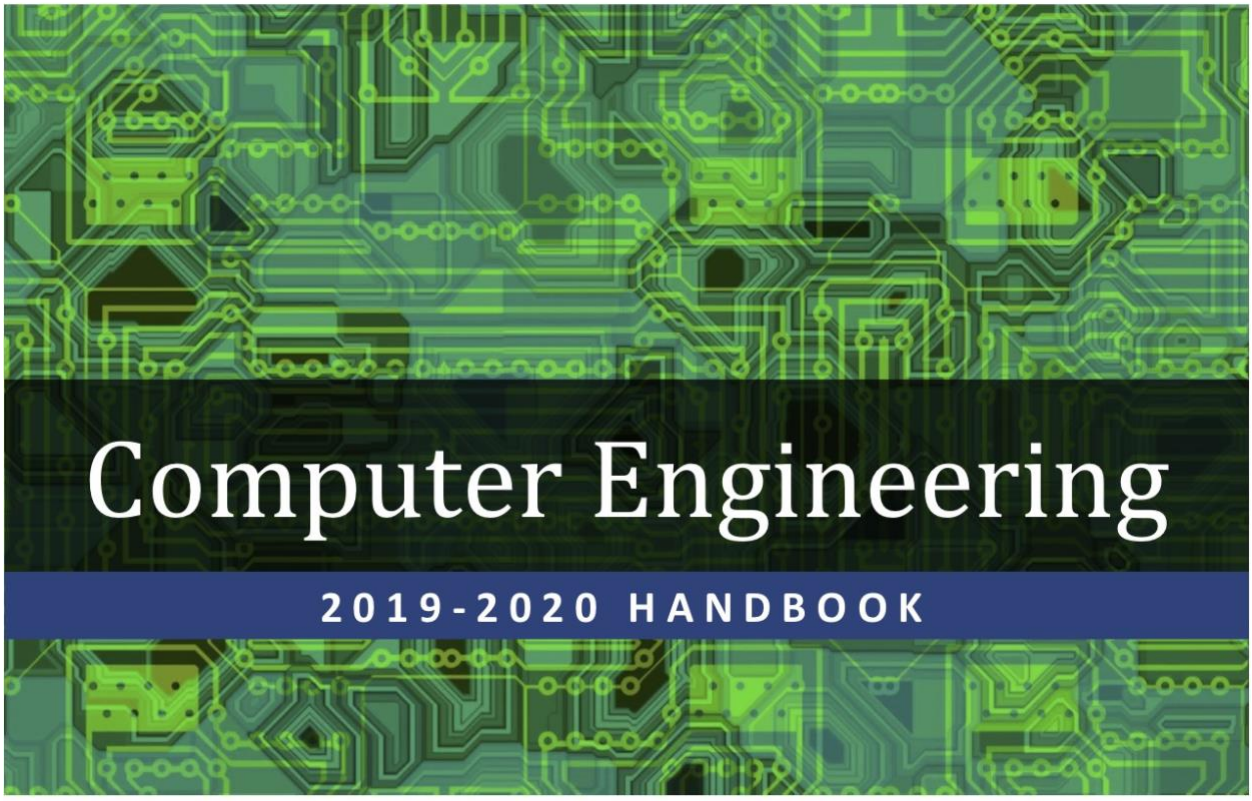

# Computer Engineering

## 2019-2020 HANDBOOK

PennState College of Engineering

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

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# Welcome

This handbook has been prepared for your use as a guide for your studies and as a means of providing you with much of the information that you may need as you continue to work towards your degree. We hope that you read it carefully, and we invite your inquiries about any of the questions or issues that are related to your program. The Academic Affairs staff in W209 Westgate is here to serve you.

Please watch for announcements of special courses, news related to scheduling or textbooks, and other special opportunities delivered via a departmental email list.

Again, welcome to Computer Science and Engineering. We wish you well in your studies and offer our services to assist you.

Tom La Porta
*Director, School of Electrical Engineering and Computer Science*

Chita Das
*Head, Department Computer Science and Engineering*

John Hannan
*Associate Head, Department Computer Science and Engineering*

Mark Mahon
*Undergraduate Advisor, School of Electrical Engineering and Computer Science*

# The Computer Engineering Major

The Department of Computer Science and Engineering was created in 1993 with the merger of the Computer Engineering Program and the Computer Science Department. The department offers B.S. degrees in both computer engineering (CMPEN) and computer science (CMPSC) through the College of Engineering.

Computer engineering is the discipline concerned with connecting abstract computation to its physical embodiments, and it focuses on the study of four primary areas. The first area includes the design, analysis, and implementation of physically realized systems that perform computational tasks, including the processing, storage, and communication of data. The second area includes the formulation of interfaces and the study of interactions between the hardware portions of these systems and the software running on, communicating with, or managing communications among them, as well as the co-development of software systems alongside their hardware platforms. The third area includes the infrastructure required to design, build, and verify such systems. The fourth area includes the theoretical foundations underpinning the intended and achievable functionality, costs, and performance of both the hardware and software components of these systems and their associated engineering tradeoffs.

