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 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 1200</td>
<td>Programming Languages and Techniques I</td>
<td>1</td>
</tr>
<tr>
<td>CIS 1210</td>
<td>Programming Languages and Techniques II</td>
<td>1</td>
</tr>
<tr>
<td>ESE 1500</td>
<td>Digital Audio Basics</td>
<td>1</td>
</tr>
<tr>
<td>ESE 2150</td>
<td>Electrical Circuits and Systems</td>
<td>1.5</td>
</tr>
<tr>
<td>CIS 2400</td>
<td>Introduction to Computer Systems</td>
<td>1</td>
</tr>
<tr>
<td>ESE 3500</td>
<td>Embedded Systems/Microcontroller Laboratory</td>
<td>1.5</td>
</tr>
<tr>
<td>CIS 3500</td>
<td>Software Design/Engineering</td>
<td>1</td>
</tr>
<tr>
<td>or CIS 4600</td>
<td>Interactive Computer Graphics</td>
<td></td>
</tr>
<tr>
<td>or CIS 5600</td>
<td>Interactive Computer Graphics</td>
<td></td>
</tr>
<tr>
<td>ESE 3700</td>
<td>Circuit-Level Modeling, Design, and Optimization for Digital Systems</td>
<td>1</td>
</tr>
<tr>
<td>CIS 3800</td>
<td>Computer Operating Systems</td>
<td>1</td>
</tr>
<tr>
<td>CIS 4410</td>
<td>Embedded Software for Life-Critical Applications</td>
<td>1</td>
</tr>
<tr>
<td>or CIS 5410</td>
<td>Embedded Software for Life-Critical Applications</td>
<td></td>
</tr>
<tr>
<td>or CIS 5470</td>
<td>Software Analysis</td>
<td></td>
</tr>
<tr>
<td>CIS 4710</td>
<td>Computer Organization and Design</td>
<td>1</td>
</tr>
<tr>
<td>or CIS 5710</td>
<td>Computer Organization and Design</td>
<td></td>
</tr>
<tr>
<td>Networking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESE 4070</td>
<td>Introduction to Networks and Protocols</td>
<td>1</td>
</tr>
<tr>
<td>or ESE 5070</td>
<td>Introduction to Networks and Protocols</td>
<td></td>
</tr>
<tr>
<td>or CIS 5530</td>
<td>Networked Systems</td>
<td></td>
</tr>
</tbody>
</table>

Concurrency Lab

CIS 4550 Internet and Web Systems
or CIS 5550 Internet and Web Systems
or CIS 5050 Software Systems
or ESE 5320 System-on-a-Chip Architecture
or CIS 5650 GPU Programming and Architecture

Senior Design

CIS 4000 Senior Project
or ESE 4500 Senior Design Project I - EE and SSE
CIS 4010 Senior Project
or ESE 4510 Senior Design Project II - EE and SSE

Math and Natural Science

MATH 1400 Calculus, Part I
MATH 1410 Calculus, Part II
or MATH 1610 Honors Calculus
MATH 2400 Calculus, Part III
or MATH 2600 Honors Calculus, Part II

ESE 3010 Engineering Probability
or CIS 2610 Discrete Probability, Stochastic Processes, and Statistical Inference
or STAT 4300 Probability

CIS 1600 Mathematical Foundations of Computer Science

MEAM 1100 Introduction to Mechanics
or PHYS 0140 Principles of Physics I (without laboratory)
or PHYS 0150 Principles of Physics I: Mechanics and Wave Motion
or PHYS 0170 Honors Physics I: Mechanics and Wave Motion

ESE 1120 Engineering Electromagnetics (students passing the ESE E&M review module may substitute an ESE approved E&M course)

CHEM 1012 General Chemistry I
or EAS 0091 Chemistry Advanced Placement/International Baccalaureate Credit (Engineering Students Only)
or BIOL 1101 Introduction to Biology A
or BIOL 1121 Introduction to Biology - The Molecular Biology of Life
or PHYS 1240 Principles of Physics IV: Modern Physics (without laboratory)

Math or Natural Science Elective

Natural Science Lab (if applicable) 2

Professional Electives 3

Math, Natural Science, or Engineering Electives

Select one of the following:

ESE 4000 Engineering Economics
EAS 5450 Engineering Entrepreneurship I
EAS 5950 Foundations of Leadership
MGMT 2370 Management of Technology
OIDD 2360 Scaling Operations in Technology Ventures: Linking Strategy and Execution

Math, Science, or Engineering Elective

General Electives 4

EAS 2030 Engineering Ethics
or CIS 4230 Ethical Algorithm Design
or CIS 5230 Ethical Algorithm Design

2 Baccalaureate Credit (Engineering Students Only)

3 Professional Electives include up to 9 units of Senior Design, Math and Natural Science.

4 General Electives include any remaining units for a total of 37 units.
or LAW 5060 ML: Technology Law

| 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.
2. If BIOL 1121, CHEM 1012, EAS 0091, MEAM 1100 or PHYS 0140 are taken, choose one natural science lab from the list: BIOL 1124, CHEM 1101, MEAM 1470, PHYS 0050 or another department approved Natural Science lab
3. At most, two freshman-level Engineering courses may be used as a Professional Elective.
4. 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/] )

The degree and major requirements displayed are intended as a guide for students entering in the Fall of 2023 and later. Students should consult with their academic program regarding final certifications and requirements for graduation.