

# COMPUTER ENGINEERING, B.S.

Computer engineers design, develop, analyze, research, and manufacture hardware, software, and systems that process, store, and convey digital information. These systems include personal computers, workstations, mainframe computers, and embedded digital systems. Embedded systems consist of one to many computers within other products such as aircraft, automobiles, communication switching systems, networking components, biomedical instrumentation, and industrial automation systems. These systems are characterized by the use of digital electronic hardware and software in performing useful tasks. Computer software in combination with digital integrated circuits provides the foundation for the current revolution in computers and communications. This focus on software and digital hardware distinguishes the computer engineer from the electrical engineer.

## ELECTRICAL ENGINEERING AND COMPUTER ENGINEERING PROGRAM EDUCATIONAL OBJECTIVES

Our graduates should be engaged in activities such as:

1. Employment in industry, government, academia, or non-profit using their degree knowledge or skills for professional functions such as teaching, research and development, quality control, technical marketing, intellectual property management, or sales. Graduates may eventually reach a leadership position supervising others.
2. Continuing education through self-study or short courses and workshops through their employer, local or online educational institutions, or attendance at professional events such as conferences.
3. Taking a principal role in starting a new business or product line.
4. Pursuing a postgraduate degree.

## HOW TO GET IN

### ADMISSION TO THE COLLEGE AS A FRESHMAN

Students applying to UW–Madison (<https://www.admissions.wisc.edu/apply/>) need to indicate an engineering major (<https://www.engr.wisc.edu/academics/undergraduate-academics/choosing-a-major/>) as their first choice in order to be considered for direct admission to the College of Engineering. Direct admission to a major means students will start in the program of their choice in the College of Engineering and will need to meet progression requirements (<https://www.engr.wisc.edu/academics/student-services/academic-advising/first-year-undergraduate-students/progression-requirements/>) at the end of the first year to guarantee advancement in that program.

### CROSS-CAMPUS TRANSFER TO ENGINEERING

UW–Madison students in other schools and colleges on campus must meet the course and credit requirements for admission to engineering degree granting classifications specified in the general college requirements (<https://www.engr.wisc.edu/academics/student-services/academic-advising/cross-campus-students/>). The requirements are the minimum for admission consideration. Cross-campus admission is competitive and selective, and the grade point average expectations may increase as demand trends change. The student's overall academic record at UW–Madison is also considered. Students apply to their

intended engineering program by submitting the online application by stated deadlines for spring and fall. The College of Engineering offers an online information tutorial and drop-in advising (<https://www.engr.wisc.edu/academics/student-services/academic-advising/cross-campus-students/>) for students to learn about the cross-campus transfer process.

### OFF-CAMPUS TRANSFER TO ENGINEERING

With careful planning, students at other accredited institutions can transfer coursework that will apply toward engineering degree requirements at UW–Madison. Off-campus transfer applicants are considered for direct admission to the College of Engineering by applying to the Office of Admissions with an engineering major listed as their first choice. Those who are admitted to their intended engineering program must meet progression requirements (<https://www.engr.wisc.edu/academics/student-services/academic-advising/transfer-students/>) at the point of transfer or within their first two semesters at UW–Madison to guarantee advancement in that program. A minimum of 30 credits in residence in the College of Engineering is required after transferring, and all students must meet all requirements for their major in the college. Transfer admission to the College of Engineering is competitive and selective, and students who have earned more than 80 transferable semester credits at the time of application are not eligible to apply.

The College of Engineering has dual degree programs with select four-year UW System campuses. Eligible dual degree applicants are not subject to the 80 credit limit.

Off-campus transfer students are encouraged to discuss their interests, academic background, and admission options with the Transfer Coordinator in the College of Engineering: [ugtransfer@engr.wisc.edu](mailto:ugtransfer@engr.wisc.edu) or 608-262-2473.

### SECOND BACHELOR'S DEGREE

The College of Engineering does not accept second undergraduate degree applications. Second degree students (<https://www.engr.wisc.edu/admissions/undergraduate-admissions/returning-adults-second-degree-students/>) might explore the Biological Systems Engineering program at UW–Madison, an undergraduate engineering degree elsewhere, or a graduate program in the College of Engineering.

