Computer Engineering is the discipline that 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 multidimensional tradeoff space associated with implementing computations. Since today’s high performance programmable computing devices mean enormous computational tasks can be performed entirely in software, the computer engineer must manage computational capabilities and functionalities which migrate between hardware and software driven by advancing technology and these engineering tradeoffs. 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.

For more information: https://www.seas.upenn.edu/prospective-students/undergrad/majors/computer-engineering/

Computer Engineering (CMPE) Major Requirements

37 course units are required.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Course Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIS 120</td>
<td>Programming Languages and Techniques I</td>
<td>1</td>
</tr>
<tr>
<td>CIS 121</td>
<td>Programming Languages and Techniques II</td>
<td>1</td>
</tr>
<tr>
<td>ESE 150</td>
<td>Digital Audio Basics</td>
<td>1</td>
</tr>
<tr>
<td>ESE 215</td>
<td>Electrical Circuits and Systems</td>
<td>1.5</td>
</tr>
<tr>
<td>CIS 240</td>
<td>Introduction to Computer Systems</td>
<td>1</td>
</tr>
<tr>
<td>ESE 350</td>
<td>Embedded Systems/Microcontroller Laboratory</td>
<td>1.5</td>
</tr>
<tr>
<td>CIS 350</td>
<td>Software Design/Engineering</td>
<td>1</td>
</tr>
<tr>
<td>or CIS 460</td>
<td>Interactive Computer Graphics</td>
<td></td>
</tr>
<tr>
<td>ESE 370</td>
<td>Circuit-Level Modeling, Design, and Optimization for Digital Systems</td>
<td>1</td>
</tr>
<tr>
<td>CIS 380</td>
<td>Computer Operating Systems</td>
<td>1</td>
</tr>
<tr>
<td>CIS 441</td>
<td>Embedded Software for Life-Critical Applications</td>
<td>1</td>
</tr>
<tr>
<td>CIS 471</td>
<td>Computer Organization and Design</td>
<td>1</td>
</tr>
<tr>
<td>Networking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESE 407</td>
<td>Introduction to Networks and Protocols</td>
<td>1</td>
</tr>
<tr>
<td>or CIS 553</td>
<td>Networked Systems</td>
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<tr>
<td>Concurrency Lab</td>
<td></td>
<td></td>
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<tr>
<td>CIS 455</td>
<td>Internet and Web Systems</td>
<td>1</td>
</tr>
<tr>
<td>or CIS 505</td>
<td>Software Systems</td>
<td></td>
</tr>
<tr>
<td>or ESE 532</td>
<td>System-on-a-Chip Architecture</td>
<td></td>
</tr>
<tr>
<td>or CIS 565</td>
<td>GPU Programming and Architecture</td>
<td></td>
</tr>
</tbody>
</table>

| Senior Design | | |
| CIS 400 | Senior Project | 1 |
| or ESE 450 | Senior Design Project I - EE and SSE | |
| CIS 401 | Senior Project | 1 |
| or ESE 451 | Senior Design Project II - EE and SSE | |

| Math and Natural Science | | |
| MATH 104 | Calculus, Part I | 1 |
| MATH 114 | Calculus, Part II | 1 |
| MATH 240 | Calculus, Part III | 1 |
| ESE 301 | Engineering Probability | 1 |
| or CIS 261 | Discrete Probability, Stochastic Processes, and Statistical Inference | |
| or STAT 430 | Probability | |
| or ENM 321 | Engineering Statistics | |
| CIS 160 | Mathematical Foundations of Computer Science | 1 |
| ME 110 | Introduction to Mechanics | 1 |
| or PHYS 140 | Principles of Physics I (without laboratory) | |
| or PHYS 150 | Principles of Physics I: Mechanics and Wave Motion | |
| or PHYS 170 | Honors Physics I: Mechanics and Wave Motion | |
| ESE 112 | Engineering Electromagnetics | 1.5 |
| or ESE 181 | Engineering Electromagnetics | |
| or ESE 183 | Electromagnetism and Radiation | |
| or PHYS 171 | Honors Physics II: Electromagnetism and Radiation | |
| CHEM 101 | General Chemistry | 1 |
| or EAS 091 | Chemistry Advanced Placement/International Baccalaureate Credit (Engineering Students Only) | |
| or BIOL 101 | Introduction to Biology A | |
| or BIOL 121 | Introduction to Biology - The Molecular Biology of Life | |
| ESE 400 | Engineering Economics | |
| EAS 545 | Engineering Entrepreneurship I | |
| EAS 595 | Foundations of Leadership | |
| MGMT 237 | Management of Technology | |
| OIDD 236 | Scaling Operations in Technology Ventures: Linking Strategy and Execution | |
| Math, Science, or Engineering Elective | | |
| CIS 400 | Engineering Economics | |

| Math or Natural Science Elective | | |
| CIS 400 | Engineering Economics | |
| EAS 545 | Engineering Entrepreneurship I | |
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| Math, Science, or Engineering Elective | | |
| CIS 400 | Engineering Economics | |

| Professional Electives | | |
| CIS 400 | Engineering Economics | |
| EAS 545 | Engineering Entrepreneurship I | |
| EAS 595 | Foundations of Leadership | |
| MGMT 237 | Management of Technology | |
| OIDD 236 | Scaling Operations in Technology Ventures: Linking Strategy and Execution | |
| Math, Science, or Engineering Elective | | |
| CIS 400 | Engineering Economics | |

| General Electives | | |
| EAS 203 | Engineering Ethics | 1 |
| Select 4 Social Science or Humanities courses | 4 |
| Select 2 Social Science, Humanities, or Technology in Business & Society courses | 2 |

| Total Course Units | 37 |

1 If not taken freshman year, must be replaced by another department approved engineering course.
If BIOL 121, CHEM 101, EAS 091, MEAM 110 or PHYS 140 are taken, choose one natural science lab from the list: BIOL 124 Introductory Organismal Biology Lab, CHEM 053 General Chemistry Laboratory I, MEAM 147 Introduction to Mechanics Lab, PHYS 050 Physics Laboratory I or another department approved Natural Science lab.

At most, two freshman-level Engineering courses may be used as a Professional Elective.

Must include a Writing Seminar (a list of approved Writing Seminars can be found in the SEAS Undergraduate Handbook (https://ugrad.seas.upenn.edu/student-handbook/courses-requirements/writing-courses/))