

# COMPUTER ENGINEERING (BS)

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The mission of the Computer Engineering Program (CPE) is to provide students with a well-rounded education encompassing the theory and practice of selected, balanced topics in electrical engineering and computer science, to enable students to contribute and continue their education in a wide range of computer-related engineering careers. The program seeks to emphasize “hands-on” experience, problem solving skills, the creative process and responsible action. Through professional development activities, faculty contribute to the advancement of the state-of-the-art, and strive to directly incorporate this experience in the classroom.

Four educational objectives inspire alumni of the Cal Poly Computer Engineering program to excel professionally:

- Make positive contributions to society and the practice of computer engineering by applying foundational knowledge and the engineering process to solve engineering problems.
- Work in an individual or team environment in a socially responsible manner.
- Engage in lifelong learning through continued professional development or graduate studies.
- Communicate effectively and demonstrate leadership.

The program prepares graduates for professional practice in industry, as well as continued study in graduate school. Cal Poly’s “learn by doing” philosophy is emphasized by integrating design throughout the curriculum, especially in the numerous design-centered laboratories. In the required senior capstone experience, which is a group-project based course completed over two quarters, students demonstrate their understanding of engineering knowledge and their ability to apply that knowledge creatively to practical problems.

This integrated approach allows students to work effectively in such diverse areas as digital systems simulation and digital control systems. Knowledge and laboratory experience in computer architecture and structures provide the understanding necessary to design and build computer systems, computer networks and digital communications systems. A thorough knowledge of modern microprocessors and microcontrollers enables the graduate to apply these technologies in applications such as robotics, medical and data acquisition. Twelve units of technical electives allow students the option to specialize in an area of special interest. Current areas of special interest include:

- robotics
- embedded systems
- computer architecture
- computer systems
- Computer security
- electronics implementation and VLSI

In addition to a sound theoretical background in computer engineering concepts, students experience practical design courses intended to build problem solving skills. Laboratory courses supplement the program to develop “hands on” skills in all areas of study. Students are exposed to a wide variety of computing equipment: microprocessor development systems, workstations and personal computers, and advanced network hardware and software.

Active student groups of interest to computer engineering majors include the Computer Engineering Society, the IEEE Student Branch, the Association for Computing Machinery, the Society of Women Engineers, Women Involved in Software and Hardware, and many other project-oriented student clubs and activities.

For more information about the CPE program, please visit <https://eadvice.calpoly.edu> (<https://eadvice.calpoly.edu/>).

## Concentrations

### General Curriculum in Computer Engineering

**Offered at: San Luis Obispo Campus**

The Bachelor of Science in Computer Engineering broadly prepares students for the design and application of computers and computer-based systems. Students learn to integrate a variety of skills, knowledge, and expertise at the intersection of hardware and software, general education, ethics, and society. Curricular concentrations provide students with autonomy to specialize in the computer engineering core, security, computer hardware, computer architecture, computer systems, embedded systems, or robotics and autonomous systems. Our graduates are valued for their diversity in body and voice, their ability to negotiate complexity and ambiguity, and their capacity and agency to make a positive impact on society.

### Computer Architecture

**Offered at: San Luis Obispo Campus**

This concentration prepares students for success in technical careers in computer architecture, including emerging architectures. Students will take a breadth of relevant courses developing their skills in hardware and software design.

## Computer Hardware Engineering

Offered at: San Luis Obispo Campus

The Computer Hardware Engineering Concentration prepares students for success in technical careers in designing and implementing computer hardware. Students will take a breadth of relevant courses developing their skills in design and engineering.

## Computer Systems

Offered at: San Luis Obispo Campus

The computer systems concentration prepares students for success in technical careers in computer systems including designing and building distributed computer systems. Evaluate computer architecture designs with particular emphasis on the balance between performance, efficiency, cost, reliability, and security. Students will take a breadth of relevant courses developing their skills in hardware and software design.

