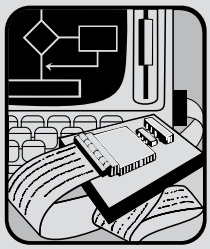
Engineering – Computer Engineering

College of Engineering and Computer Science



Bachelor of Science
Master of Science

PROGRAM DESCRIPTION

Computer Engineering is one of the newest areas of engineering, a dynamic field that thrives on innovation and challenges. Business, industry, and home applications create the need for products that often can be used both for work as well as for entertainment. In the high technology areas of the United States, Sacramento included, Computer Engineering has experienced tremendous growth, becoming one of the major driving forces behind the rapidly advancing electronics and computer industry. Employment projections consistently predict that computer engineering and computer science will continue to experience more than a doubling of growth in a ten-year period.

Nationally, nearly all engineering universities offer a degree in Computer Engineering. Being close in course content to Electrical Engineering and to Computer Science, these degrees are found in various departmental and program configurations. At Sacramento State, Computer Engineering enjoys the advantage of both areas since it is a program jointly supported by the Electrical and Electronic Engineering Department and the Computer Science Department.

Career Possibilities

Computer Engineer • Computer Architect • ASIC Designer • Chip Architect • VLSI Engineer • Real Time System Design Engineer • Design Engineer • Hardware Engineer • Software Engineer • Systems Engineer • Applications Engineer • Networking Engineer • Control Engineer • Marketing Engineer • Data Communications Engineer • Project Engineer • Research Engineer • Consulting Engineer • Test Engineer • Production Engineer • Telecommunications Engineer • Solid State Engineer • DSP Engineer

Faculty

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Lower division preparation in Computer Engineering parallels that of Computer Science, with the addition of a basic electrical circuit course and a logic design course. Except for the logic design course, most community colleges offer sufficient lower division courses in mathematics, chemistry, physics, and most importantly, computer science.

Special Features

- Due to numerous generous donations from supportive industries, the computer engineering labs are well equipped with servers and workstations, and with software development tools for VLSI application-specific integrated circuits. Industries donate large electronic devices (FPGAs, CPUs) to each student in computer engineering laboratories.
- The Sacramento State Computer Engineering BS degree is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; (410) 347-7700. Computer Engineering faculty value accreditation very highly.
- A mechanism of maintaining currency in technology, curriculum review, and outcomes assessment is in place to assure the university and graduates of the continued growth and high quality of the program.

Program Educational Objectives

The objectives of this program are to prepare graduates to:

- enter professional employment and/or graduate study in computer engineering areas, such as logic design, computer architecture, processor hardware, and computer systems;
- identify, analyze, and solve practical computer engineering problems using both hardware and software design tools and techniques;
- work cooperatively and communicate effectively through speaking, writing, and graphics, with peers, with multi-disciplinary teams, and with the general public;
- practice computer engineering in a professionally responsible and ethical manner; and
- anticipate changes in one's own career with respect to changing technology and shifting societal needs for the application of computer engineering.

UNDERGRADUATE PROGRAM

The Bachelor of Science degree in Computer Engineering is a four-year program that emphasizes engineering design of computer hardware and systems at all levels. Engineering design begins with logic design taught to entering students during their first semester. The thread of design continues through the study of architecture, CMOS and VLSI technology, ASIC design, operating systems, computer hardware design, and networking hardware. To complete their degree, students take a two-semester senior design and project course.

Students are expected to satisfy the general education requirements of the Accreditation Board for Engineering and Technology (ABET) as well as the University's General Education requirements. Students should consult the Program Coordinator for specific General Education requirements.

A second-year foreign language course (2A or equivalent) may also satisfy 3 units of GE when the course is being taken to comply with the Sacramento State foreign language requirement. Students should consult with an advisor for exact GE eligibility of these courses.

Requirements • Bachelor of Science Degree

Units required for Major: 101
Minimum total units required for the BS: 137
Additional units may be required to meet the Sacramento State foreign language requirement.

