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# Computer Engineering Undergraduate Handbook

Department of Computer Science and Engineering

## Fall 2015

## Helpful University Park Offices and Phone Numbers

College of Engineering:	
Dean's Office, 101 Hammond Building	865-7537
Associate Dean for Academic Programs, 101 Hammond Building	863-3750
Global Engineering Education, 205 Hammond Building	863-9899
Engineering Advising Center, 208 Hammond Building	863-1033
Assistant Dean for Student Services, 208G Hammond Building	865-7539
Multicultural Engineering Program, 208 Hammond Building	865-7138
Women in Engineering Program, 208 Hammond Building	863-1080
Engineering Career Resources and Employer Relations, 205 Hammond Building	863-1032
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 (CAPS), 501 Student Health Center	863-0395
Office for Disability Services, 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 (for transferring credits), 201 Shields Building	865-5471
Schreyer Honors College, 10 Schreyer Honors College (Atherton Hall)	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 engineering 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 2015, fall 2015, or spring 2016 (2015 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 science degree, refer to the *Computer Science Undergraduate Handbook*. All of these documents are available in the department office, 342G Information Sciences and Technology Building and online at [www.cse.psu.edu/current/ugrad](http://www.cse.psu.edu/current/ugrad). (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 engineering major, only those specific to computer engineering 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*.

<b>Registrar's Schedule of Courses</b> – <a href="http://schedule.psu.edu">http://schedule.psu.edu</a>
<b>Academic Advising Portal</b> – <a href="http://advising.psu.edu">http://advising.psu.edu</a>
<b>Department of Computer Science &amp; Engineering</b> – <a href="http://www.cse.psu.edu">http://www.cse.psu.edu</a>
<b>Penn State University</b> – <a href="http://www.psu.edu">http://www.psu.edu</a>
<b>Engineering Advising Center</b> – <a href="http://www.engr.psu.edu/Advising/">http://www.engr.psu.edu/Advising/</a>
<b>Bulletin of Baccalaureate Degree Programs</b> – <a href="http://bulletins.psu.edu/undergrad">http://bulletins.psu.edu/undergrad</a>
<b>University Faculty Senate Policies and Rules for Undergraduate Students</b> – <a href="http://www.senate.psu.edu/policies/">http://www.senate.psu.edu/policies/</a>
<b>Student Guide to General University Policies and Rules</b> – <a href="http://studentaffairs.psu.edu/conduct/docs/PoliciesRules.doc">http://studentaffairs.psu.edu/conduct/docs/PoliciesRules.doc</a>
<b>General Education and US &amp; International Cultures in the Curriculum</b> – <a href="http://bulletins.psu.edu/undergrad/generaleducation/">http://bulletins.psu.edu/undergrad/generaleducation/</a>
<b>eLion</b> – <a href="https://elion.psu.edu/">https://elion.psu.edu/</a>
<b>Association of Women in Computing</b> - <a href="http://www.clubs.psu.edu/up/awc/">http://www.clubs.psu.edu/up/awc/</a>
<b>Association for Computing Machinery Student Chapter</b> – <a href="http://acm.psu.edu">http://acm.psu.edu</a>

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** (342G Information Sciences and Technology Building, 865-9505). The structure in the Department of Computer Science and Engineering includes a 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 g-mail.

## 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.

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. 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.

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.

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

### Student Outcomes

1. An ability to apply knowledge of mathematics, science, and engineering.  
Analyze circuits, devices, and systems using differential and integral calculus and principles of electricity, magnetism, and physics.  
Analyze linear systems using continuous and discrete-time techniques.  
Analyze the time complexity of algorithms using discrete mathematics.
2. An ability to design and conduct experiments, as well as to analyze and interpret data.  
Test circuits, devices, and systems using software, hardware and statistical tools.  
Test algorithms or computer code and analyze their correctness and efficiency.  
Design test cases for testing hardware or software.
3. An ability to design a system, component, or process to meet desired needs.

Design the electronic/logic circuits that form the basic building blocks of a computer system.  
Design the architecture and organization of the basic components of a computer system.  
Develop a modest (on the order of a thousand lines of code) software application, using appropriate data structures and algorithms.