## Embedded Systems

Offered at: San Luis Obispo Campus

The embedded systems concentration prepares students for success in technical careers in embedded systems integrating hardware and systems in increasingly common embedded systems. Students will take a breadth of relevant courses developing their skills in hardware and software integration.

## Robotics and Autonomous Systems

Offered at: San Luis Obispo Campus

The Robotic Engineering Concentration prepares students for success in technical careers in designing and implementing robots and autonomous systems. Students will take a breadth of relevant courses developing their skills in design and engineering.

## Security

Offered at: San Luis Obispo Campus

The Privacy and Security concentration prepares students for success in technical careers in cybersecurity. Students will take a breadth of relevant courses developing their skills in hardware and software design.

## Program Learning Objectives

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively in a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

In addition to the general abilities expected of College of Engineering graduates, computer engineering students are expected to graduate with:

- Knowledge of probability and statistics, including applications appropriate to CPE program objectives.
- Knowledge of mathematics through differential and integral calculus, basic sciences, and engineering sciences necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components, as appropriate to CPE program objectives.
- Knowledge of advanced mathematics, typically including differential equations, linear algebra, complex variables, and discrete mathematics.

## Degree Requirements and Curriculum

In addition to the program requirements listed on this page, students must also satisfy requirements outlined in more detail in the Minimum Requirements for Graduation (<https://catalog.calpoly.edu/academic-standards-policies/general-requirements-bachelors-degree/#generaleducationtext>) section of this catalog, including:

- 40 units of upper-division courses
- 2.0 GPA

- Graduation Writing Requirement (GWR)
- U.S. Cultural Pluralism (USCP)

Note: No Major or Support courses may be selected as credit/no credit. In addition, no more than 12 units of cooperative or internship courses can count towards your degree requirements.

Code	Title	Units
<b>MAJOR COURSES</b>		
CPE/CSC 1000	Computing Majors Orientation	1
CSC 1001 & 1001L	Fundamentals of Computer Science and Fundamentals of Computer Science Laboratory	4
CPE/CSC 1024	Introduction to Computing	2
CSC 2001 & 2001L	Data Structures and Data Structures Laboratory	4
CPE/CSC 2050	System Software Mechanics	3
CPE 2300	Introduction to Computer Systems	3
CPE 2301	Introduction to HDL and Digital Design Laboratory	1
CPE 3160	Microcontrollers and Embedded Applications	3
CPE/CSC 3201	Introduction to Computer Security	3
CPE 3300	Computer Architecture	4
CPE 4464	Introduction to Computer Networks	3
CPE/CSC 4553	Introduction to Operating Systems	3
EE 2211 & EE 2241	Electric Circuit Analysis I and Electric Circuit Analysis Laboratory I	4
<b>General Curriculum in Computer Engineering or Concentration</b>		
(See General Curriculum and list of Concentrations below) <sup>1</sup>		27-30
<b>SUPPORT COURSES</b>		
Select from the following: (5B) <sup>2</sup>		3-4
BIO 1111	General Biology	
BIO 2213	Life Science for Engineers	
BOT 1121	General Botany	
MCRO 2221	Introduction to Microbiology	
MATH 1261	Calculus I (2) <sup>2</sup>	4
MATH 1262	Calculus II	4
MATH 2031	Transition to Advanced Mathematics	3
PHIL 3323	Ethics, Science, and Technology (Upper-Division 3) <sup>2</sup>	3
PHYS 1141	General Physics I (5A & 5C) <sup>2</sup>	4
PHYS 1143	General Physics II	4
Select from the following: (Upper-Division 2/5) <sup>2</sup>		3
STAT 3210	Engineering Statistics	
STAT 3310	Probability and Random Processes for Engineers	
WGQS 3350 or WGQS 3351	Gender, Race, Culture, Science, and Technology Gender, Race, Class, Nation: Critical Computing and Engineering Studies	4
<b>GENERAL EDUCATION (GE)</b>		
(See GE program requirements below)		27
<b>FREE ELECTIVES</b>		
Free Electives		0
<b>Total Units</b>		<b>124-128</b>

<sup>1</sup> Courses may need to be at the 3000-4000 level to ensure completion of the requirement minimum of 40 units of upper-division.