Computer engineers provide society with the myriad engines that have powered the information age from the smallest sensor motes to the fastest supercomputers and largest data centers, and with the tools and expertise to use the current generation of computers to design the next. With the ubiquitous integration of mobile communications and computational elements in everything from appliances to cars to clothing to the electrical grid, computer engineers are responsible for developing systems and devices that have transformed the capabilities of both individuals and entire economies.

The mission of the undergraduate program in Computer Engineering is to provide our students with the skills and experience necessary to engage in further study at the graduate level or to pursue any of a broad range of careers as platform integrators, hardware architects, systems programmers, embedded systems designers, network architects, and other positions relating to the design and analysis of computational and other digital hardware and hardware/software systems. The program covers, in both breadth and depth, the representation, communication, and manipulation of information utilizing finite, physical resources from both hardware and software perspectives. It includes coverage of both the fundamental science and the abstract concepts necessary to understand and evaluate the engineering tradeoffs among key performance and cost metrics in the design of hardware and hardware/software systems, including decisions relating to both partitioning and co-design of solutions spanning both hardware and software. The program is structured to ensure that graduates have a clear understanding of the design and the applications of current and historical computer systems and prepares them to be leaders in the rapidly changing field of computing throughout their careers.

**Because of the close relationship to computer engineering, concurrent majors in computer engineering and computer science or computer engineering and data science are not permitted.**

## Program Objectives

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.

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.

During the first two years, students in computer engineering take many courses in common with other engineering majors, including courses in mathematics, physics, and chemistry. In addition, students take several specialized courses in the major, such as algorithms and programming, electrical engineering, digital systems and logic, and computational theory. From these courses, students gain experience using sophisticated software tools, working in a hardware laboratory, and completing individual and group projects. During the second two years, students complete a series of courses in both hardware and software systems. Students also select from numerous electives. Throughout the four years, students develop communication skills, including a senior year course in which students examine the complete design process and participate in a series of oral and written experiences similar to those that would be seen in industry.

## Student Outcomes

The following Student Outcomes summarize the skills acquired through the computer engineering program:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
    a. Design the electronic/logic circuits that form the basic building blocks of a computer system.
    b. Design the architecture and organization of the basic components of a computer system.
    c. Develop a modest (on the order of a thousand lines of code) software application, using appropriate data structures and algorithms.
    d. Determine communication link efficiencies and queueing efficiencies, and calculate probabilities associated with link and system characteristics.

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
    a. Given specifications, design and implement a computer and/or digital system (defined as any digital device used for computation or control) under time and budget constraint.
    b. Identify and address any public health, safety, and welfare concerns in the design of a solution to an engineering problem. (CMPEN 482)
    c. Identify and address any global, cultural, social, environmental, and economic factors in the design of a solution to an engineering problem.
    d. Design components of communication and/or network systems with consideration of the impact of health, safety and welfare - power plants/grid, hospital networks, highway control systems, remote monitoring of public areas, etc.
3. An ability to communicate effectively with a range of audiences
    a. Write clear and effective technical prose for a general audience.
    b. Write clear and effective technical prose for a technical audience
    c. Speak clearly and persuasively about technical subjects in large and/or small group settings, and use supporting materials effectively.
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
    a. Identify ethical issues in engineering case studies.
    b. Be able to discuss major trends in industry and current research activities within the discipline, identifying global, economic, environment and societal impact
    c. Identify ethical and professional responsibilities in project design phase and explain all considerations and alternatives that led to final design decisions
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
    a. Demonstrate an ability to work effectively on team-based projects in which the entire team collaboratively works on designing a solution to meet specified project objectives
    b. Demonstrate an ability to work effectively on team-based projects in which each team member takes responsibility (leadership) for a component of the project and ensures all team members participate and engage in its integration
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
    a. Analyze circuits, devices, and systems using differential and integral calculus and principles of electricity, magnetism, and physics.
    b. Analyze linear systems using continuous and discrete-time techniques.
    c. Analyze the performance of software and/or hardware systems using probabilistic and statistical methods.
    d. Design and simulate computer hardware components using standard tools.
    e. Test circuits, devices, and systems using software, hardware and statistical tools.
    f. Test algorithms or computer code and analyze their correctness and efficiency.

g. Design test cases for testing hardware or software.

7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
    a. Demonstrate independent learning by using unfamiliar computer systems, test equipment, and software tools to solve technical problems.
    b. Research the current state of the art in a project domain before designing a solution to the project problem

Students who are interested in math and science and enjoy solving problems are excellent candidates for the computer engineering major. CMPEN 270 and CMPSC 121 or CMPSC 131 are excellent introductions to this major. Job opportunities are virtually limitless; graduates are employed by all sectors of industry, government, and academic institutions. Because of the close relation to computer science, concurrent majors in computer engineering and computer science are not permitted.

Computer Engineering is accredited by the Engineering Accreditation Commission of ABET, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, telephone: 410-347-7700 or http://*www.abet.org*.

## Advising and Procedures for Major

If you are a first- or second-year student at University Park who is intending to major in computer engineering, you will see an adviser at the **Engineering Advising Center** (EAC), 208 Hammond Building, 863-1033. This office is open Monday through Friday, 8:00 a.m. to 5:00 p.m. (Walk-in advising is available, but appointments are encouraged).

