COMPUTER ENGINEERING, B.S. (ENGINEERING)

Begin Campus: Any Penn State Campus
End Campus: University Park

Program Description
The mission of the faculty of the undergraduate computer engineering program at Penn State is to provide students with the knowledge and experience needed to pursue a productive lifelong career in industry or to engage in further study at the graduate level. Students participate in a balanced program of instruction covering the basic principles of the design and application of computer systems. The program includes coverage in breadth and depth of basic science, engineering, and abstract concepts of information handling. Students specialize in and are prepared for careers in the design, analysis and use of hardware, software and systems. The program is structured to ensure that graduates have a clear understanding of the design and the applications of computers, as well as the ability to apply this knowledge throughout their professional careers.

What is Computer Engineering?
Computer engineering is the study of the design, analysis, and implementation of computer systems including processors, memory, embedded devices, and data communication systems for a wide range of application domains. It includes the study of digital systems, computer architecture, and computer networks. It encompasses many design activities spanning from designing individual logic components to designing complete computer systems composed of hardware, software, and hardware-software co-design. Computer engineering drives the development of new computing systems that enable the latest technologies impacting our everyday lives.

You Might Like This Program If...
- You excel in math and physics and have an interest in designing and constructing computer hardware
- You want to build and analyze physical computing devices that go beyond traditional computers
- You want to understand how current computer hardware and software work and how to design the next generation hardware and its supporting software
- You want to design computing systems that impact and improve everyday lives

Entrance to Major
This program currently has administrative enrollment controls. Administrative Enrollment Controls are initiated when limitations of space, faculty, or other resources in a major prevent accommodating all students who request them. Students must follow the administrative enrollment controls that are in effect for the semester that they enter the university.

First-Year Students Entering Summer 2019, Fall 2019, Spring 2020
In order to be eligible for entrance to this major, students must satisfy the following requirements:
- completed with a grade of C or better: CHEM 110, MATH 140, MATH 141, MATH 250 or MATH 251, PHYS 211, PHYS 212
- earned a minimum of 3.00 cumulative GPA

Students Who Entered Prior to Summer 2019
Students who entered the University during Summer 2018, Fall 2018, and Spring 2019 should view the administrative enrollment controls in the archived 2018-19 Undergraduate Bulletin (http://bulletins.psu.edu/archive/2018-19/undergraduate/general-information/administrative-information/#administrativeenrollmentcontrolofstatetext). Students who entered the University prior to the summer 2018 semester should view the administrative enrollment controls for the semester that they entered the university (http://advising.psu.edu/entrance-major-requirements) on the Academic Advising Portal.

Degree Requirements
For the Bachelor of Science degree in Computer Engineering, a minimum of 128 credits is required:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education</td>
<td>45</td>
</tr>
<tr>
<td>Requirements for the Major</td>
<td>110</td>
</tr>
</tbody>
</table>

27 of the 45 credits for General Education are included in the Requirements for the Major. This includes: 9 credits of GN courses; 6 credits of GQ courses; 3 credits of GS courses; 9 credits of GWS courses.

General Education
Connecting career and curiosity, the General Education curriculum provides the opportunity for students to acquire transferable skills necessary to be successful in the future and to thrive while living in interconnected contexts. General Education aids students in developing intellectual curiosity, a strengthened ability to think, and a deeper sense of aesthetic appreciation. These are requirements for all baccalaureate students and are often partially incorporated into the requirements of a program. For additional information, see the General Education Requirements (http://bulletins.psu.edu/undergraduate/general-education/baccalaureate-degree-general-education-program) section of the Bulletin and consult your academic adviser.

The keystone symbol appears next to the title of any course that is designated as a General Education course. Program requirements may also satisfy General Education requirements and vary for each program.