<sup>2</sup> Required in Major or Support; also satisfies General Education (GE) requirement.

## Concentrations

### General Curriculum in Computer Engineering

Code	Title	Units
<b>REQUIRED COURSES</b>		
Select from the following: <sup>1</sup>		3
MATH 1151	Linear Algebra	
MATH 2341	Linear Analysis	
Math/Science Support Elective		
Select any ASTR, BIO, BOT, CHEM, GEOL, MATH, MCRO, MSCI, PHYS, or STAT course <sup>1</sup>		3
EE 3306 & 3306L or EE 2328	Electronics I and Electronics Laboratory I Signals and Systems	4
Technical Electives		
Select from the following: <sup>2</sup>		14
Select any 2000-5000 level course offered by the College of Engineering or Bailey College of Science and Mathematics up to 4 units		
Select any 3000-5000 level CPE, CSC, or EE courses		
Senior Project		
Select from the following: <sup>3</sup>		4
CPE 4460 & CPE 4461	Capstone Senior Project I and Capstone Senior Project II	
CSC 4260 & CSC 4261	Interdisciplinary Privacy and Security Capstone I and Senior Project - Privacy and Security Capstone II	
ENGR 4460 & ENGR 4461	Interdisciplinary Senior Project I and Interdisciplinary Senior Project II	
<b>Total Units</b>		<b>28</b>

<sup>1</sup> Excess units at the 2000-5000 level may be applied toward technical electives.

<sup>2</sup> A combined maximum of 8 units may be taken from CPE 4491, CPE 4492, CPE 4493, CPE 4495, CSC 4091, CSC 4092, CSC 4093, CSC 4191, CSC 4192, CSC 4193, CSC 4291, CSC 4292, CSC 4293, CSC 4400, CSC 4495, CSC 4691, CSC 4692, CSC 4693, CSC 4791, CSC 4792, CSC 4793, CSC 4891, CSC 4892, CSC 4893, CSC 4991, CSC 4992, CSC 4993, DATA 4720, and ENGR 4995; of which up to a combined 4 units may be taken from CPE 4400 and CSC 4400.

<sup>3</sup> Excess units completed for senior project may be applied toward technical electives.

### Computer Architecture

Code	Title	Units
<b>REQUIRED COURSES</b>		
MATH 1151 or MATH 2341	Linear Algebra Linear Analysis	3-4
MATH 2263	Calculus III	3
PHYS 2211	General Physics III: Modern Physics	4
Select from the following:		3-4
CPE 3345	Quantum Computing	
CPE 4280	Introduction to Hardware Security	
CPE 4455	Design of Fault-Tolerant Systems	
CPE 4669	Distributed Systems	
CSC 4310	Compiler Construction	
EE 3306 & 3306L	Electronics I and Electronics Laboratory I	4
CPE 4300	Advanced Computer Architecture	4
Senior Project		
Select from the following:		6
CPE 4260 & CPE 4261	Interdisciplinary Privacy and Security Capstone I and Senior Project - Privacy and Security Capstone II	

CPE 4460 & CPE 4461	Capstone Senior Project I and Capstone Senior Project II	
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**Total Units** **27-29**

