major status as a prerequisite for courses numbered 200 or above.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 101</td>
<td>Fundamentals of Biomedical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CIV ENG 201</td>
<td>Statics</td>
<td>3</td>
</tr>
<tr>
<td>CIV ENG 202</td>
<td>Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>EAS 200</td>
<td>Professional Seminar</td>
<td>1</td>
</tr>
<tr>
<td>ELECENG 301</td>
<td>Electrical Circuits I</td>
<td>3</td>
</tr>
<tr>
<td>ELECENG 305</td>
<td>Electrical Circuits II</td>
<td>4</td>
</tr>
<tr>
<td>MATLENG 201</td>
<td>Engineering Materials</td>
<td>4</td>
</tr>
<tr>
<td>MECHENG 101</td>
<td>Computational Tools for Engineers</td>
<td>2</td>
</tr>
<tr>
<td>MECHENG 301</td>
<td>Basic Engineering Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>BIO SCI 202</td>
<td>Anatomy and Physiology I</td>
<td>4</td>
</tr>
<tr>
<td>BIO SCI 203</td>
<td>Anatomy and Physiology II</td>
<td>4</td>
</tr>
<tr>
<td>BIO SCI 465 or IND ENG 367</td>
<td>Biostatistics</td>
<td>3</td>
</tr>
<tr>
<td>BME 302</td>
<td>Analysis and Modeling of Dynamic Systems</td>
<td>4</td>
</tr>
<tr>
<td>BME 305</td>
<td>Introduction to Engineering Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>BME 320</td>
<td>Engineering of Biomedical Devices I</td>
<td>4</td>
</tr>
<tr>
<td>BME 325</td>
<td>Engineering of Biomedical Devices II</td>
<td>3</td>
</tr>
<tr>
<td>BME 385</td>
<td>Introduction to Biomaterials</td>
<td>3</td>
</tr>
<tr>
<td>BME 495</td>
<td>Biomedical Instrumentation Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>BME 595</td>
<td>Capstone Design Project</td>
<td>4</td>
</tr>
<tr>
<td>ELECENG 310</td>
<td>Signals and Systems</td>
<td>3</td>
</tr>
</tbody>
</table>

**Mathematics Requirement (14 to 16 credits)**

Select one of the following Calculus sequences: 10-12

- Sequence 1:
  - MATH 231 & MATH 232: Calculus and Analytic Geometry I and Calculus and Analytic Geometry II
  - MATH 233: Calculus and Analytic Geometry III

- Sequence 2:

<table>
<thead>
<tr>
<th>Code</th>
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</tr>
</thead>
<tbody>
<tr>
<td>MATH 221 &amp; MATH 222</td>
<td>Honors Calculus I and Honors Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>ELECENG 234</td>
<td>Analytical Methods in Engineering</td>
<td>4</td>
</tr>
<tr>
<td>Physics Requirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYSICS 209 &amp; PHYSICS 214</td>
<td>Physics I (Calculus Treatment) and Lab Physics I (Calculus Treatment)</td>
<td>5</td>
</tr>
<tr>
<td>PHYSICS 210 &amp; PHYSICS 215</td>
<td>Physics II (Calculus Treatment) and Lab Physics II (Calculus Treatment)</td>
<td>5</td>
</tr>
<tr>
<td>GER Distribution Requirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arts</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Humanities</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Social Science</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>ENGLISH 310 Writing, Speaking, and Technoscience in the 21st Century</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

**Foreign Language Requirement**
The foreign language requirement can be completed with one of these options: 0-8

- Two years of a single foreign language in high school;
- Two semesters of a single foreign language in college; or
- Demonstrate ability by examination.

**Placement Examinations.** Once admitted to UWM, most engineering students are required to take placement examinations in mathematics, English, and chemistry. Students with previous college-level credits in these areas may not be required to take placement exams. The placement exams are administered by the UWM Testing Center, Mellencamp Hall, Room B28, (414) 229-4689. The results of these tests help students determine the appropriate course in which to register. Background prerequisite courses may be required in addition to the courses listed above.