If you are a junior or senior who has been admitted into the computer engineering major you can meet with Dr. Mark Mahon, the Department of Computer Science and Engineering Undergraduate Adviser (W209A Westgate Building, 867-5396). The email address, advising@cse.psu.edu will send email to him. Schreyer Scholars will be assigned a Scholar's Adviser. **If you communicate via e-mail, always use your Penn State account**, not another account such as Gmail. For non-advising issues (questions about degree audit, scheduling, etc.) see one of the CSE staff in W209 Westgate during regular business hours.

Required courses for the computer science major and a suggested schedule are given on the following pages. Information about all majors at Penn State are listed in the **Bulletin of Baccalaureate Degree Programs** at https://bulletins.psu.edu. The *Bulletin* is updated yearly and should be used along with this Handbook. Clarifications to the *Bulletin* are noted here.

The final responsibility for selecting courses and meeting degree requirements is yours. The role of your adviser is to suggest, recommend, and remind you of the requirements of the major and rules of the University. (Two helpful references for University procedures on-line are: **University Faculty Senate Policies for Students** at

https://senate.psu.edu/policies-and-rules-for-undergraduate-students/
and the **Student Guide to General University Policies and Rules** at
https://studentaffairs.psu.edu/sites/default/files/PoliciesRules16-17.docx.
When meeting with your adviser, always take a copy of your recent audits, transcript, your present schedule, and your plan for at least the next semester's courses.

Do not rely on LionPath to correctly categorize your courses. LionPath only understands the degree requirements as specified in the Bulletin and will therefore occasionally place courses into an inappropriate category. This handbook contains additional restrictions and explanations. To ensure that you meet degree requirements you must have your degree audit reviewed by your advisor periodically. You should submit petitions to correct any mis-categorization by LionPath. Failure to do so may result in delaying your graduation until degree requirements are met.

Because computer engineering is such a rapidly changing field, adjustments in course content and/or course offerings should be expected. It will be to your advantage to keep abreast of new course offerings, current course enhancements, and allowable course substitutions through regular contact with your adviser and the department office.

## Entrance to the major (ETM)

To qualify for the computer engineering major:

(1) You must complete MATH 140, MATH 141, MATH 250/251, CHEM 110, PHYS 211, and PHYS 212 with a grade of C or better in each
(2) You must have a cumulative GPA that meets or exceeds the minimum required for your ETM year. For students entering Penn State after Spring 2018, the entrance to major requirements can be found in the Undergraduate Bulletin at https://bulletins.psu.edu/undergraduate/. For students who began as a first-year student at Penn State in Spring 2018 or before see Advising at Penn State at https://advising.psu.edu/entrance-major-requirements-college-engineering.
(3) You should complete at least two full semesters of coursework appropriate to the major and be in degree status. It is advisable to be taking CMPEN 270 or (CMPEN 271 and CMPEN 275), and EE 210 during your second year in order to make normal progress. Be sure you are accumulating credits at a minimum rate of 30 credits per calendar year.

You may request admission to the major via LionPath as soon as you have completed 40 credits of **Penn State coursework** and before you complete 59 credits of Penn State coursework.

## Enrollment Controls

Due to over enrollment, the computer engineering and computer science majors are controlled majors. This means for entrance to the major you must successfully complete the required ETM courses **AND** you must have the needed minimum cumulative GPA for your ETM year when you are in the ETM credit window (40-59 cumulative Penn State credits). Because of this the CSE Department will not approve requests for transfers from other Colleges and Universities, requests for Change of Major, after a student has been admitted to a major, requests for

computer engineering or science as a second (or later) concurrent major, nor for either major as a sequential major.

## Degree Audits

You are responsible for periodically checking your *Degree Audit* on LionPath to verify that the courses you have taken and plan to take will satisfy your degree requirements and that you are on track to complete your degree when you expect to complete it. You are encouraged to meet with an advisor to review your degree audit to verify this information. **Do not rely on LionPath to place your courses into their appropriate categories.**

## Change of Major

If you discover an interest in other areas of study or you are not admitted into computer engineering, you should explore other possible majors and alternatives at the **Engineering Advising Center** or online at the **Academic Advising Portal**.

## Concurrent Major

Concurrent majors will not be allowed in computer science and computer engineering or computer engineering and data sciences, although it is possible to obtain a concurrent major with another non-enrollment-controlled program. (Also see page 3 "Enrollment Controls").

## Registration

When it is time to register for the next semester's courses, refer to this handbook and consult with your adviser to determine an appropriate set of courses. Then go to LionPath and use its Schedule Builder to construct your schedule. You should register as early as possible – **courses fill up quickly**!

Re-ordering your course schedule from the "sample schedule" will not necessarily delay graduation. The key to completing 128 credits over 4 years is to average approximately 16-17 credits per semester. Though many students do maintain this pace, it is not unusual for students to take lighter loads some semesters and to delay graduation. Experience has shown that the 5$^{th}$ semester has been difficult for many students; if you have doubts, it is a good place for a light load. Needed credits may be able to be taken during the summer (not necessarily at University Park). Some students will elect to attend for a 9$^{th}$ semester. While all required CMPEN and CMPSC courses are offered both fall and spring semesters, most electives are offered at most once per year. **EE 353 is only offered in the spring.** Take these restrictions into account when you schedule. This is especially true for co-op students.

