

# COMPUTER ENGINEERING

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## Academic Program

Program name	Program type
Computer Engineering	BS

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:

1. Make positive contributions to society and the practice of computer engineering by applying foundational knowledge and the engineering process to solve engineering problems.
2. Work in an individual or team environment in a socially responsible manner.
3. Engage in lifelong learning through continued professional development or graduate studies.
4. 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 networks
- computer based controls
- software systems
- graphics and multimedia
- 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://eadvise.calpoly.edu>.

## Undergraduate Program BS Computer Engineering

The Bachelor of Science in Computer Engineering prepares students interested in the design and application of computers and computer-based systems. The program incorporates a firm foundation in both electrical engineering and computer science, with a focus on the integration of hardware and software systems.

## Blended and Graduate Programs

Graduates of the Computer Engineering Program are qualified for admission to Cal Poly master’s degree programs in electrical engineering, computer science, general engineering, and biomedical engineering.

The opportunity also exists for advanced students to begin graduate study in these areas prior to completion of the BS degree, via a blended program. This provides a number of advantages to qualified students, and makes it possible for completion of both the BS and MS degrees in as little as five years. Computer engineering students participating in a blended program are permitted to fulfill the computer engineering senior project requirement with the master’s degree thesis. Students must be prepared for engineering practice via the curriculum which culminates in a major design experience based on the knowledge and skills acquired in earlier coursework and incorporating engineering standards and realistic constraints, as listed in the ABET Engineering Criteria. Further details are provided in the graduate study sections for each of these programs.

## CPE Courses

**CPE 100. Computer Engineering Orientation. 1 unit**  
CR/NC

Term Typically Offered: F

Introduction to the computer engineering discipline. Success skills and curricular information. Career paths and opportunities. Professional aspects of engineering and computer science. Interaction with upper division students, alumni, faculty and staff. Introduction to computer software and hardware. Credit/No Credit grading only. 1 lecture.

**CPE 101. Fundamentals of Computer Science. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: Completion of ELM requirement, and passing score on MAPE or MATH 117 with a grade of C- or better or MATH 118 with a grade of C- or better, or consent of instructor.

Basic principles of algorithmic problem solving and programming using methods of top-down design, stepwise refinement and procedural abstraction. Basic control structures, data types, and input/output. Introduction to the software development process: design, implementation, testing and documentation. The syntax and semantics of a modern programming language. Credit not available for students who have taken CSC/CPE 108. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 101.

**CPE 105. Fundamentals of Computer Science I Supplemental Instruction. 1 unit**

CR/NC

Term Typically Offered: TBD

Concurrent: CPE/CSC 101.

Facilitated study and discussion of fundamental concepts of computer science and familiarization with programming environments. Credit/No Credit grading only. 1 laboratory. Crosslisted as CPE/CSC 105.

**CPE 108. Accelerated Introduction to Computer Science. 4 units**

Term Typically Offered: TBD

Prerequisite: MATH 118 (or equivalent) with a grade of C- or better, significant experience in computer programming, and consent of instructor.

Accelerated introduction to basic principles of algorithmic and object-oriented problem solving and programming. Introduction to programming language concepts including control structures, data types, classes, and inheritance. Program design principles. Use and implementation of algorithms (searching, sorting, recursion) and data structures (lists, stacks, and queues). Intended for students with experience in algorithmic problem solving and using basic control structures and data types in a modern programming language (CPE/CSC 101), but who are not ready for CPE/CSC 202. Not open to students with credit in CPE/CSC 102 or CPE/CSC 202. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 108.

**CPE 123. Introduction to Computing. 4 units**

Term Typically Offered: F

Prerequisite: Basic computer literacy.

Use of a supportive software development environment to design, develop, and test applications in a selected topic domain that demonstrates the potential of careers in computing. An introduction to computing and to the selected topic domain. The Schedule of Classes will list topic selected. No programming experience required. Not for students with credit in CPE/CSC 103 or CPE/CSC 203. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 123.

**CPE 133. Digital Design. 4 units**

Term Typically Offered: F,W,SP,SU

Prerequisite: An orientation course in student's major (EE 111 & EE 151 for EE students, CPE 100 for CPE students), CPE/CSC 101.

Number systems, Boolean algebra, Boolean functions, and function minimization. Analysis and design of combinational and sequential logic circuits. Hardware Description Language (HDL) concepts and applications digital design and synthesis in Programmable Logic Devices (PLDs). Not open to students with credit in CPE/EE 129. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory. Crosslisted as CPE/EE 133.