## REQUIREMENTS

### UNIVERSITY GENERAL EDUCATION REQUIREMENTS

All undergraduate students at the University of Wisconsin–Madison are required to fulfill a minimum set of common university general education requirements to ensure that every graduate acquires the essential core of an undergraduate education. This core establishes a foundation for living a productive life, being a citizen of the world, appreciating aesthetic values, and engaging in lifelong learning in a continually changing world. Various schools and colleges will have requirements in addition to the requirements listed below. Consult your advisor for assistance, as needed. For additional information, see the university Undergraduate General Education Requirements (<http://guide.wisc.edu/undergraduate/#requirementsforundergraduatestudytext>) section of the *Guide*.

|                   |   |
|-------------------|---|
| General Education | • Breadth—Humanities/Literature/Arts: 6 credits   |
|                   | • Breadth—Natural Science: 4 to 6 credits, consisting of one 4- or 5-credit course with a laboratory component; or two courses providing a total of 6 credits |
|                   | • Breadth—Social Studies: 3 credits   |
|                   | • Communication Part A & Part B *   |
|                   | • Ethnic Studies *  |

\* The mortarboard symbol appears before the title of any course that fulfills one of the Communication Part A or Part B, Ethnic Studies, or Quantitative Reasoning Part A or Part B requirements.

## SUMMARY OF REQUIREMENTS

The following curriculum applies to students who were admitted to the computer engineering degree program (classification changed to CMPE) in fall 2017 or later.

| Code                                    | Title | Credits        |
|---|-------|----------------|
| Mathematics                             |       | 19             |
| Science                                 |       | 20-21          |
| Computer Engineering Core               |       | 34             |
| Computer Engineering Advanced Electives |       | 16             |
| Professional Electives                  |       | 9              |
| Communication Skills                    |       | 6              |
| Liberal Studies                         |       | 15             |
| Free Elective                           |       | 1              |
| <b>Total Credits</b>                    |       | <b>120-121</b> |

## MATHEMATICS

| Code  | Title   | Credits   |
|---|---|-----------|
| MATH 221  | Calculus and Analytic Geometry I                                | 5         |
| or MATH 217   | Calculus with Algebra and Trigonometry II                       |           |
| or MATH 275   | Topics in Calculus I  |           |
| MATH 222  | Calculus and Analytic Geometry 2                                | 4         |
| or MATH 276   | Topics in Calculus II   |           |
| MATH 234  | Calculus—Functions of Several Variables <sup>1</sup>            | 4         |
| MATH/<br>COMP SCI 240                               | Introduction to Discrete Mathematics                            | 3         |
| or MATH/<br>COMP SCI/<br>STAT 475                   | Introduction to Combinatorics                                   |           |
| <i>Probability/Statistics Elective (select one)</i> |   | 3         |
| STAT 311  | Introduction to Theory and Methods of Mathematical Statistics I |           |
| MATH/STAT 431                                       | Introduction to the Theory of Probability                       |           |
| E C E 331   | Introduction to Random Signal Analysis and Statistics           |           |
| <b>Total Credits</b>                                |   | <b>19</b> |

<sup>1</sup> MATH 375 and MATH 376 taken in sequence will fulfill the requirement for MATH 234.

## SCIENCE

| Code                         | Title                            | Credits      |
|------------------------------|----------------------------------|--------------|
| COMP SCI 300                 | Programming II                   | 3            |
| COMP SCI 400                 | Programming III                  | 3            |
| PHYSICS 201                  | General Physics <sup>1</sup>     | 5            |
| or PHYSICS 207               | General Physics                  |              |
| or PHYSICS 247               | A Modern Introduction to Physics |              |
| PHYSICS 202                  | General Physics                  | 5            |
| or PHYSICS 208               | General Physics                  |              |
| or PHYSICS 248               | A Modern Introduction to Physics |              |
| Select one of the following: |                                  | 4-5          |
| CHEM 109                     | Advanced General Chemistry       |              |
| CHEM 103                     | General Chemistry I              |              |
| CHEM 104                     | General Chemistry II             |              |
| <b>Total Credits</b>         |                                  | <b>20-21</b> |

<sup>1</sup> Students may also fulfill this requirement by taking E M A 201 Statics and E M A 202 Dynamics or E M A 201 Statics and M E 240 Dynamics.