## Prerequisite Courses

If a CMPEN or CMPSC course has prerequisites you must complete the prerequisite course before taking the successor course. For most courses an appropriate grade is a grade of D or higher. If the prerequisite course is a "Prescribed C or better" course and you receive a D you may register for the next course but you still must retake the prerequisite course. Waiving of prerequisites is rarely approved and requires approval by both the course instructor and the

associate department head. **If you schedule a course for which you have not satisfied the prerequisites you will be removed from the course near the start of the semester.**

## Schedule Changes

Schedule adjustments (course adds/drops) may be made online using LionPath during the first 6-7 calendar days of each semester. Detailed instructions, costs, and deadlines are provided by the University Registrar's Registration Information at

http://www.registrar.psu.edu/registration/registration_index.cfm.

After this time, you may still adjust your schedule, but any change is considered a late add or a late drop. REMEMBER: A student who has not yet been admitted to the major should seek advice at the Engineering Advising Center; a student who has been admitted should see the Department Undergraduate Adviser. Excessive dropping of courses may affect your eligibility for federal financial aid.

## General Education

All Baccalaureate students at the University are required to complete 45 credits of General Education. You will partially meet these requirements by taking prescribed courses required for the major, and by selecting additional courses that fulfill the remaining requirements. Details can be found in the Baccalaureate Degree General Education Requirements at

https://bulletins.psu.edu/undergraduate/general-education/baccalaureate-degree-general-education-program/.

Note: Some campuses do not have a first-year seminar requirement, but instead require participation in a first-year experience. If you started at such a campus you will need to take 1 additional credit of department list course work.

## Writing Requirement

All Penn State students have a Writing Across the Curriculum graduation requirement. You must complete at least 3 credits of writing-intensive courses selected from "W" courses offered within the major or college of enrollment. The course in the computer engineering major that fulfills this requirement is CMPEN 482W (Computer Engineering Project Design).

## Graduation Requirements

To graduate from the University, every student must:

(1) Complete the course requirements for his or her major;
(2) Earn at least a 2.0 cumulative grade-point average for all courses taken at the University; and
(3) Earn at least a C in each of these courses: CMPSC 121 or 131, CMPSC 122 or 132, CMPSC 221, CMPSC 360, CMPEN 270 or CMPEN 271 and CMPEN 275, CMPSC 311, CMPEN 331, CMPEN 431, CMPSC 465, CHEM 110, EE 210, EE 310, EE 353, MATH 140, MATH 141, MATH 250/251, PHYS 211, PHYS 212.

## Credit Acquisition

In addition to taking courses at any Penn State campus, you may be able to earn credit through World Campus or by transferring credits from another school. Before taking a course at another university, check with the Admissions office and your adviser to be sure the course will transfer usefully. **Note that CMPSC 473, CMPEN 431, CMPSC 465 and CmpSc 482W must be taken at Penn State.**

## Cooperative Education Program

The cooperative education program provides work experience by alternating periods of academic study and full-time employment in industry or government. The program typically starts at the beginning of the junior year and consists of three rotations, providing a cumulative work experience of one year. If you have interest in the co-op program, you should obtain advising no later than your fourth semester from the designated co-op adviser, who will help you plan work and study schedules. You may earn up to 3 credits toward graduation in the Department List requirements. If you prefer less of a time commitment, you can pursue one or more summer internships. You earn 1 credit per internship (maximum of 2 credits total) toward graduation in the Department List requirements. If you are not a formal co-op or internship student, you may still take related summer jobs; however, you may not claim credits for jobs you arrange outside of the formal programs.

## Honors Program

Students in the Schreyer Honors College (Atherton Hall, 863-2635) may earn honors in computer engineering by completing a dissertation with a member of the CSE faculty. See an honors adviser if you are interested in finding out more. (The department office, W209 Westgate Building, can identify the honors advisers for you).

## Minors

A minor is a specialization of at least 18 credits that supplements a major. Some courses may concurrently meet the requirements of our major. Popular minors for students in our department include:

1) Engineering Leadership Development
2) Engineering Entrepreneurship
3) Mathematics
4) Statistics

## Other Issues

For additional information on minors, withdrawal, leaves of absence, concurrent majors, change of major, satisfactory/unsatisfactory credits, and other academic issues, refer to University Faculty Senate Policies for Students at https://senate.psu.edu/policies-and-rules-for-undergraduate-students/.

## Waivers and Exceptions

All exceptions to the degree requirements must be approved and documented using Penn State's Course Substitution Request at https://coursesub.psu.edu/. Be sure to submit course

substitution petitions prior to taking courses and prior to the semester in which you plan to graduate.

Inquiries about exceptions and general degree requirements should be taken to the Department of Computer Science and Engineering Office (W209 Westgate Building), to your adviser, or to the Engineering Advising Center. Note that petitions that require College level approval (exceptions/waivers to College & University requirements) will NOT be accepted during the semester that you plan to graduate.

## Academic Integrity

Recognizing not only the value of integrity in the academic environment, but also its value for the practicing engineer and for society at large, we in the department urge you to act as a responsible professional while you are a student. Academic integrity is defined as follows in Faculty Senate rule 49-20:

> "Academic integrity is the pursuit of scholarly activity free from fraud and deception and is an educational objective of this institution. Academic dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating of information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students."

