Penn Computer Engineering, BSE

Computer Engineering (CMPE) is the discipline that creates, designs, and engineers computer systems from digital circuits, through compilers and runtime systems, to networking and world-wide distributed systems.

What is Computer Engineering?

The computational artifacts that entertain us (e.g., mp3 players, video games, digital-video recorders), keep us in touch with each other (e.g., smart phones, wired and wireless networks), reduce our work (e.g., robots), increase our safety (e.g., anti-lock brakes, traction control), and save lives (e.g., medical equipment and devices) are all products enabled by computer engineers. Computers and computational control are rapidly becoming the glue and infrastructure that connects our world, mediating interactions among people, businesses, and the physical world. The enormous computational capabilities available from modern technology continues to offer the potential to create new applications and value, and computer engineers are the people who conceive how these technological capabilities can be turned into concrete artifacts and services that improve our lives and create wealth.

Recent advances in manufacturing make it economical to construct systems containing billions of components and millions of lines of code, and these systems are increasingly invaluable in life-critical and real-time systems; computer engineering is the discipline that seeks to understand how to design and manage systems of this complexity while providing adequate guarantees of safety and trustworthiness for such systems. Computer Engineering is the discipline that creates, designs, and engineers computer systems from digital circuits, through compilers and runtime systems, to networking and world-wide distributed systems. As an engineering discipline, the computer engineer must appreciate the physical aspects of computations (energy, delay, area, reliability, costs) and be able to expertly navigate the multi-dimensional tradeoff space associated with implementing computations. Since today's high performance programmable computing devices mean enormous computational tasks can be performed entirely in soft-ware, the computer engineer must manage computational capabilities and functionalities which migrate between hardware and software driven by advancing technology and these engineering tradeoffs.

What do Computer Engineers do?

Career opportunities for computer engineers span a wide range of industries and roles. Computer engineers are needed in companies that design and program integrated circuits, circuit boards, embedded and autonomous control, computer systems, and networked distributed systems. Computer engineers are employed in a broad range of industries including semiconductor, computer, web services, telecommunication, automotive, aerospace, robotics, medical, security, media, and consumer electronics. Computer engineers work in established Fortune 500 companies, research labs, startups, and consulting firms.

The Penn Computer Engineering Program helps students develop the key skills central to the design and engineering of modern computational systems including: discrete and continuous mathematics, programming, algorithms, physical aspects of digital circuit design and implementation, computer architecture and systems, information theory, signal processing, networking, embedded systems, and soft-ware engineering. It further provides a series of collaborative, hands-on lab experiences that motivate and provide context for the domain skills while developing expertise in design and optimization.

The Computer Engineering Program also prepares students for graduate studies in a broad range of areas including: VLSI design, computer architecture, computer-aided design, robotics, embedded systems, signal and image processing, networking and telecommunications, and parallel and distributed computing.

The Penn Computer Engineering Program draws upon the strong Penn faculty in the Computer and Information Science and Electrical and Systems Engineering Departments.

Helpful Links

For course planning information, visit: http://www.seas.upenn.edu/cmpe/

https://www.facebook.com/groups/CMPEAtPenn/

ESE@Penn

Penn_ese

To make an appointment to speak with an advisor:

Staci Kaplan

Stacilk@seas.upenn.edu

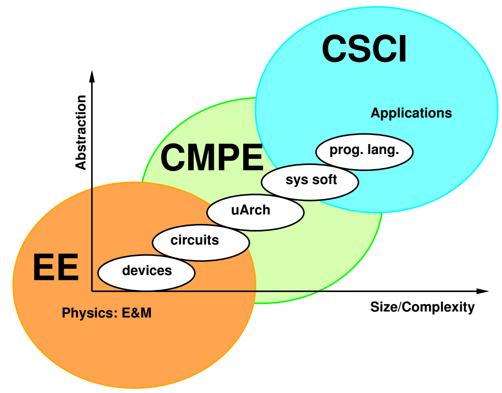
Undergraduate Program Coordinator

Room 203, Moore Building

Student Guidance

With the addition of the CMPE major, how should you choose amongst the EE, CMPE, and CSCI majors? CMPE overlaps many topics with CSCI and EE, but has a distinctly different emphasis.