## Computer Hardware Engineering

Code	Title	Units
<b>REQUIRED COURSES</b>		
EE 3306 & 3306L	Electronics I and Electronics Laboratory I	4
EE 4431	Computer-Aided Design of VLSI Devices	3
Math and Science Support		
Select from the following: <sup>1</sup>		6
MATH 1151 & MATH 2343	Linear Algebra and Differential Equations	
MATH 2341 & Select any MATH course <sup>1</sup>	Linear Analysis	
Technical Electives		
Select from the following: <sup>2,3</sup>		12
CPE 4280	Introduction to Hardware Security	
CPE 4400	Special Problems for Undergraduates	
CPE 4455	Design of Fault-Tolerant Systems	
CPE 4491	Seminar in Computer Engineering	
CPE 4492	Research Experience in Computer Engineering	
CPE 4493	Projects in Computer Engineering	
EE 2212	Electric Circuit Analysis II	
EE 2328	Signals and Systems	
EE 3302 & 3302L	Classical Control Systems and Classical Control Systems Laboratory	
EE 3308 & 3308L	Electronics II and Electronics Laboratory II	
EE 3335 & 3335L	Electromagnetic Fields and Transmission and Electromagnetic Fields and Transmission Laboratory	
EE 4412	Advanced Analog and Mixed-Signal Electronics	
EE 4452	Advanced Analog and Mixed-Signal Electronics Laboratory	
EE 4528	Digital Image Processing	
ENGR 2995	Vertically Integrated Project Experience I	
ENGR 4995	Vertically Integrated Project Experience II	
ENGR 5995	Vertically Integrated Project Experience III	
IME 1156	Introduction to Modern Electronics Manufacturing	
MATE 1220	Principles of Materials Engineering for Non-Majors	
MATE 3340	Electronic Materials Systems	
PHYS 2211	General Physics III: Modern Physics	
PHYS 4425	Solid State Physics	
Senior Project		
Select from the following: <sup>4</sup>		4
CPE 4460 & CPE 4461	Capstone Senior Project I and Capstone Senior Project II	
CSC 4260 & CSC 4261	Interdisciplinary Privacy and Security Capstone I and Senior Project - Privacy and Security Capstone II	
ENGR 4460 & ENGR 4461	Interdisciplinary Senior Project I and Interdisciplinary Senior Project II	

**Total Units** **29**

<sup>1</sup> Excess units may be applied toward technical electives.

- <sup>2</sup> A minimum of 3 units must be taken at the 3000-5000 level.
- <sup>3</sup> A combined maximum of 8 units may be taken from CPE 4491, CPE 4492, CPE 4493, CPE 4495, ENGR 2995, ENGR 4995, ENGR 5995; of which up to a combined 4 units may be taken from CPE 4495.
- <sup>4</sup> Excess units completed for senior project may be applied toward technical electives.

## Computer Systems

Code	Title	Units
<b>REQUIRED COURSES</b>		
MATH 1151	Linear Algebra	3-4
or MATH 2341	Linear Analysis	
Math/Science Elective		
Select any BIO, BOT, MCRO, MSC1, CHEM, MATH, ASTR, GEOL, PHYS, or STAT course		3
EE 3306 & 3306L	Electronics I and Electronics Laboratory I	4
or EE 2328	Signals and Systems	
Select from the following:		3
CSC 4214	Binary Exploitation: Tools and Techniques	
CPE 4220	Network Security	
CPE 4280	Introduction to Hardware Security	
Select from the following:		3-4
CSC 4310	Compiler Construction	
CSC 4554	Implementation of Operating Systems	
CPE 4465	Advanced Computer Networks	
CPE 4650	Scalable Server Implementation and Testing	3
CPE 4669	Distributed Systems	4
Senior Project		
Select from the following:		6
CPE 4460 & CPE 4461	Capstone Senior Project I and Capstone Senior Project II	
CSC 4260 & CSC 4261	Interdisciplinary Privacy and Security Capstone I and Senior Project - Privacy and Security Capstone II	
<b>Total Units</b>		<b>29-30</b>

## Embedded Systems

Code	Title	Units
<b>REQUIRED COURSES</b>		
Linear Algebra + Differential Equations		
Select from the following:		6
MATH 1151 & MATH 2343	Linear Algebra and Differential Equations	
MATH 2341	Linear Analysis	
& Select any BIO, BOT, MCRO, MSC1, CHEM, MATH, ASTR, GEOL, PHYS, or STAT course		
EE 2328	Signals and Systems	4
CPE 4180	Advanced Microcontrollers and Embedded Applications	3
CPE 4390	Introduction to Real-Time Operating Systems	3
CPE 4420	High-Performance Embedded Systems	3
CPE 4455	Design of Fault-Tolerant Systems	4
Senior Project		
Select from the following:		4-6
CPE 4460 & CPE 4461	Capstone Senior Project I and Capstone Senior Project II	
CSC 4260 & CSC 4261	Interdisciplinary Privacy and Security Capstone I and Senior Project - Privacy and Security Capstone II	