Foundations (grade of C or better is required.)
- Quantification (GQ): 6 credits
- Writing and Speaking (GWS): 9 credits

Knowledge Domains
- Arts (GA): 6 credits
- Health and Wellness (GHW): 3 credits
- Humanities (GH): 6 credits
- Social and Behavioral Sciences (GS): 6 credits
- Natural Sciences (GN): 9 credits

Integrative Studies (may also complete a Knowledge Domain requirement)
- Inter-Domain or Approved Linked Courses: 6 credits
University Degree Requirements

First Year Engagement
All students enrolled in a college or the Division of Undergraduate Studies at University Park, and the World Campus are required to take 1 to 3 credits of the First-Year Seminar, as specified by their college First-Year Engagement Plan.

Other Penn State colleges and campuses may require the First-Year Seminar; colleges and campuses that do not require a First-Year Seminar provide students with a first-year engagement experience.

First-year baccalaureate students entering Penn State should consult their academic adviser for these requirements.

Cultures Requirement
6 credits are required and may satisfy other requirements
  • United States Cultures: 3 credits
  • International Cultures: 3 credits

Writing Across the Curriculum
3 credits required from the college of graduation and likely prescribed as part of major requirements.

Total Minimum Credits
A minimum of 120 degree credits must be earned for a baccalaureate degree. The requirements for some programs may exceed 120 credits. Students should consult with their college or department adviser for information on specific credit requirements.

Quality of Work
Candidates must complete the degree requirements for their major and earn at least a 2.00 grade-point average for all courses completed within their degree program.

Limitations on Source and Time for Credit Acquisition
The college dean or campus chancellor and program faculty may require up to 24 credits of course work in the major to be taken at the location or in the college or program where the degree is earned. Credit used toward degree programs may need to be earned from a particular source or within time constraints (see Senate Policy 83-80 (http://senate.psu.edu/policies-and-rules-for-undergraduate-students/82-00-and-83-00-degree-requirements/#83-80)). For more information, check the Suggested Academic Plan for your intended program.

Requirements for the Major
To graduate, a student enrolled in the major must earn a grade of C or better in each course designated by the major as a C-required course, as specified by Senate Policy 82-44 (http://senate.psu.edu/policies-and-rules-for-undergraduate-students/82-00-and-83-00-degree-requirements/#82-44).

### Code | Title | Credits
--- | --- | ---
CMPEN 362 | Communication Networks | 3
CMPEN 482 | Computer Engineering Project Design | 3
CMPSC 473 | Operating Systems Design & Construction | 3
ENGL 202C | Effective Writing: Technical Writing | 3
MATH 220 | Matrices | 2-3
MATH 231 | Calculus of Several Variables | 2
PHYS 214 | General Physics: Wave Motion and Quantum Physics | 2
STAT 418 | Introduction to Probability and Stochastic Processes for Engineering | 3
CHEM 110 | Chemical Principles I | 3
CMPEN 331 | Computer Organization And Design | 3
CMPEN 431 | Introduction to Computer Architecture | 3
CMPSC 221 | Object Oriented Programming with Web-Based Applications | 3
CMPSC 311 | Introduction to Systems Programming | 3
CMPSC 360 | Discrete Mathematics for Computer Science | 3
CMPSC 465 | Data Structures and Algorithms | 3
EE 210 | Circuits and Devices | 4
EE 310 | Electronic Circuit Design I | 4
EE 353 | Signals and Systems: Continuous and Discrete-Time | 3
MATH 140 | Calculus With Analytic Geometry I | 4
MATH 141 | Calculus with Analytic Geometry II | 4
MATH 250 | Ordinary Differential Equations | 3
PHYS 211 | General Physics: Mechanics | 4
PHYS 212 | General Physics: Electricity and Magnetism | 4