The EECS School maintains a specific Academic Integrity Statement at
https://www.eecs.psu.edu/students/resources/EECS-CSE-Academic-Integrity.aspx
related to programming courses.

It is commonly accepted that people learn better if they can interact, discuss, and assist each other in solving problems and understanding concepts. Yet persons submitting identical homework papers overstep the bounds of beneficial interaction. The specific limits of acceptable collaboration will be spelled out by the instructor in each course in the course syllabus. The specifics may vary from course to course. Do not, for any reason, show another student a part of your code or write sections of code for another student. Do not put your code online in any location that might be publicly accessible. Any collaboration that exceeds these guidelines or the instructor's guidelines will be considered cheating. Clearly, professionals share ideas, but they should not use another's work without clear acknowledgement of who did the work. Academic dishonesty in any form is not condoned or tolerated.

## Engineering Design Experience

Design is incorporated into a majority of courses taught in the computer engineering Program. Many of the courses are split between engineering science and engineering design, so that the design experience is spread throughout the program.

At the sophomore level, in CMPEN 270 or CMPEN 271 and CMPEN 275, students design and build digital circuits consisting of combinational and sequential components. Students begin with analysis type projects, learning basic laboratory skills, problem specification, and project

planning. Projects become increasingly more design oriented and open ended, culminating in a significant two- or three-week design effort, allowing the student to make choices and trade-offs between multiple design criteria.

During the junior year, students learn about computer organization and architecture in CMPEN 331 and CMPEN 431. Trade-offs in the design of a computer are examined.

The design experience culminates in the senior year, where students choose from a variety of system-level design courses in both hardware and software areas. Choices include laboratory design courses in microcomputer systems, VLSI, FPGA, software engineering, compilers, databases, and concurrent computing. Each of these courses involves the student in a significant design problem by the end of the course.

The final design course for most students is CMPEN 482W. Students experience the entire design process, starting from problem definition and requirements analysis to proposal preparation, to steps in the design review process, and finally, to design specification and implementation. Projects require students to consider a number of design factors including cost, size, human factors, reliability, power consumption, manufacturability, etc. The course is writing intensive and includes a number of technical writing experiences, as well as oral presentations.

## Computer Engineering Topics

Students achieve breadth in computer engineering through a series of required courses. Background in software related areas is gained through CMPSC 121 or 131, CMPSC 122 or 132, CMPSC 221, CMPSC 311, CMPSC 465, and CMPSC 473. Background in hardware areas is gained through CMPEN 270 or CMPEN 271 and CMPEN 275, CMPEN 331, CMPEN 362, and CMPEN 431. It is recommended that after your first semester you take one programming course a semester (CMPSC 121 or131, 122 or 132, 221, 311, 473) until CMPSC 473 is complete (if possible).

Specialization is provided through the students' selection of senior year electives. Students must select 12 credits of technical electives (Select 6 credits from CMPEN 416, CMPEN 417, CMPEN 454, CMPEN 455, CMPEN 471, CMPEN 472, CMPEN 473, EE 453, or EE 456; AND select 6 credits from any 400-489 CMPSC/CMPEN course). **Note that none of CMPSC 494H, CMPSC 496, CMPEN 494H, or CMPEN 496 may be used as a technical elective. A CMPSC 497 or CMPEN 497 course may be allowed as a technical elective, but a petition requesting this should be filed before taking the course**.

Issues related to the integration of hardware and software, and hardware-software tradeoffs are discussed in the required courses CMPSC 311, CMPEN 331, CMPSC 473, CMPEN 482W, and CMPEN 431, as well as some elective courses such as CMPEN 472 (Microprocessors and Embedded Systems) and CMPEN 473 (Microcomputer Laboratory).

Students receive appropriate introduction to various specialized mathematics topics in a sequence of required courses that include: CMPSC 360 (Discrete Mathematics for Computer Scientists), STAT 418 (Probability), and MATH 220 (Matrices). A variety of methods for modeling

computer processes and systems are introduced in the required courses CMPSC 465, CMPEN 331, CMPSC 473, and CMPEN 431.

Students learn to use a number of computer-aided design tools through the laboratory courses and in regular lecture courses. These include a digital schematic capture and simulation tool in CMPEN 270 or CMPEN 271 and CMPEN 275; an analog simulation tool in EE 210; a hardware design language in CMPEN 331; a hardware description language simulator in CMPEN 431; logic design CAD tools in CMPEN 431 and CMPEN 471; VLSI CAD tools in CMPEN 416; and various digital image processing and computer vision software tools in CMPEN/EE 455 and CMPEN/EE 454.

All students study multiple high-level programming languages such as Python, Java, C, and C++. Students study assembly language in CMPEN 331. Students gain extensive experience in both Microsoft and UNIX operating systems.

## Program Requirement Summary Chart

On the next pages, you will find a semester-by-semester chart of what courses to take with notes describing any choices to be made or restrictions to be followed. Please realize that although all the courses listed are required for the degree, they need not be taken during the semesters shown in the charts; In particular, CMPSC 360 and CMPSC 465 should be taken two semesters earlier if you wish to improve your chances for highly competitive internships with companies such as Google.