ENGR 4460 & ENGR 4461	Interdisciplinary Senior Project I and Interdisciplinary Senior Project II	
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**Total Units** **27-29**

### Robotics and Autonomous Systems

Code	Title	Units
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#### REQUIRED COURSES

EE 2328	Signals and Systems	4
ENGR 2211	Introduction to Mechanics	4
MATH 2341	Linear Analysis	4
ME 2212	Engineering Dynamics	3

#### Robotic Electives

Select from the following: <sup>1, 2</sup> 11

BMED 3410	Biomechanics	
CPE 4140	Robotic Systems Integration	
CPE 4160	Autonomous Mobile Robotics	
CPE 4180	Advanced Microcontrollers and Embedded Applications	
CPE 4280	Introduction to Hardware Security	
CPE 4390	Introduction to Real-Time Operating Systems	
CPE 4420	High-Performance Embedded Systems	
CPE 4455	Design of Fault-Tolerant Systems	
CPE 4491	Seminar in Computer Engineering	
CPE 4492	Research Experience in Computer Engineering	
CPE 4493	Projects in Computer Engineering	
CSC 4291	Seminars in Privacy and Security	
CSC 4292	Research Experience in Privacy and Security	
CSC 4293	Projects in Privacy and Security	
CSC 4888	Computer Vision	
EE 3302 & 3302L	Classical Control Systems and Classical Control Systems Laboratory	
EE 4419	Digital Signal Processing	
EE 4528	Digital Image Processing	
IME 4456	Sensing Systems and the Industrial Internet of Things	
ME 3313	Intermediate Dynamics	
ME 3317	Vibrations and System Modeling	
ME 3318	Mechanical Vibrations	
ME 4416	Ground Vehicle Dynamics and Design	
ME 4417	Mechanical Controls and Implementations	
ME 4423	Robotics: Fundamentals and Applications	

Select any 3000-4000 level CPE, CSC, EE, ENGR, or ME courses up to 4 units

#### Senior Project

Select from the following: <sup>2</sup> 4

CPE 4460 & CPE 4461	Capstone Senior Project I and Capstone Senior Project II	
CSC 4260 & CSC 4261	Interdisciplinary Privacy and Security Capstone I and Senior Project - Privacy and Security Capstone II	
ENGR 4460 & ENGR 4461	Interdisciplinary Senior Project I and Interdisciplinary Senior Project II	

**Total Units** **30**

<sup>1</sup> A maximum of 4 units from CPE 4491, CPE 4492, CPE 4493, CPE 4495, CSC 4091, CSC 4092, CSC 4093, CSC 4192, CSC 4193, CSC 4291, CSC 4292, CSC 4293, CSC 4400, CSC 4495, CSC 4691, CSC 4692, CSC 4693, CSC 4791, CSC 4792, CSC 4793, CSC 4891, CSC 4892, CSC 4893, CSC 4991, CSC 4992, CSC 4993, DATA 4720, and ENGR 4995.

<sup>2</sup> Excess units completed for senior project may be applied toward technical electives.