Courses in parentheses are prerequisites.

A. Required Lower Division Courses (22 units)

(4)	CPE 64	Introduction to Logic Design (CSC 15 or CSC 25)
(3)	CSC 15	Programming Concepts and Methodology I (CSC 10 or programming experience)
(3)	CSC 20	Programming Concepts and Methodology II (CSC 15)
(3)	CSC 28	Discrete Structures for Computer Science (MATH 29; CSC 20, CSC 20 may be taken concurrently)
(3)	CSC 35	Introduction to Computer Architecture (CSC 15)
(3)	CSC 60	Introduction to Systems Programming in Unix (CSC 20, CSC 35)
(3)	ENGR 17	Introductory Circuit Analysis (PHYS 11C, MATH 45; either the math or physics may be taken concurrently, but not both)

B. Required Mathematics Courses (18 units)

(4)	MATH 30	Calculus I (MATH 29 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus Diagnostic Test)
(4)	MATH 31	Calculus II (MATH 30 or appropriate high school based AP credit)
(3)	MATH 45	Differential Equations for Science and Engineering (MATH 31)
(4)	STAT 50	Introduction to Probability and Statistics (MATH 26A, MATH 30, or appropriate high school based AP credit)
(3)	MATH 100	Applied Linear Algebra (MATH 26B or MATH 31) **OR**
	MATH 150	Introduction to Numerical Analysis (MATH 31; some computer programming experience is desirable)

C. Additional Required Courses (13 units)

(5)	CHEM 1A	General Chemistry I (High school algebra (two years) and high school chemistry; or equivalent)
(4)	PHYS 11A	General Physics: Mechanics (MATH 30, MATH 31; or equivalent certificated high school courses. MATH 31 may be taken concurrently)
(4)	PHYS 11C	General Physics: Electricity and Magnetism, Modern Physics (MATH 31, PHYS 11A)

D. Required Upper Division Courses (42 units)

(3)	CPE 138	Computer Networks and Internets (CSC 35, CSC 60, CSC 130)
(3)	CPE 142	Advanced Computer Organization (CPE 166, CPE 185)
(3)	CPE 151	CMOS and VLSI (CPE/EEE 64, CPE/EEE 102 or EEE 108)
(3)	CPE 159	Operating System Pragmatics (CSC 139)
(4)	CPE 166	Advanced Logic Design (CPE/EEE 64, ENGR 17)
(4)	CPE 185	Computer Interfacing (CPE/EEE 64, CSC 35, CSC 60)
(3)	CPE 186	Computer Hardware System Design (CPE 185 or EEE 174)
(2)	CPE 187	Embedded Processor System Design (CPE 166, CPE 185, CPE/EEE 102, passing score on WPE)
(2)	CPE 190	Senior Design Project I (CPE 142, CPE 166, CPE 186, CPE 187, EEE 102 and passing score on WPE)
(2)	CPE 191	Senior Design Project II (CPE 190)
(3)	CSC 130	Data Structures and Algorithm Analysis (CSC 20, CSC 28; CSC 28 may be taken concurrently)
(3)	CSC 139	Operating System Principles (CSC 60, CSC 137, or equivalents)
(3)	CPE 102/ EEE 102	Analog/Digital Electronics (ENGR 17; Corequisite: CPE/EEE 102L)
(1)	CPE 102/ EEE 102L	Analog/Digital Electronics Lab (ENGR 17; Corequisite: CPE/EEE 102)
(3)	ENGR 181	Electronic Materials (CHEM 1A, PHYS 11A, MATH 45)

E. Technical Electives (6 units)

(6)	Select two from the following;	
	CPE 144	DSP Architecture Design (CPE 142)
	CPE 153	VLSI Design (CPE 151)
	CSC 131	Computer Software Engineering (CSC 130; may be taken concurrently)
	CSC 133	Object-Oriented Computer Graphics Programming (CSC 130 and CSC 131)
	CSC 134	Database Management and File Organization (CSC 130)
	CSC 151	Compiler Construction (CSC 136, may be taken concurrently)
	CSC 155	Advanced Computer Graphics (CSC 133)
	EEE 108	Electronics I (EEE 117, EEE 166; Corequisite: EEE 108L)

