

COMPUTER ENGINEERING, BSE

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

Code	Title	Course Units
Engineering		
ESE 1110 or ESE 3600	Atoms, Bits, Circuits and Systems TinyML: Tiny Machine Learning for Embedded Systems	1
CIS 1100	Introduction to Computer Programming	1
CIS 1200	Programming Languages and Techniques I	1
CIS 1210	Programming Languages and Techniques II	1
ESE 2150	Electrical Circuits and Systems	1.5
CIS 2400	Introduction to Computer Systems	1
ESE 3500	Embedded Systems/Microcontroller Laboratory	1.5
ESE 3700	Circuit-Level Modeling, Design, and Optimization for Digital Systems	1
CIS 4480 or CIS 5480	Operating Systems Design and Implementation Operating Systems Design and Implementation	1
CIS 4710 or CIS 5710	Computer Organization and Design Computer Organization and Design	1
<i>Intermediate CIS or ESE Elective</i>		
Select 1 CU of 2000+ level CIS or ESE engineering courses		1
<i>Advanced CIS or ESE Electives</i>		
Select 2 CUs of 3000+ level CIS or ESE engineering courses		2
<i>Senior Design</i>		
CIS 4000 or ESE 4500	Senior Project Senior Design Project I - EE and SSE	1
CIS 4010	Senior Project	1

or ESE 4510	Senior Design Project II - EE and SSE	
Math and Natural Science		
MATH 1400	Calculus, Part I	1
MATH 1410 or MATH 1610	Calculus, Part II Honors Calculus	1
MATH 2400 or MATH 2600	Calculus, Part III ¹ Honors Calculus, Part II	1
or ESE 2030	Linear Algebra with Applications to Engineering and AI	
ESE 3010 or CIS 2610	Engineering Probability Discrete Probability, Stochastic Processes, and Statistical Inference	1
or STAT 4300	Probability	
CIS 1600	Mathematical Foundations of Computer Science	1
MEAM 1100 or PHYS 0140 or PHYS 0150 or PHYS 0170	Introduction to Mechanics Principles of Physics I (without laboratory) Principles of Physics I: Mechanics and Wave Motion Honors Physics I: Mechanics and Wave Motion	1
ESE 1120	Engineering Electromagnetics	1.5
CHEM 1012 or EAS 0091	General Chemistry I Chemistry Advanced Placement/International Baccalaureate Credit (Engineering Students Only)	1
or BIOL 1101 or BIOL 1121 or PHYS 1240	Introduction to Biology A Introduction to Biology - The Molecular Biology of Life Principles of Physics IV: Modern Physics (without laboratory)	
Math or Natural Science Elective		1
Natural Science Lab (if applicable) ²		.5
Professional Electives³		
Math, Natural Science, or Engineering Electives		2
Select one of the following:		1
Math, Science, or Engineering Elective		
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	
General Electives		
LAWM 5060 or EAS 2030 or CIS 4230 or CIS 5230	ML: Technology Law ⁴ Engineering Ethics Ethical Algorithm Design Ethical Algorithm Design	1
Select 4 Social Science or Humanities courses ⁵		4
Select 2 Social Science, Humanities, or Technology in Business & Society courses		2
Free Elective		1
Total Course Units		37

¹ If MATH 2400 is taken, ESE 2030 will not count. If ESE 2030 is taken, MATH 2400 will not count.

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 Only the "Technology Law and Ethics" section satisfies the Engineering Ethics requirement.

⁵ 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 2025 and later. Students should consult with their academic program regarding final certifications and requirements for graduation.

AI & Robotics

Code	Title	Course Units
AI & Robotics Concentration		
Select 4 courses:		4
CIS 2450	Big Data Analytics	
CIS 4190/5190	Applied Machine Learning or CIS 5200 Machine Learning	
CIS 4300/5300	Natural Language Processing	
CIS 4810/5810	Computer Vision & Computational Photography	
CIS 5210	Artificial Intelligence	
CIS 5650	GPU Programming and Architecture	
ESE 2000	Artificial Intelligence Lab: Data, Systems, and Decisions	
ESE 2240	Signal and Information Processing	
ESE 3060	Deep Learning: A Hands-on Introduction	
ESE 3600	TinyML: Tiny Machine Learning for Embedded Systems	
ESE 4210	Control For Autonomous Robots	
ESE 5050	Feedback Control Design and Analysis	
ESE 5390	Hardware/Software Co-Design for Machine Learning	
ESE 6150	F1/10 Autonomous Racing Cars	
ESE 6500	Learning in Robotics	
MEAM 5200	Introduction to Robotics	
Total Course Units		4

CHIPs

Code	Title	Course Units
CHIPs Concentration		
Select 4 courses:		4
ESE 3190	Fundamentals of Solid-State Circuits	
ESE 4190/5720	Analog Integrated Circuits	

ESE 4730/5730	Chips-design *	
ESE 4750/5750	Chips-measurements	
ESE 5320	System-on-a-Chip Architecture	
ESE 5780	RFIC (Radio Frequency Integrated Circuit) Design	
ESE 5800	Power Electronics	
ESE 6680	Mixed Signal Circuit Design and Modeling	
CIS 6010	Advanced Topics in Computer Architecture	
Total Course Units		4

* Students who take ESE 4730/5730 must take ESE 4750/5750.

Networking & Distributed Systems

Code	Title	Course Units
Networking and Distributed Systems Concentration		
Select 4 courses:		4
NETS 2120	Scalable and Cloud Computing	
ESE 4070/5070	Introduction to Networks and Protocols or CIS 5530 Networked Systems	
ESE 6650	Datacenter Architecture	
CIS 4550/5550	Internet and Web Systems	
CIS 5050	Software Systems	
Total Course Units		4

Security and Safety

Code	Title	Course Units
Security and Safety Concentration		
Select 4 courses:		4
CIS 2330	Introduction to Blockchain	
CIS 4410/5410	Embedded Software for Life-Critical Applications	
CIS 4510	Computer and Network Security	
CIS 5470	Software Analysis	
CIS 5560	Cryptography	
ESE 5370	Hardware Security	
Total Course Units		4