## Security

Code	Title	Units
<b>REQUIRED COURSES</b>		
MATH 1151	Linear Algebra	3
EE 3306 & 3306L	Electronics I and Electronics Laboratory I	4
CSC 4260 & CSC 4261	Interdisciplinary Privacy and Security Capstone I and Senior Project - Privacy and Security Capstone II	6
Select from the following:		3
MATH 2263	Calculus III	
MATH 3051	Combinatorics I	
MATH 3055	Graph Theory	
MATH 3111	Number Theory	
MATH 4911	Game Theory	
CPE Security Elective		
Select from the following:		3
CSC 4212	Malware Design and Analysis	
CPE 4220	Network Security	
CPE 4250	Wireless Security	
CPE 4280	Introduction to Hardware Security	
Concentration Elective		
Select from the following:		11
CSC 3001	Modern Application Development	
CSC 3100	Software Engineering	
CSC 3203	Cryptography Engineering and Applications	
CSC 3250	Introduction to Privacy: Policy and Technology	
CSC 4210	Software Security	
CSC 4212	Malware Design and Analysis	
CSC 4214	Binary Exploitation: Tools and Techniques	
CSC 4230	Web and Cloud Security	
CSC 4270	Special Advanced Topics in Computer Security	
CSC 4291	Seminars in Privacy and Security	
CSC 4292	Research Experience in Privacy and Security	
CSC 4293	Projects in Privacy and Security	
CSC 4310	Compiler Construction	
CSC 4471	Special Advanced Laboratory	
CSC 4472	Special Advanced Activity	
CSC 5201	Computer Security and Privacy	
CSC 5210	Software Security	
CSC 5220	Advanced Network Security and Privacy	
CSC 5270	Special Advanced Topics in Computer Security	
CSC 5571	Special Advanced Laboratory	
CSC 5572	Special Advanced Activity	
CPE 4220	Network Security	
CPE 4250	Wireless Security	
CPE 4280	Introduction to Hardware Security	
CPE 4495	Cooperative Education Experience	
ENGR 2995	Vertically Integrated Project Experience I	
ENGR 4995	Vertically Integrated Project Experience II	
ENGR 5995	Vertically Integrated Project Experience III	

MATH 3051	Combinatorics I
MATH 3055	Graph Theory
MATH 3111	Number Theory
MATH 4911	Game Theory

**Total Units** **30**

## General Education (GE) Requirements

- 43 units required, 16 of which are specified in Major and/or Support.
- If any of the remaining 27 Units is used to satisfy a Major or Support requirement, additional units of Free Electives may be needed to complete the total units required for the degree.
- See the complete GE course listing (<https://catalog.calpoly.edu/academic-standards-policies/general-requirements-bachelors-degree/#generaleducationtext>).
- A grade of C- or better is required in one course in each of the following GE Areas: 1A (English Composition), 1B (Critical Thinking), 1C (Oral Communication), and 2 (Mathematics and Quantitative Reasoning).

### Lower-Division General Education

<b>Area 1</b>	<b>English Communication and Critical Thinking</b>	
1A	Written Communication	3
1B	Critical Thinking	3
1C	Oral Communication	3
<b>Area 2</b>	<b>Mathematics and Quantitative Reasoning</b>	
2	Mathematics and Quantitative Reasoning (3 units in Support) <sup>1</sup>	0
<b>Area 3</b>	<b>Arts and Humanities</b>	
3A	Arts	3
3B	Humanities: Literature, Philosophy, Languages other than English	3
<b>Area 4</b>	<b>Social and Behavioral Sciences (Area 4 courses must come from at least two different course prefixes.)</b>	
4A	American Institutions (Title 5, Section 40404 Requirement)	3
4B	Social and Behavioral Sciences	3
<b>Area 5</b>	<b>Physical and Life Sciences</b>	
5A	Physical Sciences (3 units in Support) <sup>1</sup>	0
5B	Life Sciences (3 units in Support) <sup>1</sup>	0
5C	Laboratory (may be embedded in a 5A or 5B course) (1 units in Support) <sup>1</sup>	0
<b>Area 6</b>	<b>Ethnic Studies</b>	
6	Ethnic Studies	3

### Upper-Division General Education

Upper-Division 2/5	Mathematics and Quantitative Reasoning or Physical and Life Sciences (3 units in Support) <sup>1</sup>	0
Upper-Division 3	Arts and Humanities (3 units in Support) <sup>1</sup>	0
Upper-Division 4	Social and Behavioral Sciences (Area 4 courses must come from at least two different course prefixes.)	3

**Total Units** **27**

<sup>1</sup> Required in Major or Support; also satisfies General Education (GE) requirement.

**Coming soon**