EEE 117	Network Analysis (ENGR 17, CPE/EEE 64; CPE/EEE 64 may be taken concurrently. Corequisite: EEE 117L)
EEE 180	Signals and Systems (EEE 117)
EEE 187	Robotics (EEE 180 or equivalent, or instructor permission)

Cooperative Education (Work Experience)

The Computer Engineering Program encourages students to participate in the Cooperative Education Program which provides alternate periods of university study and major-related, paid off-campus work experience in private industry or government. The experience will enhance the student's employment prospects upon graduation. Most participants in this program will complete the equivalent of two six-month work periods, one in their junior year and the other in their senior year. Students must enroll in the appropriate professional practice course (CPE 195A, CPE 195B, CPE 195C, or CPE 195D) and are awarded a Certificate of Satisfactory Completion of the two work periods. However, the credits for this course do not replace the curricular requirements of the BS Computer Engineering degree. Students interested in this program should apply in the satellite office in Riverside Hall 2004 or the main office in Lassen Hall Room 2000 (*www.csus.edu/careercenter*). For information, call (916) 278-6231.

GRADUATE PROGRAM

The Master of Science degree in Computer Engineering is jointly supported by the Departments of Computer Science and Electrical and Electronic Engineering. The program is designed to provide opportunities for students with undergraduate degrees in Computer Engineering, Computer Science, Electrical Engineering, or a closely related field to pursue graduate studies in this interdisciplinary field. The program provides students with broad and advanced knowledge in areas such as advanced microprocessor architecture, parallel computer architecture, advanced microprocessor systems, distributed computing, data communication, computer networks, operating systems, and concurrent programming. The program is sufficiently flexible to allow students to conduct independent research and broaden their professional scope. Each student plans a program of study in consultation with a graduate advisor and/or his/her thesis or project advisor and works closely with these advisors.

Computer Engineering is a part of the larger Information Technology (IT) discipline. Highly skilled computer engineers who have advanced knowledge of both hardware and software and who can design, test, and implement complex digital systems are a part of the IT workforce. Networks such as the Internet, Intranets, communication systems, banking computer systems, public utility systems, and transportation systems are just a few examples of areas where high-tech solutions and skilled workers are needed. The continuing dramatic progress in hardware and the sophistication of computing devices and systems require continually increasing technical skills in hardware and software.

Admission Requirements

Admission to the graduate program in Computer Engineering requires all of the following:

- a BS degree in Computer Engineering (CPE), Computer Science (CSC), Electrical or Electronic Engineering (EEE), or a closely related field;
- at least a 3.0 GPA in the last 60 units of the BS degree;
- Graduate Record Examination (GRE) general test scores;
- two letters of recommendation from professors and/or supervisors familiar with the students' accomplishments; and
- background as specified in Required Basic Knowledge to enter the program.

Students with deficiencies in the admission requirements are advised to remove any such deficiencies before applying. However, under special circumstances, a student who does not satisfy the admission requirements may be admitted as a conditionally classified graduate student. Conditional admission may be granted to those students who are likely to complete all the admission requirements. Deficiencies will be specified in the acceptance letter to the student and must be removed by the student before the student can become a fully classified graduate student.

A student registered as an unclassified or conditionally classified graduate student cannot use graduate courses to improve his/her grade point average for admittance to the program. Only undergraduate courses required in the degree program in CPE, CSC, or EEE may be taken or retaken to improve the GPA for admittance to the graduate program.

Required Basic Knowledge

A student must have completed the following list of Required Basic Knowledge before becoming a fully classified graduate student in Computer Engineering. Courses listed in parentheses are the equivalent Sacramento State courses.