We can see one dimension of this distinct emphasis by considering the abstraction stack we use to build computing systems which spans from the physical phenomena in the world to our powerful, automated systems. EE emphasizes the physical side, understanding electricity and magnetism and harnessing them into devices and circuits, while computer science emphasizes the design, analysis and implementation of complex information processing systems which can often be abstracted from the underlying hardware implementations. Engineers employ a number of abstractions which bridge between physical circuits and abstracted programming languages which are of interest to both EEs and computer scientists. Computer Engineers sit naturally in the middle of this abstraction hierarchy with interests that extend into each side.



Notably, CMPEs are the engineers positioned to deal with the hardware/software tradeoffs. Is it better to implement this computation in hardware or software? How should we partition functionality between hardware and software? What is the right interface between hardware and software?

Computer engineering emphasizes both an understanding of physical costs and complexity management of large systems. CMPEs are the engineers who can identify the necessary physical costs associated with performing powerful, high-level computational tasks. That is, while good abstractions allow many computer scientists to largely ignore the physical limits of their machines, in the end every computation consumes silicon area and energy (battery or wall current), takes times, and may fail. The main focus of electrical engineers is to build carefully engineered powerful components; computer engineers manage the complexity of composing these components into large systems.

The Penn Computer Engineering major emphasizes design and engineering. As a result, the CMPE major includes a steady stream of hands-on projects where students conceive, design, build, measure, evaluate, and test hardware and software systems. CMPE trades off some of the depth in mathematical foundations which exists in both EE and CSCI (*e.g.* signal processing, feedback and control, linear systems, learning, computability) in order to promote experiences which connect real system design tradeoffs to mathematical guidance.

Computer Engineering is a natural path for students interested in embedded and real-time systems, consumer electronics, or computer system design (including architecture, operating systems, distributed systems, compilation and electronic design automation). Computer Engineering is also a good path for students interested in security, networking, and robotics, though these fields are broad enough that, depending on specific interests, EE or CSCI might also be good paths. For example, within robotics, strong interests in controls or sensing might be best served in EE, while strong interest in planning and world-modeling might be best addressed with a CSCI focus. If your passion lies in devices, analog circuits, control theory, or signal processing, then EE is a more appropriate major. If your passion lies in computational theory, programming languages, learning, vision, databases, linguistics, bioinformatics, or social networking, then CSCI is a more appropriate focus.

Typical Student

<table>
<tr><th>Term</th><th colspan="11">0.5 CU Increments</th><th>Total CUs</th><th>Eng. CUs</th></tr>
<tr><td>Frosh Fall</td><td colspan="2">Math 104</td><td colspan="2">CIS 120</td><td colspan="3">Phys 150</td><td colspan="2">Chem</td><td></td><td></td><td>4.5</td><td>1</td></tr>
<tr><td>Frosh Spring</td><td colspan="2">Math 114</td><td colspan="2">CIS 160</td><td colspan="3">ESE 112</td><td colspan="2">SSH</td><td colspan="2">ESE 150</td><td>5.5</td><td>2.0</td></tr>
<tr><td>Soph Fall</td><td colspan="2">Math 240</td><td colspan="2">CIS 240</td><td colspan="2">free</td><td colspan="2">SSH</td><td colspan="3">ESE 215</td><td>5.5</td><td>2.5</td></tr>
<tr><td>Soph Spring</td><td colspan="2">Statistics</td><td colspan="2">CIS 121</td><td colspan="2">free</td><td colspan="2">EAS203</td><td colspan="3">ESE 350</td><td>5.5</td><td>3.5</td></tr>
<tr><td>Junior Fall</td><td colspan="2">Tech. elec.†</td><td colspan="2">Tech. elec.</td><td colspan="2">ESE 370</td><td colspan="2">SSH</td><td colspan="2">CIS 441</td><td></td><td>5</td><td>2</td></tr>
<tr><td>Junior Spring</td><td colspan="2">M/NS elec.</td><td colspan="2">CIS 350</td><td colspan="2">CIS 371</td><td colspan="2">SSH</td><td colspan="2">Conc. Lab</td><td></td><td>5</td><td>3</td></tr>
<tr><td>Senior Fall</td><td colspan="2">Tech. elec.</td><td colspan="2">CIS 380</td><td colspan="2">ESE 407</td><td colspan="2">SSH</td><td colspan="2">Sen. Des.</td><td></td><td>5</td><td>3</td></tr>
<tr><td>Senior Spring</td><td colspan="2">Tech. elec.</td><td></td><td></td><td colspan="2">free</td><td colspan="2">SSH</td><td colspan="2">Sen. Des.</td><td></td><td>4</td><td>1</td></tr>
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Curriculum Deferred Student