### Additional Courses
Select 1 credit of First-Year Seminar 1
or CAS 100A | Effective Speech | 3
or CAS 100B | Effective Speech | 3
CMPSC 121 | Introduction to Programming Techniques | 3
or CMPSC 131 | Programming and Computation I: Fundamentals | 3
CMPSC 122 | Intermediate Programming | 3
or CMPSC 132 | Programming and Computation II: Data Structures | 3
ENGL 15 | Rhetoric and Composition | 3
or ENGL 30 | Honors Freshman Composition | 3
Select 3 credits of the following: 3
ECON 14 | Principles of Economics | 3
ECON 102 | Introductory Microeconomic Analysis and Policy | 3
ECON 104 | Introductory Macroeconomic Analysis and Policy | 3
Select 6 credits of the following: 6
CMPEN 411 | VLSI Digital Circuits | 3
CMPEN 416 | Digital Integrated Circuits | 3
CMPEN 417 | Digital Design Using Field Programmable Devices | 3
CMPEN 454 | Fundamentals of Computer Vision | 3
CMPEN 455 | An Introduction to Digital Image Processing | 3
CMPEN 471 | Logical Design of Digital Systems | 3
CMPEN 472 | Microprocessors and Embedded Systems | 3
CMPEN 473 | Microcomputer Laboratory | 3
CMPEN 475 | Functional Verification | 3
EE 453 | Fundamentals of Digital Signal Processing | 3
EE 456 | Introduction to Neural Networks | 3
Select 6 credits from any 400-level CMPEN or CMPSC course 6
### Additional Courses: Require a grade of C or better
Select 4 credits of the following: 4
CMPEN 270 | Digital Design: Theory and Practice | 3
CMPEN 271 | Introduction to Digital Systems | 3
& CMPEN 275 | and Digital Design Laboratory | 3
Supporting Courses and Related Areas
Select 6 credits from department list.\footnote{1} CMPEN 275 does not require a grade of C or better.
\footnote{2} Students may apply up to 3 credits of Co-op. Students who complete ROTC may apply up to 3 credits of ROTC as department list credits and 3 credits of ROTC as GWH credits.

Program Educational Objectives
In particular, within a few years after graduation, graduates in computer engineering should be able to:

1. Work in industry or government producing or evaluating components of computer hardware and/or software systems.
2. Work in teams to design, implement, and/or maintain components of computer hardware and/or software systems.
3. Stay current through professional conferences, certificate programs, post-baccalaureate degree programs, or other professional educational activities.

Student Outcomes
Student outcomes describe what students are expected to know and be able to do by the time of graduation. The Computer Engineering program is designed to enable students to:

1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. 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. Communicate effectively with a range of audiences.
4. 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. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.

Academic Advising
The objectives of the university's academic advising program are to help advisees identify and achieve their academic goals, to promote their intellectual discovery, and to encourage students to take advantage of both in-and-out-of class educational opportunities in order that they become self-directed learners and decision makers.

Both advisers and advisees share responsibility for making the advising relationship succeed. By encouraging their advisees to become engaged in their education, to meet their educational goals, and to develop the habit of learning, advisers assume a significant educational role. The advisee's unit of enrollment will provide each advisee with a primary academic adviser, the information needed to plan the chosen program of study, and referrals to other specialized resources.

READ SENATE POLICY 32-00: ADVISING POLICY (http://senate.psu.edu/policies-and-rules-for-undergraduate-students/32-00-advising-policy)

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Suggested Academic Plan
The suggested academic plan(s) listed on this page are the plan(s) that are in effect during the 2019-20 academic year. To access previous years' suggested academic plans, please visit the archive (http://bulletins.psu.edu/undergraduate/archive) to view the appropriate Undergraduate Bulletin edition (Note: the archive only contain suggested academic plans beginning with the 2018-19 edition of the Undergraduate Bulletin).

Computer Engineering - Ending at University Park Campus
The course series listed below provides only one of the many possible ways to move through this curriculum. The University may make changes in policies, procedures, educational offerings, and requirements at any time. This plan should be used in conjunction with your degree audit (accessible in LionPATH as either an Academic Requirements or What If report). Please consult with a Penn State academic adviser on a regular basis to develop and refine an academic plan that is appropriate for you.