**CPE 200. Special Problems for Undergraduates. 1-2 units**

Term Typically Offered: F,W,SP,SU

Prerequisite: Consent of instructor.

Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**CPE 202. Data Structures. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: CPE/CSC 101 with a grade of C- or better; MATH 141 or MATH 221 with a grade of C- or better; or consent of instructor.

Introduction to data structures and analysis of algorithms. Abstract datatypes. Specification and implementation of advanced data structures. Theoretical and empirical analysis of recursive and iterative algorithms. Software performance evaluation and testing techniques. Not open to students with credit in CSC/CPE 108. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 202. Formerly CPE/CSC 103.

**CPE 203. Project-Based Object-Oriented Programming and Design. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: CPE/CSC 202 with a grade of C- or better or consent of instructor.

Object-oriented programming and design with applications to project construction. Introduction to class design, interfaces, inheritance, generics, exceptions, streams, and testing. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 203. Formerly CPE/CSC 102.

**CPE 233. Computer Design and Assembly Language Programming. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: CPE/EE 133.

Design and implementation of digital computer circuits via CAD tools for programmable logic devices (PLDs). Basic computer design with its datapath components and control unit. Introduction to assembly language programming of an off-the-shelf RISC-based microcontroller. Not open to students with credit in CPE/EE 229. 3 lectures, 1 laboratory. Crosslisted as CPE/EE 233.

**CPE 290. Selected Topics. 1-4 units**

Term Typically Offered: TBD

Prerequisite: Open to undergraduate students and consent of instructor.

Directed group study of selected topics. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1 to 4 lectures.

**CPE 315. Computer Architecture. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: CSC/CPE 102 and CSC/CPE 103, or CSC/CPE 202 and CSC/CPE 203; and one of the following: CSC 225, CPE/EE 229, or CPE/EE 233.

In-depth study of the instruction set architecture and hardware design of a specific CPU. Introduction to pipelines, input/output and multi-processors. Computer abstractions and performance measurement. 3 lectures, 1 laboratory.

**CPE 321. Introduction to Computer Security. 4 units**

Term Typically Offered: TBD

Prerequisite: CPE/CSC 357.

Survey of topics in computer system and network security, including protection, access control, distributed access control, operating system security, applied cryptography, network security, firewalls, secure coding practices, and case studies from real-world systems. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 321.

**CPE 328. Discrete Time Signals and Systems. 3 units**

Term Typically Offered: F, W, SP

Prerequisite: BMED 355 or EE 228. Concurrent: CPE/EE 368.

Discrete-time systems and analysis, with emphasis on linear time-invariant (LTI) systems. Sampling theorem. Classification of discrete-time systems. Convolution and its application to LTI systems. The z transform, discrete-time Fourier transform, and discrete Fourier transform. Introduction to digital filters. 3 lectures. Crosslisted as CPE/EE 328.

**CPE 329. Programmable Logic and Microprocessor-Based Systems Design. 4 units**

Term Typically Offered: F, SP

Prerequisite: EE 307&347, EE 229&269 or CPE/EE 233.

Design, implementation and testing of programmable logic microprocessor-based systems. Hardware/software tradeoffs (such as timing analysis and power considerations), system economics of programmable logic and microprocessor-based system design. Interfacing hardware components (such as ADCs/DACs, sensors, transducers). 3 lectures, 1 laboratory. Not open to students with credit in CPE/EE 336. Crosslisted as CPE/EE 329.

**CPE 336. Microprocessor System Design. 4 units**

Term Typically Offered: F, SP

Prerequisite: CPE/EE 233.

Introduction to microcontrollers and integrated microprocessor systems. Hardware/software trade-offs, system economics, and functional configurations. Interface design, real-time clocks, interrupts, A/D conversion, serial and parallel communications, watch-dog timers, low power operation, event-based inter-peripheral communication, and assembly and higher-level language programming techniques. Architecture and design of sampled data and low-power systems. Not open to students with credit in CPE/EE 329. 3 lectures, 1 laboratory. Crosslisted as CPE/EE 336.

**CPE 350. Capstone I. 4 units**

Term Typically Offered: F

Prerequisite: CPE 329, may be concurrent.

Definition and specification of a system to be constructed in CPE 450; requirements elicitation techniques, research and data gathering methods; project planning, time and budget estimating; project team organization. Ethics and professionalism. 3 lectures, 1 laboratory.