**Technical Electives**
The Biomedical Engineering program requires a total of 15 credits of technical electives, chosen from the following list:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO SCI 150</td>
<td>Foundations of Biological Sciences I</td>
<td>4</td>
</tr>
<tr>
<td>BIO SCI 152</td>
<td>Foundations of Biological Sciences II</td>
<td>4</td>
</tr>
<tr>
<td>BIO SCI 354</td>
<td>Introduction to Neuroscience I: From Neuron to Brain</td>
<td>3</td>
</tr>
<tr>
<td>BIO SCI 355</td>
<td>Introduction to Neuroscience II: From Brain to Behavior</td>
<td>3</td>
</tr>
<tr>
<td>BME 585</td>
<td>Advanced Biomaterials</td>
<td>3</td>
</tr>
<tr>
<td>BME 599</td>
<td>Senior Thesis</td>
<td>3</td>
</tr>
<tr>
<td>BME 690</td>
<td>Topics in Biomedical Engineering:</td>
<td>3</td>
</tr>
<tr>
<td>BME 699</td>
<td>Independent Study</td>
<td>1-3</td>
</tr>
<tr>
<td>BUS ADM 447</td>
<td>Entrepreneurship</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 102</td>
<td>General Chemistry</td>
<td>5</td>
</tr>
</tbody>
</table>
Minimum Requirements

Students must maintain an average GPA of at least 2.00 on all work attempted at the University and in all courses offered by the College. Students majoring in biomedical engineering, computer engineering, computer science, industrial engineering, and materials engineering must maintain an average GPA of at least 2.00 in all 300-level and above courses in the student’s major department. Students majoring in civil engineering, electrical engineering, and mechanical engineering must maintain an average GPA of at least 2.50 in all 300-level and above courses in the major department. Transferable courses will be included as appropriate. Advancement to major status is required for graduation.

In order to provide maximum flexibility while preserving the institutional identity of a UWM degree, the College requires residence:

1. during the last 30 credits, or
2. during 45 of the last 60 credits, or
3. during any 90 credits of a student's undergraduate career.

At least 15 credits of advanced work in the major must be completed in residence at UWM.

A student who does not maintain continuous registration during the academic year and is re-admitted to the College must meet the program and graduation requirements in effect at the time of re-entry.

Degree and major requirements must be completed within 10 years of initial enrollment at UW-Milwaukee. Should students not complete the major within the 10-year time frame, the students will switch to the most current degree and major requirements. A new 10-year time frame would then begin.

Dual Majors

Students wishing to major in more than one field can do so in two ways:

1. Complete the requirements for more than one major before receiving a degree from the College. In this case, the degree will list both majors.
2. Be admitted to the College as a second degree candidate (after earning a bachelor's degree in any field), providing University and College entrance requirements are met. Such a student must meet all undergraduate degree requirements in the College and present a minimum of 30 credits beyond the previous bachelor's degree.

Concurrent Registration at Other Institutions

CEAS students wishing to establish concurrent enrollment at another institution must obtain prior permission from their academic advisor.

Student Academic Appeals

Students may appeal an academic action to the Office of Student Services. An appeal is a request for an exception to an established policy or rule. The content of each appeal is carefully reviewed in order to reach a decision. Appeals should be submitted in writing to the Office of Student Services. The appeals committee considers individual cases concerning the degree requirements and other academic rules and regulations established by the College of Engineering and Applied Science faculty.

The College of Engineering and Applied Science has established written procedures for undergraduate student academic grievances. Copies of the grievance procedure are available in the Office of Student Services. As a first step, students must discuss the grievance with the faculty member or administrator as soon as possible to attempt to resolve the issue, but not later than 30 days after the action that prompted the grievance/appeal.

Computer Science and Engineering Programs

Detailed descriptions of the CEAS undergraduate programs are provided in this catalog. All courses are not offered every semester. A few technical elective courses may be offered only once every three to four semesters. In addition, since computer science and engineering curricula are continually evolving to keep current, students are encouraged to consult with their advisors to plan each semester’s list of classes. Part-time students should always maintain a plan that looks ahead two to three semesters to avoid scheduling difficulties.

The curricula outlined in the pages are applicable to new students entering CEAS in fall 2016 or later. Students who enrolled in computer science or engineering programs prior to that date should consult with the appropriate previous editions of this catalog for information about their program requirements. As a general rule, when program changes occur, continuing students have the choice of continuing in their existing program or following the new requirements. Occasionally,
program change will be required of all students regardless of their date of matriculation, so long as it does not increase the total credits needed for graduation.

These program descriptions represent the minimum requirements for graduation from UWM in computer science or engineering. In all cases, it is important that students consult with their advisor before making course selections to avoid errors in programming.