If you are starting at a campus other than the one this plan is ending at, please refer here:
http://advising. engr.psu.edu/degree-requirements/academic-plans-by-major.aspx

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credits</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 110 (GN)†</td>
<td>3</td>
<td>CMPSC 131 or 121 (GQ)*</td>
</tr>
<tr>
<td>MATH 140 or 140E (GQ)‡†</td>
<td>4</td>
<td>ENGL 15, 30, or ESL 15 (GWS)‡†</td>
</tr>
<tr>
<td>PHYS 211 (GN, PHYSICS 211L &amp; PHYSICS 211R)†‡</td>
<td>4</td>
<td>MATH 141 or 141E (GQ)‡†</td>
</tr>
<tr>
<td>CMPEN 111 (or First Year Seminar)†</td>
<td>1</td>
<td>PHYS 212 (GN, PHYSICS 212L &amp; PHYSICS 212R)†‡</td>
</tr>
<tr>
<td>General Education Course‡</td>
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<td>General Education Course‡</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<table>
<thead>
<tr>
<th>Second Year</th>
<th>Credits</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMPSC 132 or 122‡</td>
<td>3</td>
<td>CMPSC 331†</td>
</tr>
<tr>
<td>CMPEN 270 or 271 and 275‡</td>
<td>4</td>
<td>CMPSC 221†</td>
</tr>
<tr>
<td>MATH 220</td>
<td>2-3</td>
<td>ECON 102 or 104 (GS)‡</td>
</tr>
<tr>
<td>MATH 250†</td>
<td>3</td>
<td>EE 210*</td>
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<tr>
<td>PHYS 214</td>
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<td>MATH 231</td>
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<tr>
<td>General Education Course‡</td>
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<td><strong>Total</strong></td>
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### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMPEN 431*</td>
<td>3</td>
<td>CMPEN 362</td>
<td>3</td>
</tr>
<tr>
<td>CMPSC 311*</td>
<td>3</td>
<td>CMPSC 465*</td>
<td>3</td>
</tr>
<tr>
<td>CMPSC 360*</td>
<td>3</td>
<td>CMPSC 473</td>
<td>3</td>
</tr>
<tr>
<td>EE 310*</td>
<td>4</td>
<td>EE 353*</td>
<td>3</td>
</tr>
<tr>
<td>STAT 418</td>
<td>3</td>
<td>ENGL 202C (GWS)*</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total Credits 12-15**

* Course requires a grade of C or better for the major
*† Course requires a grade of C or better for General Education
‡ Course is an Entrance to Major requirement
†† Course satisfies General Education and degree requirement

### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAS 100A or 100B (GWS)*††</td>
<td>3</td>
<td>CMPEN/CMPSC 4XX</td>
<td>3</td>
</tr>
<tr>
<td>CMPEN 482</td>
<td>3</td>
<td>CMPEN/CMPSC 4XX</td>
<td>3</td>
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<td>Computer Engineering Elective</td>
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<td>Computer Engineering Elective</td>
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<tr>
<td>Department List Elective</td>
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<td>Department List Elective</td>
<td>3</td>
</tr>
<tr>
<td>General Education Course†</td>
<td>3</td>
<td>General Education Course†</td>
<td>3</td>
</tr>
<tr>
<td>General Education Course (GHW)†</td>
<td>1.5</td>
<td>General Education Course (GHW)†</td>
<td>1.5</td>
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</tbody>
</table>

**Total Credits 15-16**

* Course requires a grade of C or better for the major
† Course requires a grade of C or better for General Education
‡ Course is an Entrance to Major requirement
†† Course satisfies General Education and degree requirement

### University Requirements and General Education Notes:

US and IL are abbreviations used to designate courses that satisfy University Requirements (United States and International Cultures).