You should be sure to check course prerequisites before you deviate from the suggested schedule. **Care should be exercised to be sure core courses are taken in the proper sequence and in a timeframe allowing you to meet entrance to major requirements.** You should not wait until your last semester to take C required courses. A total of 128 credits are required for graduation.

## Sample Schedule of Courses by Semester

| SEMESTER 1 | Credits | SEMESTER 2 | Credits |
|---|---|---|---|
| MATH 140 (Calculus I)* | 4 | CMPSC 121* or 131* | 3 |
| PHYS 211 (Mechanics)* | 4 | MATH 141 (Calculus II)* | 4 |
| CHEM 110 GN (Chem Principles)* | 3 | PHYS 212 (Electricity & Magnetism)* | 4 |
| ENGL 15 GWS (Rhetoric & Comp.) | 3 | GA, GH, or GS course | 3 |
| First Year Seminar | 1 | GA, GH, or GS course | 3 |

| SEMESTER 3 | Credits | SEMESTER 4 | Credits |
|---|---|---|---|
| CMPEN 270 (Digital Systems)◊* | 3 | CMPEN 331 (Computer Org.)* | 3 |
| CMPSC 122* or 132* | 4 | CMPSC 221 (Java with Web)* | 3 |
| MATH 250 (Differential Equations)* | 3 | EE 210 (Circuits and Devices)* | 4 |
| MATH 220 GQ (Matrices) | 2 | MATH 231 (Multi-Variable) | 2 |
| PHYS 214 GN (Wave & Quantum) | 2 | ECON 102 or 104,(GS) | 3 |
| GA, GH, or GS course | 3 | | |

| SEMESTER 5 | Credits | SEMESTER 6 | Credits |
|---|---|---|---|
| CMPEN 431 (Computer Arch.)* | 3 | CMPEN 362 (Comm. Networks) | 3 |
| CMPSC 311 (Sys. Programming)* | 3 | CMPSC 465 (Data Struct. & Alg.)* | 3 |
| EE 310 (Electronic Circuit Design)* | 4 | CMPSC 473 (Operating Systems)* | 3 |
| STAT 418 (Probability) | 3 | EE 353 (Signals & Systems)*# | 3 |
| CMPSC 360 (Discrete Math)* | 3 | ENGL 202C (Technical Writing) | 3 |

| SEMESTER 7 | Credits | SEMESTER 8 | Credits |
|---|---|---|---|
| CMPEN 482W (Capstone Design) | 3 | CMPEN Elective | 3 |
| CMPEN Elective | 3 | CMPSC/CMPEN Elective† | 3 |
| CAS 100 A/B (Effective Speech) | 3 | CMPSC/CMPEN Elective† | 3 |
| Department List (General Elective) | 3 | Department List (General Elective) | 2-3 |
| GA, GH, or GS course | 3 | GA, GH, or GS course | 3 |
| Health & Wellness (GHW) | 1.5 | Health & Wellness (GHW) | 1.5 |

* A grade of C or better in these courses is required for graduation. (MATH 140, MATH 141, MATH 250/251, CHEM 110, PHYS 211, and PHYS 212 require a C or better for entrance to the major). If a course requires a “C” or better and the course is a prerequisite for another course, a “C” is required to meet the prerequisite.

†Select from any 400-level CMPSC/CMPEN course (may not duplicate material already taken or required).

◊ This course is the equivalent of the combination of CMPEN 271 and CMPEN 275.

# EE 353 is only offered in the spring semester

# GRADUATION REQUIREMENTS

*Many of the courses below have prerequisites; some prerequisites are shown in parentheses; others are given in the Bulletin.*

## Computer Science and Engineering (34 credits)

- CMPEN 270 (4) – Introduction to Digital Systems (Concurrent: PHYS 212)
- CMPEN 331 (3) – Computer Organization and Design (CMPEN 271 or CMPEN 270; CMPSC 121 or CMPSC 201)
- CMPEN 362 (3) – Communication Networks (CMPEN 271 or CMPEN 270; Concurrent: STAT 301 or STAT 318 or STAT 401 or STAT 414 or STAT 418)
- CMPEN 431[†] (3) – Introduction to Computer Architecture (CMPEN 331 or CMPEN 371)
- CMPSC 121 GQ (3) – Introduction to Programming Techniques (MATH 110 or MATH 140 concurrently or as a prerequisite) OR
  CMPSC 131 (3) – Programming and Computation I Fundamentals (MATH 110 or MATH 140 concurrently or as a prerequisite)
- CMPSC 122 (3) – Intermediate Programming (CMPSC 121) OR
  CMPSC 132 (3) - Programming and Computation II Data Structures (CMPSC 121 or CMPSC 131)
- CMPSC 221 (3) – Object Oriented Programming with Web-Based Applications (CMPSC 122 or 132)
- CMPSC 311 (3) – Systems Programming (CMPSC 221)
- CMPSC 360 (3) – Discrete Mathematics for Computer Science (Concurrent: CMPSC 122 or 132)
- CMPSC 465[†] (3) – Data Structures and Algorithms (CMPSC 360 or MATH 311W
- CMPSC 473[†] (3) – Operating Systems (CMPSC 311; CMPEN 331)

[†]Neither transfer credits nor study abroad credits may substitute.

