



CALIFORNIA STATE UNIVERSITY
FULLERTON

MASTER OF SCIENCE

IN

COMPUTER ENGINEERING

**Computer Engineering Program
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COMPUTER ENGINEERING PROGRAM

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INTRODUCTION

Welcome to the Computer Engineering Program (CpE) in the College of Engineering and Computer Science at California State University, Fullerton (CSUF).

Over the past decade, there has been a rapid increase in demand for computer engineers in various fields ranging from the area of mobile devices (iPad, iPhone, etc.) to high-performance computing systems needed for e-prescription and electronic health record keeping. This trend only continues to grow.

CpE is committed to providing exciting academic programs. It strives to combine the best facilities along with a driven faculty and an innovative curriculum to prepare students for the great engineering challenges of the 21st century.

The MS degree program in Computer Engineering is designed to provide students with a strong understanding of the hardware design and practical applications of computer-based systems. Students in the program must complete all the requirements for the MS degree with a total of 30 semester units. The courses in contemporary and highly evolving computer engineering areas provide students with extensive hardware design and modeling experience, exposure to state-of-the-art electronic design automation (EDA) tools and the ability to design and analyze today's modern computer systems. Students are also encouraged to take courses from the graduate program in Computer Science and key courses in Electrical Engineering to expand their background. After completion of the degree program, graduates will have extensive theoretical knowledge and practical background in all aspects of computer-based systems, along with an in-depth knowledge in engineering analysis, design, implementation and testing. The program will prepare students for engineering jobs that require computer hardware skills.

The Master's degree program in Computer Engineering is open to students who have earned a bachelor's degree in computer engineering or a related discipline.

ADMISSION REQUIREMENTS

General Requirements:

At the time of admission into the M.S. program, students should:

1. Have completed a four-year college course of study and hold an undergraduate degree in computer engineering or a related discipline from an ABET accredited institution, or from an institution accredited by a regional accrediting association;
2. Be in good academic standing at the last college or university attended; and
3. Have attained a minimum grade point average (GPA) of 2.5 in cumulative or the last 60 semester units (90 quarter units). A GPA of 3.0 is required of students whose Bachelor's degree is from a non-ABET accredited university or if the Bachelor's degree is in an area other than engineering or computer science.

Additional Information for International Students:

In addition to meeting the general admission requirements, international students from countries where English is not the native language should have a minimum valid TOEFL score as noted below:

- 80 on the Internet Based TOEFL (IBT), or
- 550 on the Paper Based TOEFL (PBT)

The TOEFL score should be directly reported to California State University, Fullerton (ETS Institution Code: 4589). Alternatively, the following are also acceptable to meet this requirement:

- A minimum International English Language Testing System (IELTS) score of 6.5, or
- A minimum PTE score of 58

Additional information regarding graduate admissions in the College of Engineering and Computer Science (ECS) can be obtained at the following website:

<http://www.fullerton.edu/ecs/future/graduate.php>

DEGREE REQUIREMENTS

In order to obtain the M.S. degree in Computer Engineering, a student must complete 30 semester units of coursework beyond the Bachelor's degree, which will be included in a formal Study Plan.

Residence Requirement

A minimum of 21 semester units required by the program must be taken in residence at California State University, Fullerton. Residence units are granted for courses taken at the University during regular sessions of fall and spring and any special session.

Classified Graduate Standing

A student will obtain the status of Classified Graduate Standing upon the fulfillment of the following requirements:

1. Approval of a formal Study Plan by the Computer Engineering Graduate Advisor or the Program Coordinator and the Office of Graduate Studies;
2. Satisfactory completion of no more than 13 units on the Study Plan;
3. Fulfillment of the University writing requirement.

University Writing Requirement

The University writing requirement can be met by obtaining a passing score on the California State University Examination in Writing Proficiency (EWP) exam. A score of 4.0 or more on the GRE Analytical Writing section is also acceptable for meeting the University writing requirement.

The University writing requirement must be satisfied before the student can be classified. Students who fail to pass the EWP test may complete ENGL 301 or ENGL 360 or TESL 301 with a “C” (2.0) or better as an alternative to the EWP requirement.

Study Plan

Prior to the completion of 13 units towards the M.S degree requirements, the student must meet with the graduate advisor and develop a formal Study Plan. The latest version of the CpE Study Plan template can be obtained from the Computer Engineering website or from the CpE Program office.