**CPE 357. Systems Programming. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: CSC/CPE 102 and CSC/CPE 103 with a grade of C- or better or consent of instructor, or CSC/CPE 202 and CSC/CPE 203 with a grade of C- or better or consent of instructor; and CSC 225 or CPE/EE 229 or CPE/EE 233.

C programming language from a system programming perspective. Standard C language including operators, I/O functions, and data types in the context of system functions. Unix commands, shell scripting, file system, editors. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 357.

**CPE 368. Signals and Systems Laboratory. 1 unit**

Term Typically Offered: F, W, SP

Prerequisite: BMED 355 or EE 228. Concurrent: CPE/EE 328.

Laboratory work pertaining to linear systems, including Fourier analysis, time and frequency responses, and system transfer function. 1 laboratory. Crosslisted as CPE/EE 368.

**CPE 400. Special Problems for Undergraduates. 1-4 units**

Term Typically Offered: F,W,SP,SU

Prerequisite: Consent of instructor.

Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 4 units.

**CPE 416. Autonomous Mobile Robotics. 4 units**

Term Typically Offered: TBD

Prerequisite: CPE/EE 329 or CPE/EE 336 or both CPE 315 and CPE/CSC 357.

Theory and application of concepts relevant to autonomous mobile robots. Sensor and actuator interfacing, programming mobile robots, mobile robot configurations, software architectures and algorithms. 3 lectures, 1 laboratory.

**CPE 419. Applied Parallel Computing. 4 units**

Term Typically Offered: TBD

Prerequisite: CPE/CSC 357. Corequisite: CSC 141 or CSC 348.

Recommended: CPE 315.

Introduction to applied parallel computing paradigms: software models, resource allocation, performance measurement, and data sharing. Emphasis on massively parallel computation and performance improvement for a real-world application of significant scope. 3 lectures, 1 laboratory.

**CPE 422. Network and Web Security. 4 units**

Term Typically Offered: W  
Prerequisite: CPE 464.

Introduction to network and web security, including denial of service, botnets, access control, routing attacks, transport layer attacks, tunneling mechanisms, VPNs, IDS, firewalls, penetration testing, key distribution, browser security, social network security, email security, jamming, and wireless security. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 422.

**CPE 428. Computer Vision. 4 units**

Term Typically Offered: W  
Prerequisite: CPE/CSC 357 or EE 328 or ME 305.

Introduction to the concepts of 2D and 3D computer vision: low-level image processing methods such as filtering and edge detection; feature extraction; segmentation and clustering; stereo vision; appearance-based and model-based algorithms. 3 lectures, 1 laboratory. Crosslisted as CPE/EE 428.

**CPE 431. Programming Languages II. 4 units**

Term Typically Offered: SP  
Prerequisite: CSC 430.

Language principles and design issues: bindings, conversion, parameter passing, and dynamic semantics. Language implementation: intermediate code representation, memory management, code optimization, and code generation. Functional programming languages. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 431.

**CPE 432. Digital Control Systems. 3 units**

Term Typically Offered: F  
Prerequisite: EE 302 & EE 342. Concurrent: CPE/EE 472. Recommended: Prior background in discrete time systems, for example EE 328, EE 368.

Theory and applications of digital computers in linear control systems. Discrete time methods are used in analysis and design studies. Digital control systems are synthesized. 3 lectures. Crosslisted as CPE/EE 432.

**CPE 439. Introduction to Real-Time Operating Systems. 4 units**

Term Typically Offered: F  
Prerequisite: CPE/EE 329 or CPE/EE 336.

Theory, design and implementation of real-time operating system-based embedded systems. Scheduling algorithms, operating system resources, peripheral device interfacing and embedded system architecture. Resource management issues in a resource-limited (microcontroller-based) environment. 3 lectures, 1 laboratory. Crosslisted as CPE/EE 439.

**CPE 441. Computer-Aided Design of VLSI Devices. 4 units**

Term Typically Offered: F  
Prerequisite: EE 307 and EE 347. Recommended: EE 308 and EE 348, for students interested in analog design.

Design of VLSI circuits using state-of-the-art CAD software. Design issues and algorithms related to design using CAD. Full custom design through automated design and a major multi-week chip design project in lab. 3 lectures, 1 laboratory. Crosslisted as CPE 441/EE 431.

**CPE 450. Capstone II. 3 units**

Term Typically Offered: W  
Prerequisite: CPE 350.

Team-based design, construction and deployment of an embedded system that includes a custom-built computer. Technical management of product development teams. Technical documentation, configuration management, quality assurance, integration and systems testing. Professionalism. 1 lecture, 2 laboratories.