## COMPUTER ENGINEERING CORE

| Code                 | Title   | Credits   |
|----------------------|---|-----------|
| E C E 203            | Signals, Information, and Computation               | 3         |
| E C E 210            | Introductory Experience in Electrical Engineering   | 2         |
| E C E 219            | Analytical Methods for Electromagnetics Engineering | 2         |
| E C E 220            | Electrodynamics I                                   | 3         |
| E C E 230            | Circuit Analysis                                    | 4         |
| E C E/COMP SCI 252   | Introduction to Computer Engineering                | 3         |
| E C E 270            | Circuits Laboratory I                               | 1         |
| E C E 315            | Introductory Microprocessor Laboratory              | 1         |
| E C E 340            | Electronic Circuits I                               | 3         |
| E C E/COMP SCI 352   | Digital System Fundamentals                         | 3         |
| E C E 353            | Introduction to Microprocessor Systems              | 3         |
| E C E/COMP SCI 354   | Machine Organization and Programming                | 3         |
| E C E 551            | Digital System Design and Synthesis                 | 3         |
| <b>Total Credits</b> |   | <b>34</b> |

## COMPUTER ENGINEERING ADVANCED ELECTIVES

| Code                                | Title  | Credits |
|-------------------------------------|--|---------|
| <i>Electronic Circuits Elective</i> |  | 3       |
| E C E 342                           | Electronic Circuits II                         |         |
| E C E 447                           | Applied Communications Systems                 |         |
| E C E 541                           | Analog MOS Integrated Circuit Design           |         |
| E C E 542                           | Introduction to Microelectromechanical Systems |         |

|  |  |              |
|--|--|--------------|
| E C E 548  | Integrated Circuit Design                              |              |
| E C E 555  | Digital Circuits and Components                        |              |
| <b>Systems Software Elective</b>                     |  | <b>3-4</b>   |
| E C E/<br>COMP SCI 506                               | Software Engineering                                   |              |
| COMP SCI 536   | Introduction to Programming Languages and Compilers    |              |
| COMP SCI 537   | Introduction to Operating Systems                      |              |
| COMP SCI 564   | Database Management Systems: Design and Implementation |              |
| <b>Capstone Design</b>                               |  | <b>4</b>     |
| E C E 453  | Embedded Microprocessor System Design                  |              |
| E C E 454  | Mobile Computing Laboratory <sup>1</sup>               |              |
| E C E 554  | Digital Engineering Laboratory                         |              |
| <b>CMPE Elective I</b>                               |  | <b>3</b>     |
| E C E 537  | Communication Networks                                 |              |
| E C E/<br>COMP SCI 552                               | Introduction to Computer Architecture                  |              |
| E C E 553  | Testing and Testable Design of Digital Systems         |              |
| E C E 556  | Design Automation of Digital Systems                   |              |
| <b>CMPE Elective II</b>                              |  | <b>3</b>     |
| Select from E C E 399 - E C E 699                    |  |              |
| Select from COMP SCI 400 - COMP SCI 699 <sup>1</sup> |  |              |
| <b>Total Credits</b>                                 |  | <b>16-17</b> |

<sup>1</sup> E C E 454 Mobile Computing Laboratory and COMP SCI 407 Foundations of Mobile Systems and Applications cannot both be taken for degree credit.

## PROFESSIONAL ELECTIVES

| Code  | Title  | Credits  |
|---|--|----------|
| <b>Professional Electives</b>   |  | <b>9</b> |
| <i>Courses to be taken in an area of professional interest. The following courses are acceptable as professional electives if the courses are not used to meet any other degree requirements.</i> |  |          |
| E C E 1   | Cooperative Education Program (One co-op credit can count towards professional electives.)           |          |
| E C E 204   | Data Science & Engineering   |          |
| E C E/<br>PHYSICS 235   | Introduction to Solid State Electronics  |          |
| E C E 320   | Electrodynamics II   |          |
| E C E 330   | Signals and Systems  |          |
| E C E 331   | Introduction to Random Signal Analysis and Statistics  |          |
| E C E 332   | Feedback Control Systems   |          |
| E C E 334   | State Space Systems Analysis   |          |
| E C E 335   | Microelectronic Devices  |          |
| E C E 342   | Electronic Circuits II (may be used if not already used as an Electronic Circuits Advanced Elective) |          |

|   |  |  |
|---|--|--|
| E C E 355   | Electromechanical Energy Conversion                                  |  |
| E C E 356   | Electric Power Processing for Alternative Energy Systems             |  |
| E C E courses numbered 399 and higher   |  |  |
| COMP SCI courses numbered 400 and higher  |  |  |
| MATH 319  | Techniques in Ordinary Differential Equations                        |  |
| MATH 320  | Linear Algebra and Differential Equations <sup>1</sup>               |  |
| MATH 321  | Applied Mathematical Analysis  |  |
| MATH 322  | Applied Mathematical Analysis  |  |
| MATH 340  | Elementary Matrix and Linear Algebra <sup>1</sup>                    |  |
| MATH 341  | Linear Algebra   |  |
| MATH courses numbered 400 and higher  |  |  |
| STATS courses numbered 400 and higher   |  |  |
| Any biological sciences course that is designated as intermediate or advanced level   |  |  |
| Any physical science course that is designated as intermediate or advanced level  |  |  |
| Any natural science course that is designated as advanced level, except that math, computer sciences, and statistics courses must follow the above criteria |  |  |
| Engineering courses numbered 300 and higher that are not E C E or cross-listed with E C E   |  |  |
| Up to six credits of Professional Electives can be taken from School of Business classes numbered 300 and higher.   |  |  |
| DS 501  | Special Topics (Wearable Technologies)                               |  |
| DANCE 560   | Current Topics in Dance: Workshop (Making Digital Lighting Controls) |  |