4. An ability to function on multi-disciplinary teams.  
Demonstrate an ability to work effectively in multi-disciplinary teams. The term multi-disciplinary is used here in the broader sense to include teams of computer professional having different skills; e.g., one team member might be familiar with web development, whereas another might have experience with microprocessor systems.
5. An ability to identify, formulate, and solve engineering problems.  
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.
6. An understanding of professional and ethical responsibility.  
Be able to identify ethical issues in engineering case studies.
7. An ability to communicate effectively.  
Write clear and effective technical prose.  
Speak clearly and persuasively about technical subjects in large and/or small group settings, and use supporting materials effectively.
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context.  
Be able to discuss major trends in industry and current research activities within the discipline.
9. A recognition of the need for, and an ability to engage in life-long learning.  
Demonstrate independent learning by using unfamiliar computer systems, test equipment, and software tools to solve technical problems.
10. A knowledge of contemporary issues.  
Be able to discuss major trends in industry and current research activities within the discipline.
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.  
Analyze the performance of software and/or hardware systems using probabilistic and statistical methods.  
Design and simulate computer hardware components using standard tools.

Students who are interested in math and science and enjoy solving problems are excellent candidates for the computer engineering major. CMPEN 270 or 271 and CMPSC 121 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 will see the Department of Computer Science and Engineering Undergraduate Adviser. The email address, [advising@cse.psu.edu](mailto:advising@cse.psu.edu) will send mail to the Undergraduate Adviser. Schreyer Scholars will be assigned a Scholar's Adviser.

Required courses for the computer engineering 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**. 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** and the **Student Guide to General University Policies and Rules**). 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.

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 and have at least a 2.6 cumulative GPA in order to be admitted to the computer engineering program. You may request admission to the major via eLion as soon as you have completed 40 credits of **Penn State coursework** and before you complete 59 credits of Penn State coursework.
- (2) 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're accumulating credits at a minimum rate of 30 credits per calendar year.

**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 of 2.6. 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.

**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, although it is possible to obtain a concurrent major with another non-enrollment controlled program. (Also see page 3 “Enrollment Controls”).

**Registration** – Each semester, you register for classes by planning what you need to take (referring to this *Handbook* and the *College of Engineering Undergraduate Programs Guide* by checking with your adviser, and then by following the instructions in the *Schedule of Courses* that is published each semester. 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<sup>th</sup> 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<sup>th</sup> semester. Some electives are not offered every semester, so please be careful in your scheduling. This is especially true for co-op students.

**Prerequisite Courses** – If a CMPEN or CMPSC course has a prerequisite course(s) specified you must complete the prerequisite course with an appropriate grade before taking the successor course. For most courses an appropriate grade is a grade of D or higher. **However, if the prerequisite course is a “C or higher” course, the appropriate grade is a C or higher.** Waiving of prerequisites is not normally approved.

**Schedule Changes** – Schedule adjustments (course adds/drops) may be made online through **eLion** during the first 10 calendar days of each semester. Detailed instructions, costs, and deadlines are provided in the *Schedule of Courses*. After this time, you may still adjust your schedule, but any change is considered a late add or a late drop. *You have a limit of 16 late-drop credits, so consultation with your adviser is important.* (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 46 credits of General Education. A General Education course can be identified by its course suffix. You will partially meet these requirements by taking specific courses required for the computer engineering major, and by following the general guidelines below.

General Education consists of the following categories:

- first year seminar - at least 1 credit - courses with the designation PSU will fulfill this requirement, as will courses with the suffix S, T or X (see NOTE below).
- writing/speaking - 9 credits - course suffix of GWS
- quantification - 6 credits - suffix of GQ
- health and physical activity - 3 credits - suffix GHA

- natural sciences - 9 credits - suffix GN
- arts - 6 credits - suffix GA
- humanities - 6 credits - suffix GH
- social and behavioral sciences - 6 credits - suffix GS

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.

College of Engineering students follow the University's General Education guidelines; refer to the *College of Engineering Undergraduate Programs Guide* and to the University's **Baccalaureate Degree Programs Bulletin** for a complete list of available courses.

**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).

**US & International Cultures Requirement** – Courses approved to fulfill this requirement will be designated as US, IL, or both US and IL. Students must complete 3 credits in United States Cultures (US) and 3 credits in International Cultures (IL). If a student takes a 3-credit course that is both US and IL, to complete the requirement, he/she must take another 3-credit course that is US, IL, or both US and IL. Education abroad courses and other credit-bearing experiences such as internships that meet this requirement will be designated as US, IL, or both US and IL. Most students complete this requirement by selecting GA, GS or GH courses which also satisfy the US/IL requirement.

**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, CMPSC 122, 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, 342G Information Sciences and Technology 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) Business/Liberal Arts

**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**. For information on campus and community resources (parking, libraries, museums, etc.; referrals for returning adult students, minority students, veterans, women), refer to *Easy Access*, available during orientation and published by Student Life.

