

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.

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.

Applicants who do not meet the requirements for admission to the College of Engineering & Applied Science will automatically be considered for admission to the Pre-Engineering program in the UWM College of General Studies.

The Pre-Engineering program is an Associate degree level program offered jointly by the College of General Studies and the College of Engineering & Applied Science. The curriculum is designed to prepare students for the engineering program with emphasis on mathematics.

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.

Code	Title	Credits
Major Requirement - 51 credits		
BIO SCI 202	Anatomy and Physiology I	4
BIO SCI 203	Anatomy and Physiology II	4
BME 101	Fundamentals of Biomedical Engineering	3
BME 296	Fundamentals of Biomaterials	4
BME 302	Analysis and Modeling of Dynamic Systems	4
BME 306	Introduction to Engineering Biomechanics	4
BME 310	Biomedical Signals and Systems	3
BME 320	Engineering of Biomedical Devices I	4
BME 325	Engineering of Biomedical Devices II	3
BME 495	Biomedical Instrumentation Laboratory	3
BME 595	Capstone Design Project	4
EAS 110	Fundamentals of Smart Systems Engineering I	2
EAS 200	Professional Seminar	1

EAS 210	Fundamentals of Smart Systems Engineering II	2
COMPSCI 202	Introductory Programming Using Python	3
or COMPSCI 250	Introductory Computer Programming	
IND ENG 367	Engineering Statistics	3
Engineering Requirement- 15 credits		
Select any 15 credits from 200 or higher-level courses from BME, CIV ENG, ELECENG, IND ENG, MATLENG, MECHENG; at least 9 of these credits must be from 300 or higher-level courses. Courses cannot be double counted as part of other requirements of the program.		15
Mathematics Requirement - 16 credits ¹		
MATH 231	Calculus and Analytic Geometry I	4
MATH 232	Calculus and Analytic Geometry II	4
MATH 233	Calculus and Analytic Geometry III	4
ELECENG 234	Analytical Methods in Engineering	4
Physics Requirement - 8 credits		
PHYSICS 209	Physics I (Calculus Treatment)	4
PHYSICS 210	Physics II (Calculus Treatment)	4
Technical Electives - 9 credits		
Select 9 credits from the approved technical electives list below: ²		9
BIO SCI 150	Foundations of Biological Sciences I	
BIO SCI 152	Foundations of Biological Sciences II	
BME 585	Advanced Biomaterials	
BME 599	Senior Thesis	
BME 690	Topics in Biomedical Engineering:	
BME 699	Independent Study	
BUS ADM 447	Entrepreneurship	
CHEM 102	General Chemistry	
CHEM 104	General Chemistry and Qualitative Analysis	
CHEM 343	Organic Chemistry	
CHEM 344	Organic Chemistry Laboratory	
CHEM 345	Organic Chemistry	
CIV ENG 311	Introduction to Energy, Environment and Sustainability	
COMPSCI 411	Machine Learning and Applications	
EAS 1	Engineering Co-op Work Period	
EAS 497	Study Abroad:	
ELECENG 361	Electromagnetic Fields	
ELECENG 410	Digital Signal Processing	
ELECENG 436	Introduction to Medical Instrumentation	
ELECENG 437	Introduction to Biomedical Imaging	
IND ENG 360	Engineering Economics	
MECHENG 320	Introduction to Fluid Mechanics	
MECHENG 474	Introduction to Control Systems	
GER Distribution Requirement - 15 credits		
Arts		3
Humanities		3
Social Science		6
ENGLISH 310	Writing, Speaking, and Technoscience in the 21st Century	3

Cultural Diversity - Arts, Humanities, or Social Science course must also satisfy UWM Cultural Diversity Requirement	
Free Electives	6
Students must also satisfy Oral and Written Communication (OWA) Part A ³	0-6
Students must also Satisfy the UWM Foreign Language requirements (0-8) ³	0-8
Total Credits	120

¹ MATH 221 and MATH 222 may substitute for MATH 231, MATH 232, and MATH 233.

² The following courses are approved technical electives, but are currently inactive: ELECENG 437, ELECENG 438, ELECENG 539.

³ See General Education Requirements (<https://catalog.uwm.edu/policies/undergraduate-policies/#bachelorsdegreegeneraleducation>).

Biomedical Engineering BSE Objectives and Outcomes

Program Educational Objectives

Upon completing the UWM Biomedical Engineering undergraduate program, our graduates will possess the necessary tools for opportunities in graduate study or careers in the biomedical industry. Our graduates will differentiate themselves by their ability to:

Objective 1. Apply broad-based knowledge of mathematics, engineering, physical sciences, and life sciences to solve biomedical engineering problems, including those associated with the interactions between living and non-living systems.

Objective 2. Perform measurements on, and interpret data from, both living and non-living systems.

Objective 3. Contribute as valued members of medical device design and/or development teams, and communicate effectively across diverse audiences.

Objective 4. Translate engineering principles into clinical methods through coursework and participation in collaborative and interdisciplinary research projects.

Objective 5. Maintain an appreciation of the life of learning essential to successful engineers.

Student Outcomes

Graduates of the Biomedical Engineering Department at the University of Wisconsin – Milwaukee will have:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. an ability to communicate effectively with a range of audiences.
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

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.

For the Engineering BS program only:

1. complete at least 30 credits at UWM; and
2. complete at least 15 credits in upper-division (numbered 300 or above) courses in the major 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, a 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.

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.

Honors in the Major

Students in Biomedical Engineering who meet all of the following criteria can be awarded honors in the major upon graduation:

1. A 3.000 cumulative GPA in all UWM graded credits;
2. A 3.500 GPA over all CEAS courses counting toward the Biomedical Engineering major;
3. A 3.500 GPA over all upper-division (300 level and higher) BME courses; and
4. At least one of the following:
 - a. Successful completion of 3 credits of research experience via senior thesis (BME 599) and/or an approved independent study (BME 699).
 - b. Participation in the Accelerated MS program with successful completion of 6 credits in approved courses for the Biomedical Engineering concentration in the MS in Engineering Program.

Students who believe they may qualify for honors in Biomedical Engineering should apply to the College of Engineering & Applied Science during their last semester of study.

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 College Degree and Honors College Degree with Distinction

Granted to graduating seniors who complete Honors College requirements, as listed in the Honors College (<https://catalog.uwm.edu/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. 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.