**CPE 453. Introduction to Operating Systems. 4 units**

Term Typically Offered: F, W, SP  
Prerequisite: CSC/CPE 357, and CSC/CPE 225 or CPE/EE 229 or CPE/EE 233.

Introduction to sequential and multiprogramming operating systems; kernel calls, interrupt service mechanisms, scheduling, files and protection mechanisms, conventional machine attributes that apply to operating system implementation, virtual memory management, and I/O control systems. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 453.

**CPE 454. Implementation of Operating Systems. 4 units**

Term Typically Offered: TBD  
Prerequisite: CSC/CPE 453.

Design and implementation of multiprogramming kernels, systems programming methodology, interprocess communications, synchronization, device drivers and network access methods. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 454.

**CPE 458. Current Topics in Computer Systems. 4 units**

Term Typically Offered: TBD  
Prerequisite: CSC/CPE 357.

Selected aspects of design, implementation and analysis of networks, advanced operating and distributed systems. Topics may include process management, virtual memory, process communication, context switching, file system designs, persistent objects, process and data migration, load balancing, security and networks. The Schedule of Classes will list topic selected. Total credit limited to 8 units. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 458.

**CPE 461. Senior Project I. 3 units**

Term Typically Offered: F,W,SP,SU  
Prerequisite: CPE 350.

Selection and completion of an individual or team project in laboratory environment. Project results are presented in a formal report. 3 laboratories.

**CPE 462. Senior Project II. 2 units**

Term Typically Offered: F,W,SP,SU  
Prerequisite: CPE 450.

Selection and completion of an individual or team project in laboratory environment. Project results are presented in a formal report. 2 laboratories.

**CPE 464. Introduction to Computer Networks. 4 units**

Term Typically Offered: F, W, SP

Prerequisite: CSC/CPE 357. Recommended: STAT 312 or STAT 321 or STAT 350.

Computer network architectures; communications protocol standards; services provided by the network; historical and current examples presented. 3 lectures, 1 laboratory.

**CPE 465. Advanced Computer Networks. 4 units**

Term Typically Offered: TBD

Prerequisite: CSC/CPE 453 and CPE 464.

Advanced topics in computer networks; greater detail of protocol standards and services provided by the network; focus on current industry and research topics. 3 lectures, 1 laboratory.

**CPE 469. Distributed Systems. 4 units**

Term Typically Offered: TBD

Prerequisite: CSC/CPE 357.

Foundations of distributed systems, distributed hash tables (peer-to-peer systems), failure detectors, synchronization, election, inter-process communication, consensus, replication, key-value stores, and measurements. 3 lectures, 1 laboratory. Crosslisted as CSC/CPE 469.

**CPE 470. Selected Advanced Topics. 1-4 units**

Term Typically Offered: TBD

Prerequisite: Consent of instructor.

Directed group study of selected topics for advanced students. Open to undergraduate and graduate students. Class schedule will list topic selected. Total credit limited to 8 units. 1 to 4 lectures.

**CPE 471. Introduction to Computer Graphics. 4 units**

Term Typically Offered: TBD

Prerequisite: CPE/CSC 357.

Graphics software development and use of application programming interfaces for 3D graphics. The graphics pipeline, modeling, geometric and viewing transforms, lighting and shading, rendering, interaction techniques and graphics hardware. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 471.

**CPE 472. Digital Control Systems Laboratory. 1 unit**

Term Typically Offered: F

Concurrent: CPE/EE 432.

Design and programming of microprocessor-based digital controls for electro-mechanical plants. Topics include digital control laws, translation of transfer functions into algorithms, assembly language programming, real-time software design, sample rate selection, finite word-length considerations. 1 laboratory. Crosslisted as CPE/EE 472.

**CPE 476. Real-Time 3D Computer Graphics Software. 4 units**

Term Typically Offered: TBD

Prerequisite: CSC/CPE 471.

Basic and advanced algorithms for real-time, interactive, 3D graphics software. Modeling (polygon mesh, height field, scene graph), real-time rendering and shading (visibility processing, LOD, texture and light maps), collision detection (bounding volumes, complexity management), interactive controls, multi-player game technology, game engine architecture. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 476.

**CPE 479. Selected Advanced Laboratory. 1-4 units**

Term Typically Offered: TBD

Prerequisite: Consent of instructor.

Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1 to 4 laboratories.

**CPE 482. Advanced Topics in Systems for Computer Engineering. 4 units**

Term Typically Offered: TBD

Corequisite: CPE 350.