**Waivers & Exceptions** - All exceptions made in the degree requirements must be approved and documented using a College of Engineering petition form found and submitted online (<http://www.engr.psu.edu/e-petition/>). Inquiries about exceptions and general degree requirements should be taken to the Department of Computer Science and Engineering Office (342G Information Sciences and Technology Building), to your adviser, or to the Engineering Advising Center. (Note that petitions which 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.”

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 can vary from course to course. Do not, for any reason, show another student sections of your code or write sections of code for another student. 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.

**Engineering Topics** – Students achieve breadth in computer engineering through a series of required courses. Background in software related areas is gained through CMPSC 121, CMPSC 122, 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, 122, 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 471, CMPEN 472, CMPEN 473, CMPEN 411, CMPEN 417, CMPEN 416, CMPEN 455, CMPEN 454, EE 453, or EE 456; AND select 6 credits from any 400-level CMPSC/CMPEN 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 and a microprocessor emulation system in CMPEN 473; a hardware description language simulator in CMPEN 431; logic design CAD tools in CMPEN 431 and CMPEN 471; VLSI CAD tools in CMPEN 411; and various digital image processing and computer vision software tools in CMPEN/EE 455 and CMPEN/EE 454.

All students learn at least three programming languages, JAVA, C, and C++. Assembly language is studied in CMPEN 331 and CMPEN 472. Students make extensive use of 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; however, 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 time frame allowing you to meet entrance to major requirements.** Also remember that a course that is designated as **C required** must be completed with a C or higher in order to both move on to a course for which it is a prerequisite and to graduate. If possible, you 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 (15 credits)

MATH 140 GQ or MATH 140E (Calculus I)*	4
PHYS 211 GN (Mechanics)*	4
CHEM 110 GN (Chemical Principles)*	3
ENGL 15 or 30 GWS (Rhetoric & Composition) (or GA/GH/GS)	3
First Year Seminar <sup>xi</sup>	1

### SEMESTER 2 (17 credits)

MATH 141 GQ or MATH 141E (Calculus II)*	4
PHYS 212 GN (Electricity & Magnetism)*	4
CMPSC 121 GQ (Intro. To Prog. Techniques)*	3
GA, GH, or GS course (or ENGL 15 or 30)	3
GA, GH, or GS course	3

### SEMESTER 3 (17 credits)

MATH 250 (Differential Equations)*	3
MATH 220 GQ (Matrices)	2
CMPSC 122 (Intermediate Programming)*	3
CMPEN 270 (Intro to Digital Systems) <sup>◇</sup> *	4
PHYS 214 GN (Wave Motion & Quantum Physics)	2
GA, GH, or GS course	3

### SEMESTER 4 (15 credits)

MATH 231 (Calculus of Several Variables)	2
CMPSC 221 (OOP with Web Applications)*	3
EE 210 (Circuits and Devices)*	4
ECON 102,104, or ENNEC 100 (GS) <sup>x</sup>	3
CMPEN 331 (Computer Organization & Design)*	3

### SEMESTER 5 (16 credits)

CMPEN 431 (Intro to Computer Architecture)*	3
EE 310 (Electronic Circuit Design)*	4
CMPSC 311 (Systems Programming)*	3
STAT 418 (Probability)	3
CAS 100 A/B (Effective Speech)	3

### SEMESTER 6 (15 credits)

CMPEN 362 (Communication Networks)	3
CMPSC 360 (Discrete Math for Comp. Science)*	3
CMPSC 473 (Operating Systems)	3
ENGL 202C (Technical Writing)	3
EE 353 (Signals & Systems)*#	3

### SEMESTER 7 (16.5 credits)

GA, GH, or GS course	3
CMPEN 482W (Comp. Eng. Project Design)	3
CMPSC 465 (Data Structures & Algorithms)*	3
CMPEN Computer Engineering Elective <sup>ii</sup>	3
Department List (General Elective) <sup>x</sup>	3
Health & Physical Activity (GHA) <sup>vii</sup>	1.5

### SEMESTER 8 (16.5 credits)

CMPEN Computer Engineering Elective <sup>ii</sup>	3
CMPSC/CMPEN 400-level~	3
CMPSC/CMPEN 400-level~	3
Department List (General Elective) <sup>x</sup>	3
GA, GH, or GS course	3
Health & Physical Activity (GHA) <sup>vii</sup>	1.5

Superscripts in Roman numerals refer to the Graduation Requirements Notes on the following pages.