W, M, X, and Y are the suffixes at the end of a course number used to designate courses that satisfy University Writing Across the Curriculum requirement.

GWS, GQ, GHW, GN, GA, GH, and GS are abbreviations used to identify General Education program courses. General Education includes Foundations (GWS and GQ) and Knowledge Domains (GHW, GN, GA, GH, GS, and Integrative Studies). Foundations courses (GWS and GQ) require a grade of ‘C’ or better.

Integrative Studies courses are required for the General Education program. N is the suffix at the end of a course number used to designate an Inter-Domain course and Z is the suffix at the end of a course number used to designate a Linked course.

All incoming Schreyer Honors College first-year students at University Park will take ENGL/CAS 137 in the fall semester and ENGL/CAS 138 in the spring semester. These courses carry the GWS designation and replace both ENGL 30 and CAS 100. Each course is 3 credits.

### College Note

**CMPEN/CMPSC 4XX**: Select any 400-489 CMPEN or CMPSC course offered at University Park.

**Computer Engineering Elective**: Select from department list. Restrictions may apply. Computer Engineering Electives are NOT offered every semester or every year. Contact the department for information on which classes are scheduled to be offered during a given semester.

### Department List Elective:

Select from department list. Restrictions may apply. Students who complete the ROTC Program may substitute 3 ROTC credits for a Department List Elective. Students who complete the Cooperative Education Program may substitute 3 co-op credits for a Department List Elective.

### Health and Physical Activity Elective:

Students who complete the ROTC Program may substitute 3 ROTC credits for the GHW requirement and 3 ROTC credits for a Department List Elective.

**These courses offered at University Park in spring semester only:**

- E E 353

### Career Paths

Computer engineering graduates understand all aspects of computing hardware, are well-studied in the use of modern tools used to design and analyze hardware, are able to think at multiple levels of abstraction when working with system-level design, and have a solid foundation in software development. This background prepares graduates for a wide range of exciting careers in the technology industry and almost all other industry sectors as computer/hardware/embedded system designers. It also prepares them for pursuing academic careers. Computer engineers apply their skills and knowledge to solve challenging problems related to computer hardware. They work collaboratively in teams to design and build complex systems with many integrated parts. They research, study, and develop the new technologies that drive the advances in computing that impact our everyday lives.

### Careers

Computer engineering graduates typically find positions as computer/hardware/embedded system designers in major technology companies like IBM, Intel, Cisco, and Qualcomm. Graduates are also highly recruited by major companies in areas such as aerospace, communication, transportation, and defense. Most graduates will find themselves a part of a team of engineers and after a few years possibly leading a design team. With the rapid changes and advances in the field of computing, graduates must continually keep up with the latest technology as their careers adapt and evolve to meet the new opportunities and challenges of computing.

MORE INFORMATION ABOUT POTENTIAL CAREER OPTIONS FOR GRADUATES OF THE COMPUTER ENGINEERING PROGRAM (https://career.engr.psu.edu)

### Opportunities for Graduate Studies

Graduates of this program can pursue graduate studies in computer engineering, computer science, and related disciplines, concentrating in specialized areas such as multicore architectures, low-power architectures, application-specific hardware architectures, and computer networking. A master's degree allows one to specialize beyond the broad foundations offered by a bachelor's degree. A doctoral degree prepares one for a career in research and academia.

MORE INFORMATION ABOUT OPPORTUNITIES FOR GRADUATE STUDIES (https://www.eecs.psu.edu/students/graduate/EECS-Graduate-Prospective.aspx)
Professional Resources
- ACM (https://acm.psu.edu)
- Association of Women in Computing (https://awc.cse.psu.edu)
- IEEE (https://sites.psu.edu/psuieee)

Accreditation
The baccalaureate program in Computer Engineering is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (http://www.abet.org).

MORE INFORMATION ABOUT ABET ACCREDITATION (http://www.abet.org)

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