Minimum required GPA in the following subject areas: 3.0

Electrical Fundamentals (ENGR 17)
Analog/Digital Electronics (CPE/EEE 102)
CMOS and VLSI (CPE 151)
Digital Logic Design and Introduction to Computer Organization (CPE 64 or CSC 137)
Assembly Language (CSC 35 or EEE 174)
Computer Interfacing (CPE 185)
Object Oriented Programming (CSC 20)
Algorithms and Data Structure (CSC 130)
Systems Programming (CSC 60)
Introduction to Operating Systems (CSC 139)
Computer Networks and Internets (CPE 138)
Differential Equations for Science and Engineering (MATH 45)
Statistics and Probability (STAT 50)
Applied Linear Algebra (MATH 100) [Numerical Analysis (MATH 150) may be substituted]

Graduate Admission Procedures

Applications will be accepted as long as there is space available. However, it is strongly recommended that students apply during the initial filing period of each semester (February for fall semester and August for spring semester). All prospective graduate students, including Sacramento State graduates, must file all of the following with the Office of Graduate Studies, River Front Center 206, (916) 278-6470:

- an online application for graduate admission;
- two sets of official transcripts from colleges and universities attended, *other than Sacramento State;*
- Graduate Record Examination (GRE) scores; and
- two letters of recommendation from professors and/or supervisors familiar with the student's accomplishments.

Approximately six weeks after receipt of all items listed above, a decision regarding admission will be mailed to the applicant.

Advancement to Candidacy

Each student must file an application for Advancement to Candidacy indicating a proposed program of graduate study. This procedure should begin as soon as the classified graduate student has:

- removed any deficiencies in the admission requirements;
- completed at least 12 units of graduate level (200 series) Computer Engineering courses with a minimum 3.0 GPA; and
- passed the Writing Proficiency Examination (WPE) or secured approval for a WPE waiver.

Students must have been advanced to candidacy before they can register for Master's thesis or project. Advancement to Candidacy forms are available in the Office of Graduate Studies. The student should fill out the form after planning a degree program in consultation with a Computer Engineering graduate advisor. The completed form must be signed by the CPE Graduate Coordinator and is then returned by the student to the Office of Graduate Studies for approval.

Requirements • Master of Science Degree

Units required for MS: 30, including 2-5 units of 500-level courses and the remaining units from the list of required and elective courses. Minimum required GPA: 3.0

Students may take no more than 3 units of CPE 299 to fulfill the unit requirements. Only those courses completed within seven years prior to date of graduation will satisfy course requirements.

Courses in parentheses are prerequisites.

A. Required Core Courses (13 units)

(1)	CPE 201	Research Methodology (classified graduate status)
(3)	CPE 273*	Hierarchical Digital Design Methodology (CSC 205, EEE 285 or their equivalents)
(3)	CPE 280	Advanced Computer Architecture (CSC 205, fully classified graduate standing)
(3)	CSC 205*	Computer System Structure (Fully classified graduate standing in Computer Science, Software Engineering or Computer Engineering)
(3)	EEE 285*	Micro-Computer System Design I (EEE 174 or CPE 185)

*Students whose undergraduate preparation has covered a significant amount of the material in CPE 273, CSC 205, or EEE 285 may be allowed to waive these courses. The course waiver form must be signed by the designated Computer Engineering faculty member for each course and signed by the Computer Engineering Graduate Coordinator. In this case, for each course waived, the student must take three additional units from Required Courses B through D or Elective Courses E to satisfy the program unit requirement.