<sup>1</sup> Students may only earn degree credit for MATH 320 Linear Algebra and Differential Equations or MATH 340 Elementary Matrix and Linear Algebra, not both.

## COMMUNICATION SKILLS

| Code                 | Title  | Credits  |
|----------------------|--|----------|
| ENGL 100             | Introduction to College Composition                      | 3        |
| or LSC 100           | Science and Storytelling                                 |          |
| or COM ARTS 100      | Introduction to Speech Composition                       |          |
| or COM ARTS 181      | Elements of Speech-Honors Course                         |          |
| or ESL 118           | Academic Writing II                                      |          |
| INTEREGR 397         | Engineering Communication (was EPD 397 before Fall 2020) | 3        |
| <b>Total Credits</b> |  | <b>6</b> |

## LIBERAL STUDIES ELECTIVES

| Code   | Title | Credits   |
|--|-------|-----------|
| <b>College of Engineering Liberal Studies Requirements</b>   |       |           |
| Complete requirements ( <a href="http://guide.wisc.edu/undergraduate/engineering/#requirementstext">http://guide.wisc.edu/undergraduate/engineering/#requirementstext</a> ) <sup>1</sup> |       | 15        |
| <b>Total Credits</b>   |       | <b>15</b> |

<sup>1</sup> All liberal studies credits must be identified with the letter H, S, L, or Z. Language courses are acceptable without the letter and are considered humanities. **Note:** See an E C E advisor and/or the EE Curriculum Guide (<https://www.engr.wisc.edu/department/electrical-computer-engineering/academics/bachelor-of-science-computer-engineering/>) for additional information.

## NAMED OPTION

View as list | View as grid

- **COMPUTER ENGINEERING: MACHINE LEARNING AND DATA SCIENCE, B.S. ([HTTP://GUIDE.WISC.EDU/UNDERGRADUATE/ENGINEERING/ELECTRICAL-COMPUTER-ENGINEERING/COMPUTER-ENGINEERING-BS/COMPUTER-ENGINEERING-MACHINE-LEARNING-DATA-SCIENCE-BS/](http://guide.wisc.edu/undergraduate/engineering/electrical-computer-engineering/computer-engineering-bs/computer-engineering-machine-learning-data-science-bs/))**

**TOTAL DEGREE CREDITS: 120**

## UNIVERSITY DEGREE REQUIREMENTS

**Total Degree** To receive a bachelor's degree from UW–Madison, students must earn a minimum of 120 degree credits. The requirements for some programs may exceed 120 degree credits. Students should consult with their college or department advisor for information on specific credit requirements.

**Residency** Degree candidates are required to earn a minimum of 30 credits in residence at UW–Madison. "In residence" means on the UW–Madison campus with an undergraduate degree classification. "In residence" credit also includes UW–Madison courses offered in distance or online formats and credits earned in UW–Madison Study Abroad/Study Away programs.

**Quality of Work** Undergraduate students must maintain the minimum grade point average specified by the school, college, or academic program to remain in good academic standing. Students whose academic performance drops below these minimum thresholds will be placed on academic probation.

## LEARNING OUTCOMES

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.

## FOUR-YEAR PLAN

### SAMPLE FOUR-YEAR PLAN

#### First Year

| Fall                     | Credits | Spring             | Credits   |
|--------------------------|---------|--------------------|-----------|
| MATH 221                 |         | 5 MATH 222         | 4         |
| E C E/COMP SCI 252       |         | 3 PHYSICS 201      | 5         |
| CHEM 103, 104, or 109    |         | 4-5 E C E 210      | 2         |
| Liberal Studies Elective |         | 3 Communications A | 3         |
|                          |         | <b>15-16</b>       | <b>14</b> |