## Computer Engineering Electives (12 credits)

Select 6 credits from any 400-level CMPSC or CMPEN course, **excluding 494, 496, 497 and courses offered at non-UP locations which cover duplicate material**.

Select 6 credits from the following list (prerequisites appear in parentheses).

- CMPEN 416 (3) – Digital Integrated Circuits (EE 310)

- CMPEN 417 (3) – Digital Design using Field Programmable Devices (CMPEN 331)
- CMPEN 454 (3) – Fundamentals of Computer Vision (MATH 230 or MATH 231; CMPSC 121 or CMPSC 201)
- CMPEN 455 (3) – Digital Image Processing (EE 353 or EE 350; CMPSC 121 or CMPSC 201)
- CMPEN 462 (3) Wireless Communication Systems and Security (CMPEN/EE 362)
- CMPEN 471 (3) – Logical Design of Digital Systems (CMPEN 331)
- CMPEN 472 (3) – Microprocessors and Embedded Systems (CMPEN 331)
- CMPEN 473 (3) – Microcomputer Laboratory (CMPEN 472)
- CMPEN 475 (3) – Functional Verification (CMPEN 331)
- EE 453 (3) – Fundamentals of Digital Signal Processing (EE 351 or EE 351 or EE 353)
- EE 456 (3) – Introduction to Neural Networks (CMPSC 201; MATH 220)

**Some courses are NOT offered every semester or even every year.**

## Writing Intensive Course (3 credits)

- CMPEN 482W (3) – Computer Engineering Project Design (EE 310, EE 353, CMPSC 473, ENGL 202C)

## Electrical Engineering (11 credits)

- EE 210 (4) – Circuits and Devices (: PHYS 212; concurrent: MATH 250)
- EE 310 (4) – Introduction to Electron Devices and Circuits (EE 210)
- EE 353 (3) – Signals and Systems: Continuous and Discrete-Time (CMPSC 201 or CMPSC 202, EE 210, MATH 250)

**EE 353 is only offered in the Spring semester**

## Communications (9 credits)

- ENGL 15 GWS (3) – Rhetoric and Composition (ENGL 30 GWS may be substituted)
- ENGL 202C GWS (3) – Technical Writing
- CAS 100 A/B (3) – Effective Speech

**ENGL/CAS 137 & 138 may substitute for ENGL 15 and CAS 100**

## Quantification and Statistics (18 credits)

- MATH 140 GQ (4) – Calculus with Analytic Geometry I
- MATH 141 GQ (4) – Calculus with Analytic Geometry II
- MATH 220 GQ (2) – Matrices
- MATH 231 (2) – Calculus of Several Variables
- MATH 250 (3) – Ordinary Differential Equations
- STAT (MATH) 418 (3) – Probability

## Health Sciences and Physical Education (3 credits)

The Health Science/Physical Activity (ESACT) requirement can be met by taking one 3-credit course or various credit combinations, most frequently two 1.5 credit courses, (which can be taken in different semesters). A student who completes an ROTC program may use 3 credits of ROTC to satisfy the GHA requirement.

## Natural Sciences (13 credits)

- CHEM 110 GN (3) – Chemical Principles
- PHYS 211 GN (4) – General Physics (mechanics)
- PHYS 212 GN (4) – General Physics (electricity, magnetism)
- PHYS 214 GN (2) – General Physics (wave motion and quantum physics)

## Arts, Humanities, Social and Behavioral Sciences, US & International Cultures (18 credits)

Details for the remaining General Education requirements can be found in the Baccalaureate Degree General Education Requirements at https://bulletins.psu.edu/undergraduate/general-education/baccalaureate-degree-general-education-program/

## Department List (General Elective) Guidelines (6 credits)

These 6 credits are sometimes called approved free electives or general electives, but restrictions apply as described below. These credits provide some flexibility and also allow inclusion of up to 3 credits of ROTC or up to 3 Cooperative Education credits. If your US/IL course was not an Arts, Humanities, Social or Behavioral Sciences course, it may be counted in this list. (For US/IL courses, see the *General Education and US & International Cultures in the Curriculum* booklet and the *Schedule of Courses).* We encourage, but do not require, the taking of technical electives in Computer Science, Engineering, Math or Physics in this category.

The following restrictions apply:

- No courses not satisfying minimum requirements for a baccalaureate degree program (see course descriptions in University *Bulletin*)
- No courses described as intended for non-science or non-technical majors in course descriptions in the University *Bulletin* (**You may take non-technical courses**, but look at the *Bulletin* to be sure the description doesn't say "for non-science majors only").