B. Required Courses (9 units)

Select at least one course from each of the following areas:

Architecture:

(3)	CSC 237	Microprocessor Systems Architecture (CSC 205)
(3)	EEE 286	Microcomputer System Design II (CPE 186 or EEE 285)

Network:

(3)	CSC 255	Computer Networks (CPE 138 or CSC 138)
(3)	CSC 258	Distributed Systems (fully classified graduate standing in Computer Science, Software Engineering, or Computer Engineering and CSC 204)
(3)	CSC 275	Advanced Data Communication Systems (CPE 138 or CSC 138 or CSC 205 or instructor permission)

Software:

(3)	CSC 239	Advanced Operating Systems Principles and Design (CSC 205)

C . Elective Courses

CPE 299	Special Problems
CSC 159	Operating System Pragmatics (CSC 139)
CSC 215	Artificial Intelligence (fully classified graduate standing in Computer Science, Software Engineering, or Computer Engineering)
CSC 219	Machine Learning (fully classified graduate standing in Computer Science, Software Engineering, or Computer Engineering)
CSC 230	Software System Engineering (fully classified graduate standing in Computer Science, Software Engineering, or Computer Engineering and CSC 131)
CSC 234	Software Verification and Validation (fully classified graduate standing in Computer Science, Software Engineering, or Computer Engineering and CSC 131)
CSC 242	Computer Aided Systems Design and Verification (CSC 205)
CSC 244	Database System Design (CSC 174 or CSC 204)
CSC 245	Performance Modeling and Evaluation (Fully classified graduate status in Computer Science or Software Engineering)
CSC 250	Computer Security (fully classified graduate standing in Computer Science, Software Engineering, or Computer Engineering)
CSC 251	Principles of Compiler Design (CSC 151 or CSC 201)
EEE 215	Lasers (EEE 180 and EEE 161 or instructor permission)
EEE 221	Machine Vision
EEE 222	Electronic Neural Networks
EEE 225	Advanced Robotic Control (EEE 184)
EEE 230	Analog and Mixed Signal Integrated Circuit Design (EEE 109 and instructor permission)
EEE 233	Advanced Digital Signal Processing (EEE 174, EEE 181 or equivalent)
EEE 236	Advanced Semiconductor Devices
EEE 238	Advanced VLSI Design-For-Test I (CPE 151 and CPE 166)
EEE 242	Statistical Signal Processing
EEE 243	Applied Stochastic Processes (ENGR 120)
EEE 260	Statistical Theory of Communication (EEE 185)
EEE 261	Information Theory, Coding, and Detection (EEE 185)

EEE 267	Fiber Optic Communications (EEE 185 or instructor permission)
MATH 210A	Algebraic Structures I (MATH 110B)
MATH 241A	Methods of Applied Mathematics (MATH 134 recommended)

Certain special offerings in CSC, EEE or MATH with CPE advisor approval.

D. Culminating Requirement (2-5 units)

CPE 500	Master's Thesis **OR** Master's Project (Advanced to candidacy and graduate coordinator's permission)

Lower Division Courses

CPE 64. Introduction to Logic Design. Covers the following topics: logic gates, binary number system, conversion between number systems, Boolean algebra, Karnaugh maps, combinational logic, digital logic design, flip-flops, programmable logic devices (PLDs), counters, registers, memories, state machines, designing combinational logic and state machines into PLDs, and basic computer architecture. Lab emphasizes the use of software equation entry design tools, the use of a schematic entry, and the use of a logic simulation design tool. Lab assignments are design-oriented. Lecture three hours; laboratory three hours. **Prerequisite:** CSC 15 or CSC 25. **Cross-listed:** EEE 64; only one may be counted for credit. **Units:** 4.0.

CPE 64W. Introduction to Logic Design Workshop. Designated to assist students in developing a more thorough understanding of logic simulation and logic design. Focus is on problem solving and design. Activity two hours. **Corequisite:** CPE 64. **Cross-listed:** EEE 64W; only one may be counted for credit. **Graded:** Credit / No Credit. **Units:** 1.0.

CPE 96. Experimental Offerings in Computer Engineering. Current topics in computer engineering. Topics will vary. **Note:** May be repeated for credit. **Units:** 1.0-4.0.

Upper Division Courses

CPE 102. Analog/Digital Electronics. Introduction to analog/digital electronics, diodes, FET's, BJT's, DC biasing, VI characteristics, single-stage amplifiers, power supplies and voltage regulators, power electronic devices, OP-amps, active filters, A/D and D/A converters. PSPICE use extensively. **Note:** Cannot be taken for credit by EEE majors. **Prerequisite:** ENGR 17 **Corequisite:** CPE 102L **Units:** 3.0.

