

# ELECTRICAL ENGINEERING, BSE

Electrical engineering graduates pursue careers in fields such as energy generation and transmission, renewable energy, power electronics, bio-imaging and devices, signal and image processing, communications, optical and photonic circuits and devices, controls and automation, and many other areas.

## Concentrations

Several possible technical elective course groupings are listed below, as an aid in choosing technical electives. Electrical engineering students do not need to follow any particular grouping – the listings described below are provided as a guide only. In the long term, students will be better prepared for an engineering career having a broad exposure to different technical areas, rather than a narrow focus in one specialized area.

- Power Electronics and Power Systems
- Optics
- Nanotechnology/Nanoengineering
- Microwave/Radio-Frequency Engineering
- Electronics
- Controls
- Computer Systems
- Communications and Signal Processing
- Biomedical Imaging
- Embedded Systems

## Research

Work with faculty (<http://uwm.edu/engineering/classification/faculty/electrical-engineering/>) engaged in leading-edge research in areas such as:

- Optics and photonics in neuroscience
- Renewable energy
- Machine learning
- Artificial intelligence
- Data visualization
- Electric vehicles, aircraft and ships

## Accreditation

The Electrical Engineering program is accredited by the Engineering Accreditation Commission of ABET: <https://www.abet.org> (<https://tinyurl.com/u7fsfevw/>).

## 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.

## Electrical Engineering Curriculum

The minimum number of credits required to complete the Bachelor of Science in Engineering with a major in Electrical Engineering is 120.

Code	Title	Credits
<b>Electrical Engineering Major Requirements (35 credits)</b>		
EAS 200	Professional Seminar	1
<i>Fundamentals of Electrical Engineering (Select one from the following two courses)<sup>1</sup></i>		3
ELECENG 101	Fundamentals of Electrical Engineering	
ELECENG 201	Foundations of Electrical Engineering	
ELECENG 140	Intro to Embedded Computing I: Digital Logic and Microprocessors	3
ELECENG 240	Intro to Embedded Computing II: C Programming for Embedded Applications	4
ELECENG 301	Electrical Circuits and Electronics I	3
ELECENG 310	Signals and Systems	3
ELECENG 330	Electrical Circuits and Electronics II	4
ELECENG 420	Random Signals and Systems	3
ELECENG 596	Capstone Design I	3
ELECENG 597	Capstone Design II	2
<b>Electrical and Computer Engineering Electives</b>		
Select at least TWO from the following courses. If the chosen courses carry more than 6 credits, the extra credits will be counted as Group A technical Elective credits.		6
ELECENG 305	Electrical Circuits II	
ELECENG 335	Electronics II	
ELECENG 340	Embedded Systems I: C and C++ Programming for Embedded Applications	
ELECENG 361	Electromagnetic Fields	
ELECENG 362	Electromechanical Energy Conversion	

ELECENG 440	Embedded Systems II: Advanced Embedded Systems	
<b>Mathematics Requirement (16 credits)</b> <sup>2</sup>		
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
<b>Chemistry and Biology Requirements (4 credits)</b>		
Select one from the following options:		4
<i>Option I (4 credits will be counted here and 1 credit will be counted as Group A technical elective credit)</i>		
CHEM 105 or CHEM 102	General Chemistry for Engineering General Chemistry	
<i>Option II</i>		
BIO SCI 202	Anatomy and Physiology I	
<b>Physics Requirement (10 credits)</b>		
PHYSICS 209 & PHYSICS 214	Physics I (Calculus Treatment) and Lab Physics I (Calculus Treatment)	5
PHYSICS 210 & PHYSICS 215	Physics II (Calculus Treatment) and Lab Physics II (Calculus Treatment)	5
<b>Technical Electives - Select 31 credits from approved lists</b>		<b>31</b>
<b>GER Distribution Requirement (15 credits)</b>		
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		
<b>Free Electives (9 Credits)</b>		<b>9</b>
<b>Students must also satisfy Oral and Written Communication (OWA) Part A</b> <sup>3</sup>		<b>0-6</b>
<b>Students must also satisfy the UWM Foreign Language requirements</b> <sup>3</sup>		<b>0-8</b>
<b>Total Credits</b>		<b>120</b>

<sup>1</sup> Students can take both ELECENG 101 and ELECENG 201, but only 3 credits will be counted towards the graduation requirements.

<sup>2</sup> MATH 221, MATH 222 and two free electives may substitute for MATH 231, MATH 232 and MATH 233.