- No courses similar or remedial to a required course or course already taken (when in doubt, check with your advisor before scheduling the course). For example, you may not include 2 credits of MATH 140A or 2 credits of CHEM 106.
- No more than 3 credits of ROTC
- No more than 3 additional credits of physical education
- No more than 3 credits of Cooperative Education
- No more than 2 credits of Engineering Internship
- None of the following:
    - Astronomy (ASTRO) 1, 7N, 10, 11, 120, 140
    - Biological Science (BI SC) 1, 2, 3, 4
    - Chemistry (CHEM) 1, 3, 108, 101
    - Computer Science (CMPSC) 100, 101, 200, 201, 203
    - Earth and Mineral Sciences (EM SC) 150
    - English as a Second Language (ESL) 004
    - Information Science & Technology (IST) 140, 210, 220, 230, 240, 242, 261, 311, 361
    - Language and Literacy Education (LL ED) 5, 10
    - Mathematics (MATH) 200, MATH below 140
    - Philosophy (PHIL) 12
    - Physical Science (PH SC) 7
    - Physics (PHYS) 250, 251, PHYS below 211
    - Science, Technology, and Society (S T S) 150
    - Speech Communication (CAS) 126, 283
    - Statistics (STAT/MATH) below 319
    - Statistics (STAT/MATH) 401, 414

## First Year Seminar (1 credit)

Small interactive classes that allow first-year students to meet faculty and alumni, explore different majors and career opportunities, or focus on hands-on projects and skill development. If you started at a campus that did not require First Year Seminar or are a transfer student then you must add an additional credit to the Department List requirement.

# Helpful University Park Offices and Phone Numbers

**College of Engineering:**

| | |
|---|---|
| Dean's Office, 101 Hammond Building | 865-7537 |
| Associate Dean for Education, 101 Hammond Building | 863-3750 |
| Global Engineering Education, 205 Hammond Building | 863-9899 |
| Engineering Advising Center, 208 Hammond Building | 863-1033 |
| Assistant Dean for Academics, 208 Hammond Building | 865-7539 |
| Engineering Outreach and Inclusion, 211 Hammond Building | 865-4287 |
| Career Resources and Employer Relations, 117 Hammond Building | 863-1032 |

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|---|---|
| Outreach for Adult Learners, 128 Outreach Building | 863-2504 |
| Career Services, 101 MBNA Career Services Center | 865-2377 |
| Information Technology Services (ITS) Help Desk, 204 Wagner Building | 865-4357 |
| Counseling and Psychological Services, 501 Student Health Center | 863-0395 |
| Student Disability Resources, 116 Boucke Building | 863-1807 |
| Penn State World Campus, 128 Outreach Building | 865-5403 |
| Division of Undergraduate Studies (DUS), 101 Grange Building | 865-7576 |
| Penn State Learning, 220 Boucke Building | 865-1841 |
| Office of Student Aid, 314 Shields Building | 865-6301 |
| Residence Life, 201 Johnston Commons | 863-1710 |
| Undergraduate Admissions, 201 Shields Building | 865-5471 |
| Schreyer Honors College, 10 Schreyer Honors College | 863-2635 |
| Office of Veterans Programs, 325 Boucke Building | 863-0465 |
| General Information, HUB Desk, First Floor Lobby | 865-2000 |

# Sources of Information

This *Handbook* provides program information specifically for the undergraduate computer science major. It should be used as a supplement to the *College of Engineering Undergraduate Programs Guide* that is available online. The information in this *Handbook* pertains to students who entered or will be entering the major in Summer 2018, Fall 2018, or Spring 2019 semesters (2018 program year). Students entering the major in an earlier year should refer to the appropriate earlier version of the Handbook. Students in pre-major (ENGR) status may use this Handbook as a reference for scheduling; however, your official degree requirements will be established when you enter the major. For information about the computer engineering degree, refer to the *Computer Engineering Undergraduate Handbook*. For information about the data science (computational option) degree, refer to the *Data Science Computational Option Undergraduate Handbook*. All of these documents are available in the department office, W209 Westgate Building and online at http://eecs.psu.edu/students/undergraduate/Majors-Minors-Certificates.aspx. (If you are at a campus other than University Park, you should contact the College of Engineering representative at your location).

Although this *Handbook* lists all requirements for the computer science major, only those specific to computer science are described in detail. Other general College and University requirements are discussed only briefly with references to more comprehensive supporting documents. Hard copies of these documents can be obtained from a Dean's office or local bookstore. Many are available on-line. A list of useful web resources is provided below. For easy reference, resource names are printed in bold throughout the *Handbook*.

School of EECS – http://eecs.psu.edu
Engineering Advising Center – https://advising.engr.psu.edu
Academic Advising Portal – http://advising.psu.edu
Bulletin of Baccalaureate Degree Programs – http://bulletins.psu.edu/undergrad
University Faculty Senate – http://www.senate.psu.edu/policies/
Student Affairs – https://studentaffairs.psu.edu
General Education – https://gened.psu.edu
LionPath – http://launch.lionpath.psu.edu
Association of Women in Computing - http://www.awc.cse.psu.edu
Association for Computing Machinery Student Chapter – http://acm.psu.edu

For additional information, you can contact the **Engineering Advising Center** (208 Hammond, 863-1033), the Assistant Dean for Student Services (208 Hammond, 865-7539), or the **Department of Computer Science and Engineering** (W209A Westgate Building, 865-9505). The structure in the Department of Computer Science and Engineering includes an Undergraduate Program Coordinator, an Undergraduate Adviser and an Undergraduate Staff Assistant, all of whom can provide information and guidance during your academic. **If you communicate via e-mail, always use your Penn State account**, not another account such as Gmail.