\* 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 usually only offered in the spring semester

## GRADUATION REQUIREMENTS NOTES

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

### I. Computer Science and Engineering (34 credits):

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

\*Neither transfer credits nor study abroad credits may substitute.

### II. Computer Engineering Electives (12 credits):

Select 6 credits from any 400-level CMPSC or COMPEN course. (Courses offered at non-UP locations which cover duplicate material may not be used, e.g. CMPSC 425).

Select 6 credits from:

- COMPEN 411 (3) – VLSI Digital Circuits  
(prerequisite: COMPEN 371 or COMPEN 471; EE 310)
- COMPEN 416 (3) – Digital Integrated Circuits  
(prerequisite: EE 310)
- COMPEN 417 (3) – Digital Design using Field Programmable Devices  
(prerequisite: COMPEN 331)
- COMPEN 454 (3) – Fundamentals of Computer Vision  
(prerequisite: MATH 230 or MATH 231; CMPSC 121 or CMPSC 201)
- COMPEN 455 (3) – Digital Image Processing  
(prerequisite: EE 353 or EE 350; CMPSC 121 or CMPSC 201)

- CMPEN 471 (3) – Logical Design of Digital Systems  
(prerequisite: CMPEN 331)
- CMPEN 472 (3) – Microprocessors and Embedded Systems  
(prerequisite: CMPEN 331)
- CMPEN 473 (3) – Microcomputer Laboratory  
(prerequisite: CMPEN 472)
- CMPEN 475 (3) – Functional Verification  
(prerequisite: CMPEN 331)
- EE 453 (3) – Fundamentals of Digital Signal Processing  
(prerequisite: EE 351 or EE 351 or EE 353)
- EE 456 (3) – Introduction to Neural Networks  
(prerequisite: CMPSC 201 or CMPSC 202; MATH 220)
- EE 497E (3) – Software-defined Radio  
(prerequisite: EE 351 or EE 353)

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

### **III. Writing Intensive Course (3 credits):**

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

### **IV. Electrical Engineering (11 credits):**

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

### **V. 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

### **VI. 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

### **VII. 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.

### VIII. Natural Sciences (13 credits):

- 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)
- CHEM 110 GN (3) – Chemical Principles

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

Six credits are required in each of the 3 categories: Arts (A), Humanities (H), and Social and Behavioral Sciences (S), as listed under the University's General Education Guidelines [see the University's **Baccalaureate Degree Programs Bulletin**]. See page 5 [this *Handbook*], **General education**, for an explanation of the 9-6-3 sequence as it pertains to AHS courses. You may use one of your Arts, Humanities, or Social or Behavioral Sciences selections to fulfill the University's US & International Cultures requirement (see page 6 [this *Handbook*], **US/IL requirement\*\***). A work chart follows.

<b>Arts</b>	
<b>Humanities</b>	
<b>Social Sci.</b>	<b>ECON 102*, ECON 104*, or ENNEC 100*</b>
<b>US/IL Course</b>	

*\*Either ECON 102, 104, or ENNEC 100 is required for College of Engineering majors.*

*\*\*For US/IL courses, see **General Education and US & International Cultures in the Curriculum** on-line and the **Semester Courses Schedules**. The College of Engineering encourages you to be a Globally Ready student in which Global Readiness is defined as having the knowledge and appreciation of the global nature of engineering and related professions, as well as the challenges and opportunities associated with contemporary worldwide issues. Students should graduate, being ready to practice their profession in a global context by being sensitive to and respectful of the differences that affect professional practice throughout the world. To assist you in being Globally Ready the College of Engineering encourages you to select as an IL course one of the courses off the list which may be found at:*

*<http://www.engr.psu.edu/global/students/illimited.htm>*

### X. 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.
- none of the following:
  - Astronomy (ASTRO) 1, 10, 11, 120, 140
  - Biological Science (BI SC) 1, 2, 3, 4
  - Chemistry (CHEM) 1, 3, 108, 101
  - Computer Science (CMPSC) 100, 203
  - Earth and Mineral Sciences (EM SC) 150
  - English as a Second Language (ESL) 004
  - 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
- 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
- **IST courses except for the following:**
  - IST 140 – may never be used
  - IST 210 – may not be used if the student takes CMPSC 431W
  - IST 220 – may never be used
  - IST 242 – may never be used
  - IST 230 – may never be used
  - IST 261 – may never be used
  - IST 311 – may never be used
  - IST 361 – may never be used

**XI. 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 credit then you must add an additional credit to the Department List requirement.