The Study Plan must be approved by the Computer Engineering graduate advisor or the program coordinator and the Office of Graduate Studies. Courses taken towards meeting the undergraduate degree requirements cannot be used towards the Graduate Study Plan.

Changes in Study Plan

If a classified graduate student needs to make a change in the approved Study Plan, a request should be made to the student’s departmental Graduate Program Advisor. Requests must be made prior to registration for any coursework to be substituted or added. No course may be removed from the Study Plan after a student has taken it. Forms which may be used to file a request for change in Study Plan are available in the Graduate Studies Office, or on the Graduate Studies website.

Communication of Policies, Procedures and Deadlines

CpE graduate students may receive communication from various individuals and/or campus offices regarding various policies, procedures and deadlines pertaining to graduate students. These include, but are not limited to, the CpE Program office, graduate advisor, program coordinator, Office of Graduate Studies, members of the CpE graduate committee, ECS Dean’s office, Admissions and Records (A&R), and International Program and Global Engagement (IPGE). The modes of communication may include emails, memos, letters or phone calls. CpE graduate students are expected to follow instructions and follow up on such communication in a timely manner.

Core Courses

Out of the 30 semester units required for the M.S degree, 18 units must be comprised of required core courses. These courses are listed below:

1. EGCP 456 – Introduction to Logic Design in Nanotechnology (3 units)
2. EGCP 461 – Low Power Digital IC Design (3 units)
3. EGCP 520 – Advanced Computer Architecture (3 units)
4. EGCP 541 – Mixed-Signal IC Design (3 units)
5. EGCP 542 – VLSI Testing and Design for Testability (3 units)
6. EGCP 556 – Advanced Nanoelectronics (3 units)

Culminating Experience

The culminating experience can be met through of any one of the following options: Comprehensive Examination, Project, or Thesis. These culminating experience options are outlined below:

Option 1 (Comprehensive Examination):

This option requires 18 units of core courses, 12 units of approved elective courses (out of which, a maximum of 3 units may be at 400-level), and the culminating experience met through a comprehensive examination.

Option 2 (Project):

This option requires 18 units of core courses, 9 units of approved elective courses (out of which, a maximum of 3 units may be at 400-level) and the culminating experience met through 3 units of Project.

The Project (*EGCP 597*) course is designed to replicate a full spectrum of design processes that are involved in a medium-sized computer engineering project in the industry. The experience includes a creative design effort with realistic socio economic constraints and development of skills such as feasibility study, project planning, design formulation, time budgeting, task division among team members, oral, written and visual communication to document and disseminate the design adequately to others. The project requires students to think independently, research and brainstorm different project concepts before settling on a project that meets several criteria set forth by the Computer Engineering program. Students are provided with systematic faculty guidance during the project to ensure a well-rounded experience.

To enroll in the Project, a student must have Classified Graduate Standing. Before enrolling in the Project, a Project Proposal must be submitted to the Computer Engineering Program office no later than the last day of instruction of the semester preceding the semester in which the student plans to enroll for the Project. This form must be signed by a supervising full-time faculty member and by a second faculty reviewer.

The Project option requires the presentation of project work and a question-and-answer session before the supervising faculty member and one or more members of the CpE program graduate committee.

Option 3 (Thesis):

This option requires 18 units of core courses, 6 units of approved elective courses (out of which, a maximum of 3 units may be at 400-level), and the culminating experience met through 6 units of Thesis.

To enroll in the Thesis (*EGCP 598*), a student must have Classified Graduate Standing. The student shall first choose a faculty advisor and then, in consultation with the faculty advisor, choose a thesis committee consisting of three faculty members, including the faculty advisor. The thesis should cover original research and be prepared according to the university guidelines. The thesis committee will judge the research competence of the student during the thesis defense. The student is also required to complete an oral defense, a demo and a final thesis report by the deadlines set for the spring semester of the fourth year. Thesis defense is announced in advance and open to the university community.

Before enrolling in the Thesis, a Thesis proposal must be submitted to the Computer Engineering Program office no later than the last day of instruction of the semester preceding the semester in which the student plans to enroll for the Thesis. This form must be signed by a supervising full-time faculty member and by a second faculty reviewer.

Approved Technical Elective Courses

The technical electives shall constitute a coherent body of study consistent with the student's professional and educational objectives.