#### Second Year

| Fall               | Credits | Spring                   | Credits   |
|--------------------|---------|--------------------------|-----------|
| E C E 203          |         | 3 MATH/COMP SCI 240      | 3         |
| E C E/COMP SCI 352 |         | 3 E C E 219              | 2         |
| MATH 234           |         | 4 E C E 230              | 4         |
| PHYSICS 202        |         | 5 E C E 270              | 1         |
|                    |         | COMP SCI 300             | 3         |
|                    |         | Liberal Studies Elective | 3         |
|                    |         | <b>15</b>                | <b>16</b> |

#### Third Year

| Fall               | Credits | Spring                                | Credits   |
|--------------------|---------|---------------------------------------|-----------|
| E C E 353          |         | 3 E C E 315                           | 1         |
| E C E 220          |         | 3 E C E 551                           | 3         |
| E C E 340          |         | 3 Circuits Elective                   | 3         |
| E C E/COMP SCI 354 |         | 3 Probability and Statistics Elective | 3         |
| COMP SCI 400       |         | 3 INTEREGR 397 (was EPD 397)          | 3         |
|                    |         | Liberal Studies Elective              | 3         |
|                    |         | <b>15</b>                             | <b>16</b> |

#### Fourth Year

| Fall                          | Credits | Spring                          | Credits      |
|-------------------------------|---------|---------------------------------|--------------|
| E C E 453, 454, or 554        |         | 4 COMP SCI 536, 537, or 564     | 3-4          |
| Computer Engineering Elective |         | 3 Computer Engineering Elective | 3            |
| Professional Elective         |         | 3 Professional Elective         | 3            |
| Liberal Studies Elective      |         | 3 Liberal Studies Elective      | 3            |
| Professional Elective         |         | 3 Free Elective                 | 1            |
|                               |         | <b>16</b>                       | <b>13-14</b> |

**Total Credits 120-122**

## ADVISING AND CAREERS

### ADVISING

Each College of Engineering program has academic advisors dedicated to serving its students. Program advisors can help current College of

Engineering students with questions about accessing courses, navigating degree requirements, resolving academic issues and more. Students can find their assigned advisor on the homepage of their student center.

## ENGINEERING CAREER SERVICES

Engineering Career Services (ECS) assists students in identifying pre-professional work-based learning experiences such as co-ops and summer internships, considering and applying to graduate or professional school, and finding full-time professional employment during their graduation year.

ECS offers two major career fairs per year, assists with resume writing and interviewing skills, hosts workshops on the job search, and meets one-on-one with students to discuss offer negotiations.

Students are encouraged to utilize the ECS office early in their academic careers. For comprehensive information on ECS programs and workshops, see the ECS website or call 608-262-3471.

Chu Ma  
Matthew Malloy (adjunct)  
Dimitris Papailiopoulos  
Line Roald  
Joshua San Miguel  
Eric Severson  
Andreas Velten  
Ramya Korlakai Vinayak  
Ying Wang

## FACULTY ASSOCIATES

Mark C. Allie  
Eduardo Arvelo  
Steven Fredette  
Eric Hoffman  
Joe Krachey  
Srdjan Milicic  
Pia Strampp (associate lecturer)

\*For scholarship information, please contact Professor Lesieutre.

See also Electrical and Computer Engineering Faculty Directory (<https://directory.engr.wisc.edu/ece/faculty/>).

## PEOPLE

### PROFESSORS

Susan Hagness (Chair)  
David T. Anderson  
Nader Behdad  
John Booske  
Dan Botez  
Azadeh Davoodi  
John A. Gubner (Associate Chair for Operations)  
William N. Hitchon  
Yu Hen Hu  
Thomas Jahns  
Hongrui Jiang  
Irena Knezevic  
Bernard Lesieutre (Associate Chair for Undergraduate Studies)\*  
Mikko Lipasti  
Zhenqiang Ma  
Luke J. Mawst  
Robert Nowak  
Parameswaran Ramanathan  
William A. Sethares  
Daniel van der Weide  
Barry Van Veen (Associate Chair for Graduate and Online Studies)  
Giri Venkataramanan  
Amy E. Wendt

### ASSOCIATE PROFESSORS

Mikhail Kats  
Daniel Ludois  
Paul H. Milenkovic  
Umit Ogras  
Bulent Sarlioglu  
Zongfu Yu

### ASSISTANT PROFESSORS

Joseph Andrews  
Kassem Fawaz  
Dominic Gross  
Younghyun Kim  
Bhuvana Krishnaswamy  
Kangwook Lee

## ACCREDITATION

Accreditation.

Accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org> (<http://www.abet.org/>).

Note: Undergraduate Program Educational Objectives and Student Outcomes are made publicly available at the Departmental website. (In this Guide, the program's Student Outcomes are designated by our campus as "Learning Outcomes.")