<table>
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<tr><td>Frosh Fall</td><td colspan="2">Math 104</td><td colspan="2">CIS 110</td><td colspan="3">Phys 150</td><td colspan="2">SSH</td><td></td><td></td><td>4.5</td><td>1</td></tr>
<tr><td>Frosh Spring</td><td colspan="2">Math 114</td><td colspan="2">Chem</td><td colspan="3">Phys 151</td><td colspan="2">SSH</td><td colspan="2">free</td><td>5.5</td><td>0</td></tr>
<tr><td>Soph Fall</td><td colspan="2">Math 240</td><td colspan="2">CIS 160</td><td colspan="2">CIS 240</td><td colspan="2">EAS 203</td><td colspan="3">ESE 215</td><td>5.5</td><td>3.5</td></tr>
<tr><td>Soph Spring</td><td colspan="2">Statistics</td><td colspan="2">CIS 120</td><td colspan="2">free</td><td colspan="3">ESE 350</td><td></td><td></td><td>4.5</td><td>3.5</td></tr>
<tr><td>Junior Fall</td><td colspan="2">M/NS elec.</td><td colspan="2">CIS 121</td><td colspan="2">ESE 370</td><td colspan="2">SSH</td><td colspan="2">CIS 441</td><td></td><td>5</td><td>3</td></tr>
<tr><td>Junior Spring</td><td colspan="2">Tech. elec.†</td><td colspan="2">CIS 350</td><td colspan="2">CIS 371</td><td colspan="2">SSH</td><td colspan="2">Conc. Lab</td><td></td><td>5</td><td>3</td></tr>
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<tr><td>Senior Spring</td><td colspan="2">Tech. elec.</td><td colspan="2">Tech. elec.</td><td colspan="2">free</td><td colspan="2">SSH</td><td colspan="2">Sen. Des.</td><td></td><td>5</td><td>1</td></tr>
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† – students interested in submatriculating into CIS, EMBS, or ROBO MSE programs should consider taking CIS 320 during the junior year.

Common Prefix for CIS and ESE Majors

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<tr><th>Term</th><th colspan="10">0.5 CU Increments</th><th>Total CUs</th><th>Eng. CUs</th></tr>
<tr><td>Frosh Fall</td><td colspan="2">Math 104</td><td colspan="2">CIS 110 or CIS 120</td><td colspan="2">Phys 140</td><td colspan="2">SSH</td><td colspan="2">ESE 111</td><td>5</td><td>2</td></tr>
<tr><td>Frosh Spring</td><td colspan="2">Math 114</td><td colspan="2">CIS 160</td><td colspan="3">ESE 112</td><td></td><td colspan="2">ESE 150</td><td>4.5</td><td>2</td></tr>
</table>

This prefix should be suitable for students majoring in any of: CMPE, CSCI, DMD, EE, SSE. This allows students generally interested in CIS/ESE topics to start into common core courses in the Freshman year before making a final decision about a particular major of focus.