The number of electives to be taken depends upon the culminating experience option, as explained below:

Option 1 (Comprehensive Exam): Students who wish to take the comprehensive exam option must take 12 units of advisor approved elective courses. At least 9 of these 12 units must be at the 500-level.

Option 2 (Project): Students who wish to take the Project option must, in addition to the Project (*EGCP 597:3 units*), take 9 units of advisor approved elective courses. At least 6 of these 9 units must be at the 500-level.

Option 3 (Thesis): Students who wish to take the Thesis option must, in addition to the Thesis (*EGCP 598:6 units*), take 6 units of advisor approved elective courses. At least 3 of these 6 units must be at the 500-level.

A list of approved elective courses is given below. Course designations are as follows: CPSC for computer science courses, EGCP for computer engineering courses, and EGEE for electrical engineering courses.

The CpE program may offer, from time to time, additional CpE elective courses that are not listed here. Information about these courses may be obtained from the CpE program office.

Prerequisites for electives: Prior to enrolling in any approved elective course, CpE graduate students are urged to ensure that they meet all the prerequisite requirements for that course. It is the student's responsibility to ensure that he/she has the background knowledge and preparation required to enroll and successfully complete the course.

The approved elective courses are listed below according to subject area.

Course No.		Units
Wireless Communication		
EGEE 443	Electronic Communication Systems	3
EGEE 460	Introduction to Cellular Mobile Communications Systems	3
EGEE 522	Spread Spectrum Communications	3
EGEE 537	Satellite Communications	3
Computer Communication and Networks		
CPSC 471	Computer Communications	
CPSC 558	Advanced Computer Networking	3
Very Large Scale Integration (VLSI) and Optics		
EGCP 446	Advanced Digital Design using Verilog HDL	3
EGEE 410	Electro-Optical Systems	3
EGEE 455	Microelectronics and Nano Devices	3
EGEE 465	Introduction to VLSI Design	3
EGEE 480	Optical Engineering and Communications	3
EGEE 510	Optics & Electromagnetics in Communications	3
EGEE 523A	VLSI and Nano Technology and Devices	3
EGEE 523B	CMOS VLSI Design	3
Hardware Security		
EGCP 447	Introduction to Hardware Security and Trust	3
EGCP 543	Advanced Secure Hardware Design	3
Software Security		
CPSC 452	Cryptography	3
CPSC 454	Cloud Computing and Security	3
CPSC 456	Network Security Fundamentals	3
Microprocessors and Microcomputer Systems		
EGEE 404	Introduction to Microprocessors and Microcomputers	3
EGEE 406	Design Applications with Microcontroller and FPGA	3
EGEE 557	Microprogramming and Embedded Microprocessors	3
EGEE 558A	Microprocessors and System Applications I	3
EGEE 558B	Microprocessors and System Applications II	3
Control Systems and Systems Engineering		
EGEE 416	Feedback Control Systems	3
EGEE 424	Computer Simulation of Continuous Systems	3
EGEE 518	Digital Signal Processing	3
EGEE 526	Digital Control Systems	3
EGEE 580	Analysis of Random Signals	3
EGEE 559	Introduction to Robotics	3
Global Positioning Systems (GPS)		
EGEE 483	Introduction to Global Positioning Systems	3
System Software		
CPSC 451	Advanced Operating Systems	3

CPSC 477	Introduction to Grid Computing	3
CPSC 551	Operating Systems Design	3
Software Engineering		
CPSC 462	Software Design	3
CPSC 463	Software Testing	3
CPSC 464	Software Architecture	3
CPSC 466	Software Process	3
CPSC 541	Systems and Software Standards and Requirements	3
CPSC 542	Software Verification and Validation	3
CPSC 543	Software Maintenance	3
CPSC 544	Advanced Software Process	3
CPSC 545	Software Design and Architecture	3
CPSC546	Modern Software Management	3
CPSC 547	Software Measurement	3
Database System Design		
CPSC 431	Database and Applications	3
CPSC 474	Parallel and Distributed Computing	3
CPSC 531	Advanced Database Management	3
Multimedia and Digital Game Development		
CPSC 484	Principles of Computer Graphics	3
CPSC 486	Game Programming	3
CPSC 489	Game Development Project	3
CPSC 566	Advanced Computer Graphics	3
Software Application Development		
CPSC 411	Mobile Device Application Programming	3
CPSC 473	Web Front-End Engineering for Internet Applications	3
Intelligent Systems		
CPSC 476	Web Back-End Engineering for Enterprise Applications	3
CPSC 481	Artificial Intelligence	3
CPSC 483	Data Mining and Pattern Recognition	3
CPSC 583	Expert Systems Design Theory	3
CPSC 585	Artificial Neural Networks	3
Others		
EGCP 463	Current Topics in Computer Engineering	3
EGCP 599	Independent Graduate Research	1 - 3
Graduate Project and Thesis		
EGCP 597	Graduate Project	3
EGCP 598	Graduate Thesis	6