CPE 102L. Analog/Digital Electronics Laboratory. Introduction to analog/digital electronics, diodes, FET's, BJT's, DC biasing, VI characteristics, single stage amplifiers, power supplies and voltage regulators, power electronic devices, OP-amps, active filters, A/D and D/A converters. PSPICE used extensively. **Prerequisite:** ENGR 17 **Corequisite:** CPE 102 **Units:** 1.0.

CPE 138. Computer Networks and Internets. Overview of the fundamentals of computer networks and connections between networks, from the physical layer up through peer-to-peer communications at the application level. Lower layer characteristics including serial vs. parallel, capacity issues, high-speed connections, LAN framing and error handling. LAN vs. WAN characteristics, network architecture and the ISO network model. Internetworking components including LANs, repeaters, routers, bridges, and gateways. Internet addresses, TCP/IP, and the Domain Name System. Common Internet client/server application protocols including SMTP and FTP. Client/Server programming involving sockets. World Wide Web characteristics including CGI and HTTP protocol, Web pages, Web browsers, Web servers, and Applets. Introduction to advanced Web issues such as Web security, Search engine operations, and Web database operations. **Prerequisite:** CSC 35, CSC 60, CSC 130. **Cross-listed:** CSC 138; only one may be counted for credit. **Units:** 3.0.

CPE 142. Advanced Computer Organization. Design and performance issues of computers: CPU, I/O interface and memory. Design alternatives for arithmetic functions, CPU internal architecture, instruction set, instruction cycle, I/O, interrupt, direct memory access, and bus and memory hierarchy. CAD tools for schematic capture and simulations. Students will design and simulate a micro-computer. **Prerequisite:** CPE 166 and CPE 185. **Cross-listed:** CSC 142; only one may be counted for credit. **Units:** 3.0.

CPE 144. DSP Architecture Design. Fundamental principles of Digital Signal Processing (DSP): sampling theory, aliasing effects, frequency response, Finite Impulse Response filters, Infinite Impulse Response filters, spectrum analysis, Z transforms, Discrete Fourier Transform, and Fast Fourier Transform. Emphasis on hardware design to achieve high-speed real and complex multiplications and additions. Pipelining, Harvard, and modified Harvard architectures are included. Concludes with architectural overviews of modern DSP applications: modems, speech processing, audio and video compression and expansion, and cellular. **Prerequisite:** CPE 142. **Units:** 3.0.

CPE 151. CMOS and VLSI. Begins with an introduction to CMOS gates and design of CMOS combinational and sequential functions at the gate level, including CMOS memory. The theory of MOS transistors is covered including: DC equations, threshold voltage, body effect, subthreshold region, channel length modulation, tunneling, punch through, basic CMOS invertor, and the CMOS transmission gate. A basic exposure to VLSI includes the following topics: CMOS processing technology, CMOS layout, CMOS circuit design and CMOS logic design. Simulations on SPICE and basic VLSI layouts using LEDIT will be included. **Prerequisite:** CPE 64, EEE 102 or EEE 108. **Units:** 3.0.

CPE 153. VLSI Design. Review basic CMOS VLSI technology, circuit characterization and performance estimation, and provides detailed information on synthesis, placing and routing, clocking strategies, quality and reliability, and I/O structures. Design examples, design techniques, and testing techniques will be presented via current EDA design tools. Students assigned one project from concept design through validation. **Prerequisite:** CPE 151. **Units:** 3.0.

CPE 159. Operating System Pragmatics. Application of operating system principles to the design and implementation of a multi-tasking operating system. Students will write an operating system for a computer system. Topics include scheduling of processes, control and allocation of computer resources and user interfacing. **Prerequisite:** CSC 139. **Cross-listed:** CSC 159; only one may be counted for credit. **Units:** 3.0.