Academic Advising
The Office of Student Services in the College of Engineering and Applied Science, located in Room E386 of the Engineering and Mathematical Sciences Building, offers undergraduate students academic advising from professional advisors who are familiar with the curriculum, College requirements, and the special needs of engineering and computer science students. These advisors provide services such as freshman orientation, course selection, program planning, and credit transfer evaluation. Students are assigned to a permanent professional advisor as soon as they are accepted into the College, and are urged to confer with their advisor at least once each semester. Students also are assigned to a faculty advisor who provides technical expertise specific to the student’s area of study.

We understand that it can be a delicate balance managing school, work, family, and active social lives. The College of Engineering and Applied Science advisors are here to help you achieve that balance.

You will be assigned a professional academic advisor upon being admitted to the College of Engineering & Applied Science. Your advisor will work with you throughout your undergraduate experience, providing guidance on:

- course registration,
- graduation planning,
- career preparation,
- and serving as a liaison to the many other resources available on our campus.

Advisors are also a great source of information on student organizations, tutoring and scholarship opportunities.

In addition to professional academic advisors, you will also have access to faculty advisors. These advisors can provide insights into the technical aspects of the engineering and computer science curricula while mentoring you as you define your professional goals.

Student Learning Outcomes
Upon the completion of the program, a graduate of the program will be able to:

1. Apply principles of engineering, biology, human physiology, basic science, mathematics, and statistics.
2. Solve biomedical engineering problems, including those associated with the interaction between living and non-living systems.
3. Analyze, model, design, and realize biomedical engineering devices, systems, components, or processes, and make measurements and interpret data from living systems.
4. Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

5. Demonstrate an understanding of professional and ethical responsibility.
6. Demonstrate the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
7. Demonstrate an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Honors in the College of Engineering and Applied Science
Dean's Honor List
GPA of 3.500 or above, earned on a full-time student’s GPA on 12 or more graded credits in a given semester.

Honors Degree and Honors Degree with Thesis
Granted to graduating seniors who complete Honors College requirements, as listed in the Honors College (http://catalog.uwm.edu/opportunities-resources/honors-college) section of this site.

Commencement Honors
Students with a cumulative GPA of 3.500 or above, based on a minimum of 40 graded UWM credits earned prior to the final semester, will receive all-university commencement honors and be awarded the traditional gold cord at the December or May Honors Convocation. In schools and colleges in which fewer than 15% of the traditional students have a 3.500 GPA, all-university honors will be awarded to approximately the top 15% of graduating students. A criterion GPA (not lower than 3.200) for this 15% will be calculated based on statistics from the previous comparable semester. Please note that for honors calculation, the GPA is not rounded and is truncated at the third decimal (e.g., 3.499).

Final Honors
Earned on a minimum of 60 graded UWM credits: Cum Laude - 3.500 or above; Magna Cum Laude - 3.650 or above; Summa Cum Laude - 3.800 or above.

Joint Programs with Other Campuses
Pre-engineering
Qualified students may enroll in coordinated pre-engineering programs at UW-Green Bay, UW-Parkside, and UW-Waukesha for two years of pre-engineering coursework. These coordinated programs ensure equivalent coursework, appropriate advising, and early access to the Cooperative Education Program at UWM.

Dual Degree Programs
Qualified students may enroll in coordinated dual degree programs at Alverno College, Carroll University, UW-Eau Claire, UW-Green Bay, UW-La Crosse, UW-Oshkosh, UW-Stevens Point, UW-Whitewater and Wisconsin Lutheran College. Students in these programs will earn a bachelor’s degree at both universities in five years. Students transfer to UWM after three years at the partner university. For more information, contact the Office of Student Services at (414) 229-4667.
Joint Programs with Wisconsin Technical Colleges

Gateway Technical College
An agreement with GTC allows those students having associate degrees in the Electrical Engineering - Technology the opportunity to be given credit for courses required in the UWM bachelor of science in engineering program. For more information, contact the Office of Student Services at (414) 229-4667.

Milwaukee Area Technical College
An agreement with MATC allows joint admission and enrollment at MATC and CEAS. Qualified students may take English, mathematics, chemistry, and general education courses at MATC. The program ensures equivalent coursework and appropriate advising. Students complete a bachelor of science degree in engineering or computer science at UWM.

Waukesha County Technical College
An agreement with WCTC allows those students having associate degrees in the Industrial Occupations Division at WCTC the opportunity to be given credit for courses required in the UWM bachelor of science in engineering or bachelor of science in computer science program. For more information, contact the Office of Student Services at (414) 229-4667.