Selected aspects of design, implementation, verification and analysis of advanced computer systems. Topics may include computer systems, embedded systems, robotics, mechatronics, haptics, human computer interfaces, digital control, digital signal processing, wireless computing, real time operating systems, and networks. Class Schedule will list topic selected. Total credit limited to 8 units, repeatable in same term. 3 lectures, 1 laboratory.

**CPE 485. Autonomous Robot Navigation. 4 units**

Term Typically Offered: TBD

Prerequisite: CPE/CSC 357.

Overview of existing autonomous mobile robot systems, basic kinematic modeling, control structures, sensing and sensor modeling, localization, and motion planning algorithms. Implementation of autonomous navigation capabilities. 3 lectures, 1 laboratory.

**CPE 488. Microelectronics and Electronics Packaging. 4 units**

Term Typically Offered: SP

Prerequisite: EE 112 or EE 201. Recommended: MATE 210.

Materials, processes, and reliability of microelectronics and electronics packaging, surface mount assembly and printed circuit board fabrication. Organic substrates and ceramic substrates. Mechanical design, thermal, and electrical considerations in electronic packaging. Design for manufacturability. Overview of optoelectronics packaging and other emerging technologies in microelectronics and electronic packaging. Project on design and manufacture of an electronic device. 3 lectures, 1 laboratory. Crosslisted as CPE 488/IME 458/MATE 458.

**CPE 493. Cooperative Education Experience. 2 units**

CR/NC

Term Typically Offered: F,W,SP,SU

Prerequisite: Sophomore standing and consent of instructor.

Part-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 6 units.

**CPE 494. Cooperative Education Experience. 6 units**

CR/NC

Term Typically Offered: F,W,SP,SU

Prerequisite: Sophomore standing and consent of instructor.

Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 18 units.



**CPE 495. Cooperative Education Experience. 12 units**

CR/NC

Term Typically Offered: F,W,SP,SU

Prerequisite: Sophomore standing and consent of instructor.

Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. A more fully developed formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 24 units.

**CPE 515. Computer Architecture. 4 units**

Term Typically Offered: TBD

Prerequisite: CPE 315 and graduate standing, or consent of instructor.

Comparative study and design of multiprocessor, dataflow, RISC, high level language and other new computer architectures. VLSI processor design techniques. 3 seminars, 1 laboratory. Crosslisted as CPE/CSC 515.

**CPE 521. Computer Systems. 4 units**

Term Typically Offered: SP

Prerequisite: CPE/EE 329 or CPE/EE 336, or equivalent, and graduate standing or consent of instructor.

Organization of modern general purpose, high speed digital computer systems. Design of arithmetic units, control units, memories and memory subsystems. Cost, power and speed trade-offs in the design of such systems. 3 seminars, 1 laboratory. Crosslisted as CPE/EE 521.

**CPE 522. Advanced Real-Time Operating Systems Design. 4 units**

Term Typically Offered: W

Prerequisite: CPE/EE 439.

Define and implement a microcontroller-based Real-Time Operating System (RTOS). Advanced real-time concepts, kernel structure, task and time management, various intertask communication constructs including semaphores, queues and mailboxes. Scheduler design, memory management and shared resource management in a resource-constrained microcontroller environment. 3 seminars, 1 laboratory. Crosslisted as CPE/EE 522.

**CPE 523. Digital Systems Design. 4 units**

Term Typically Offered: F

Prerequisite: CPE/EE 329 or CPE/EE 336, and graduate standing.

Full-custom design and analysis of digital circuits using full CMOS, pass-transistor and dynamic circuit topologies. Transistor sizing for minimizing power consumption, delay and other design criteria. 3 seminars, 1 laboratory. Crosslisted as CPE/EE 523.

**CPE 564. Computer Networks: Research Topics. 4 units**

Term Typically Offered: TBD

Prerequisite: CSC/CPE 464 and graduate standing, or consent of instructor.

Exploration of advanced topics in emerging computer networking technologies; focus on leading edge computer network research topics. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 564.

**CPE 569. Distributed Computing. 4 units**

Term Typically Offered: TBD

Prerequisite: CSC 141 or CSC 348; and CPE/CSC 357; or graduate standing and consent of instructor.

Principles and practices in distributed computing: interprocess communications, group communications, client-server model, distributed objects, message queue system, distributed services, mobile agents, object space, Internet protocols. Distributed algorithms: consensus protocols, global state protocols. Fault tolerance: classification of faults, replication. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 569.