CPE 166. Advanced Logic Design. VHDL and Verilog Hardware Description Languages are studied and used on the following advanced level logic design topics: synchronous state machines, asynchronous state machines, metastability, hazards, races, testability, boundary scan, scan chains, and built-in self-tests. Commercial Electronic Design Automation (EDA) toolsets are used to synthesize lab projects containing a hierarchy of modules into Field Programmable Gate Arrays (FPGAs). Post synthesis simulations by these same tools verify the design before implementation on rapid prototyping boards in the lab. **Prerequisite:** CPE 64, ENGR 17. **Units:** 4.0.

CPE 185. Computer Interfacing. Design of microcomputer systems including memory systems, parallel and serial input/output, timer modules, and interrupt structures; designing "C" language code, in laboratory, to exercise interface modules of parallel and serial input/output, timer modules, and interrupts; extensive study of interrupt handlers, assemblers, linkers, and loaders. Practical features of interfaces, handshaking techniques, displays, keypads, and trackballs are included. **Prerequisite:** CPE 64, CSC 35 and CSC 60. **Units:** 4.0.

CPE 186. Computer Hardware System Design. Study of Intel and Motorola architectures, bus structures, interrupts, memory interface and controllers, bus arbitration, DMA controllers, I/O interface, bridges and microcontroller. Electromagnetic compatibility and regulations, cabling and shielding, grounding, digital circuit noise and layout. **Prerequisite:** CPE 185 or EEE 174. **Units:** 3.0.

CPE 187. Embedded Processor System Design. Students will design, construct and test an embedded processor system project. All address decoding, control functions, input and output ports, handshaking signals and interrupt control will be implemented in an FPGA. The system will interface to a microcontroller system. Students will use an assembler, a "C" compiler and either VHDL or Verilog to fully test their project. Laboratory techniques include oscilloscopes, logic analyzers, protocol analyzers and programmers for EPROMs, FLASH and microcontrollers. One lecture per week and one three-hour laboratory per week. **Prerequisite:** CPE 166, CPE 185, EEE 102, passing score on WPE. **Units:** 2.0.

CPE 190. Senior Design Project I. Centers on developing hardware and software project planning and engineering design skills. Emphasis is placed on design philosophies, problem definition, project planning and budgeting, written and oral communication skills, working with others in a team arrangement, development of specifications and effective utilization of available resources. Lecture one hour per week, laboratory three hours per week. **Prerequisite:** CPE 142, CPE 166, CPE 186, CPE 187, EEE 102, and passing score on WPE. **Units:** 2.0.

CPE 191. Senior Design Project II. Continuation of CPE 190. Students are expected to continue the project started by design teams in CPE 190. The hardware will be completed, tested and redesigned if necessary. At the same time, software for the project will be finished and debugged. The final results of the team project will be presented to the CPE faculty and students at a prearranged seminar. Lecture one hour, laboratory three hours. **Prerequisite:** CPE 190. **Units:** 2.0.

CPE 194. Career Development in Computer Engineering. Designed for Computer Engineering students making career decisions. Instruction will include effective career planning strategies and techniques including skill assessments, employment search strategy, goal setting, time management, interview techniques and resume writing. Lecture one hour. **Prerequisite:** CPE 190 may be taken concurrently. **Graded:** Credit / No Credit. **Units:** 1.0.

CPE 195. Fieldwork in Computer Engineering. Directed observations and work experience in computer engineering with firms in the industry or public agencies. Supervision is provided by the instructional staff and the cooperating agencies. Faculty approval required. **Note:** May be repeated for credit. **Graded:** Credit / No Credit. **Units:** 1.0-3.0.

CPE 195A. Professional Practice. Supervised employment in a professional engineering or computer science environment. Placement arranged through the College of Engineering and Computer Science. Requires satisfactory completion of the work assignment and a written report. **Prerequisite:** Instructor permission. **Graded:** Credit / No Credit. **Units:** 1.0-12.0.