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

## Technical Electives

The electrical engineering program requires a total of 31 credits of technical electives, chosen as follows. All non-required Electrical Engineering courses numbered 400-699 are Group A Technical Electives.

Code	Title	Credits
<b>Group A Technical Electives</b>		
Select at least 25 credits from the following or any electrical and computer engineering elective course which hasn't been used to satisfy the Electrical and Computer Engineering Elective requirement. The extra credits above 6 and 1 extra credit from CHEM 102 or CHEM 105 are also counted towards Group A technical elective credits.		25-31

BUS ADM 447	Entrepreneurship
COMPSCI 459	Fundamentals of Computer Graphics
COMPSCI 520	Computer Networks
COMPSCI 530	Computer Networks Laboratory
EAS 1	Engineering Co-op Work Period <sup>1</sup>
EAS 497	Study Abroad: <sup>2</sup>
ELECENG 410	Digital Signal Processing
ELECENG 421	Communication Systems
ELECENG 436	Introduction to Medical Instrumentation
ELECENG 437	Introduction to Biomedical Imaging
ELECENG 451	Introduction to VLSI Design
ELECENG 457	Digital Logic Laboratory
ELECENG 458	Computer Architecture
ELECENG 461	Microwave Engineering
ELECENG 464	Fundamentals of Photonics
ELECENG 465	Broadband Optical Networks
ELECENG 471	Electric Power Systems
ELECENG 474	Introduction to Control Systems
ELECENG 481	Electronic Materials
ELECENG 490	Topics in Electrical Engineering:
ELECENG 541	Integrated Circuits and Systems
ELECENG 565	Optical Communication
ELECENG 572	Power Electronics
ELECENG 574	Intermediate Control Systems
ELECENG 575	Analysis of Electric Machines and Motor Drives
ELECENG 599	Senior Thesis
IND ENG 360	Engineering Economics
IND ENG 550	Control of Automated Manufacturing Systems
MECHENG 301	Basic Engineering Thermodynamics
MECHENG 321	Basic Heat Transfer

### Group B Technical Electives

Select up to 6 credits from the following:		0-6
IND ENG 112	Computer-Aided Design	
MATLENG 201	Engineering Materials	
Any BIO SCI course 150-level or above <sup>3</sup>		
Any CHEM course 200-level or above, or CHEM 104 <sup>4</sup>		
Any COMPSCI course 200-level or above		
Any MATH course 400-level or above, or MATH 313, MATH 322, or MATH 325		
Any PHYSICS course 300-level or above		

<sup>1</sup> Students who earn 3 or more credits of Co-op may use 3 of those credits as approved technical electives.

<sup>2</sup> Students who earn 3 or more credits of Study Abroad may use 3 of those credits as approved technical electives.

<sup>3</sup> Students who take BIO SCI 202 to satisfy Chemistry and Biology requirements cannot double count 4 credits here.

<sup>4</sup> Students who take CHEM 102 and CHEM 104 (equaling a minimum of 8 credits) may use up to 3 credits of CHEM 104 as Group B technical electives.

# Electrical Engineering BSE Objectives and Outcomes

## Program Educational Objectives

The Electrical Engineering program educational objectives prepare students to:

**Objective 1:** Graduates are creative problem solvers who provide and communicate solutions to challenging problems by applying fundamental mathematical, scientific and engineering principles, while giving special considerations to social issues, human factors and ethical issues.

**Objective 2:** Graduates solve problems as members of a team, and will exhibit high levels of professionalism in their work.

**Objective 3:** Graduates successfully engage in careers in electrical engineering and related fields that support the regional and national economy.

**Objective 4:** Graduates are engaged in continued professional development.

## Student Outcomes

The BSE program in Electrical Engineering will prepare students to attain:

- an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- 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.
- an ability to communicate effectively with a range of audiences.
- 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.
- 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.
- an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
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## 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 Electrical 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 EE major;
3. A 3.500 GPA over all upper-division (300 level and higher) EE courses; and
4. At least one of the following:
  - a. Successful completion of 3-cr of research experience via senior thesis (ELECENG 599).
  - b. Participation in accelerated MS program with successful completion of 6 credits in approved courses for the EE concentration in MS in Engineering program.

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

NOTE: The Senior Thesis consists of working with a professor to define a project, perform the project, and write up results of the project to present to a three-professor committee for acceptance. A typical Senior Thesis report would be 15-30 pages consisting of project description, literature search, what was done, and conclusions.

## **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.