CPE 195B. Professional Practice. Supervised employment in a professional engineering or computer science environment. Placement arranged through the College of Engineering and Computer Science. Requires satisfactory completion of the work assignment and a written report. **Prerequisite:** Instructor permission. **Graded:** Credit / No Credit. **Units:** 1.0-12.0.

CPE 195C. Professional Practice. Supervised employment in a professional engineering or computer science environment. Placement arranged through the College of Engineering and Computer Science. Requires satisfactory completion of the work assignment and a written report. **Prerequisite:** Instructor permission. **Graded:** Credit / No Credit. **Units:** 1.0-12.0.

CPE 195D. Professional Practice. Supervised employment in a professional engineering or computer science environment. Placement arranged through the College of Engineering and Computer Science. Requires satisfactory completion of the work assignment and a written report. **Prerequisite:** Instructor permission. **Graded:** Credit / No Credit. **Units:** 1.0-12.0.

CPE 196. Experimental Offerings in Computer Engineering. Current topics in computer engineering. Topics will vary. **Note:** May be repeated for credit. **Units:** 1.0-4.0.

CPE 199. Special Problems. Individual projects or directed reading. **Note:** Open only to those students who appear competent to carry on individual work. Admission to this course requires approval of the faculty member under whom the individual work is to be conducted, in addition to the approval of the advisor. May be repeated for credit. **Graded:** Credit / No Credit. **Units:** 1.0-3.0.

Graduate Courses

CPE 201. Research Methodology. Research methodology, problem formulation and problem solving. Collective and individual study of selective issues and problems relating to fields of study in the Computer Engineering Graduate Program. Orientation to the requirements for Master's Thesis or Project in Computer Engineering. **Prerequisite:** Fully classified graduate status. **Graded:** Credit / No Credit. **Units:** 1.0.

CPE 273. Hierarchical Digital Design Methodology. Advanced logic modeling, simulation, and synthesis techniques. Topics include modeling, simulation, and synthesis techniques, using Hardware Description Language (HDL's), Register Transfer Level (RTL) representation, high level functional partitioning, functional verification and testing, computer-aided logic synthesis, logical verification and testing, timing and delay analysis, automated place and route process', and design with Application Specific Integrated Circuits (ASICs) and programmable logic. **Prerequisite:** CSC 205, EEE 285 or their equivalents. **Units:** 3.0.

CPE 274. Advanced Timing Analysis. Timing analysis of Application Specific Integrated Circuit (ASIC) designs: Topics include ASIC design methodology, static timing analysis, timing design constraints, design reports, clock timing issues, timing exceptions, operating conditions, hierarchical analysis, analyzing designs with asynchronous logic, performance measurement and power issues. **Prerequisite:** EEE 273, CSC 273, CPE 273 or instructor permission. **Cross-listed:** EEE 274; only one may be counted for credit. **Units:** 3.0.

CPE 280. Advanced Computer Architecture. Introduction to parallel architecture covering computer classification schemes, fine and course grain parallelism, processor interconnections, and performance issues of multiprocessor systems. Includes parallel and pipelined instruction execution, structure of multiprocessor systems, memory hierarchy and coherency in shared memory systems, programming issues of multiprocessor systems, arithmetic pipeline design, and design for testability. **Prerequisite:** CSC 205, fully classified graduate status. **Units:** 3.0.

CPE 296. Experimental Offerings in Computer Engineering. When a sufficient number of qualified students are interested, one of the staff will conduct a seminar on some topic of Computer Engineering. **Note:** may be repeated for credit. **Units:** 1.0-4.0.

CPE 299. Special Problems. Open to qualified students who wish to pursue problems of their own choice. Projects must have approval and supervision of a faculty advisor. **Graded:** Credit / No Credit. **Units:** 1.0-3.0.

CPE 500. Culminating Experience. Completion of a thesis or project approved for the master's degree. **Note:** May be repeated for credit. **Prerequisite:** Advanced to candidacy and graduate coordinator's permission. **Graded:** Thesis in Progress. **Units:** 1.0-3.0.