Time limit for Completion

All requirements for the graduate degree, including all coursework on the student's Study Plan, normally should be completed within five years. This time limit begins with the semester of the earliest course used on the student's Study Plan and consists of a total of ten (10) consecutive semesters. When individual circumstances warrant, this time limit may be extended for up to two years (four additional consecutive semesters).

A student may request an extension of the five-year time limit by filing a petition with the Graduate Studies Office. The petition must contain a full explanation of the circumstances that prevented completion of the degree requirements within the normal five-year limit. The petition must be approved (signed) by the Graduate Program Advisor, the Chair of the appropriate

Graduate Committee, and the Associate Vice President for Academic Programs (or designee). Approvals for extension must be obtained prior to the expiration of the five-year limit.

Applying for Graduation

Students must apply for a graduation check and pay the graduation and diploma fee prior to the deadline.

The last date to file the application is listed in the Registration Guide for each regular semester and is posted on the Graduate Studies website. Candidates for summer (August) graduation must also obtain departmental approval prior to the summer term by filing a Petition for Summer Completion. The form is available in the Graduate Studies Office. The approved form must be returned to Graduate Studies during the spring semester.

Students who fail to complete requirements as planned must update the application for a graduation check and do so by the appropriate deadline. A fee is required to change the graduation date. Forms for changing the graduation date are available at the Graduate Studies Office.

Graduation and Commencement

The effective date of graduation will be the last day of the specific term in which requirements are completed.

Commencement ceremonies are held only at the end of the spring semester. Once you have completed the graduation check process, i.e., filed for graduation check and paid the graduation fee, you are eligible to participate in the commencement ceremonies appropriate to your graduate date. Students completing requirements at the end of the fall and spring semesters and during the following summer may participate in those ceremonies.

Information concerning commencement activities is sent to students from the college dean's office usually in April of each year. Check the University's website (fullerton.edu/commencement) for further details about commencement events and procedures. Arrangements for cap, gown and hood purchase are to be made in the campus bookstore at Titan Shops.

GRADE POINT AVERAGE (GPA) REQUIREMENTS

Grade Point Average (GPA) is measured on a 0-4.0 scale and is calculated by dividing the total number of grade points accumulated by the number of units attempted. For a 3-unit course, the relation between the various letter grades and grade points is as follows:

A+	12 points (<i>4 points per unit x 3 units = 12 points for 3 units</i>)
A	12 points
A-	11.1 points
B+	9.9 points
B	9 points
B-	8.1 points
C+	6.9 points

C	6 points
C-	5.1 points
D+	3.9 points
D	3 points
D-	2.1 points
F	0 points
IC	0 points (Incomplete Charged)
WU	0 points (Withdrawal Unauthorized)

The “+/-“ grading system may not be used in some courses. In such courses, the possible letter grades are A, B, C, D, F, IC, WU etc.

It is to be noted that the list of letter grades mentioned here is not exhaustive. For more information regarding the grading policies and the grading systems, refer to the latest University catalog.

An online GPA calculator from the CSUF Academic Advisement Center can be accessed at http://www.fullerton.edu/aac/resources/gpa_calculator.php

A GPA of at least 3.0 is required for graduation with a graduate degree. This grade point average applies to (1) all 400-level and 500-level courses attempted subsequent to admission to a degree program (*Graduate GPA*); and (2) all courses required on the graduate Study Plan, including transfer courses (*Study Plan GPA*). Each course on the master’s Study Plan must be completed with a grade of “C” (2.0) or better.

A master’s degree student may request a change in the Study Plan in order to raise the Study Plan grade point average by:

1. adding no more than six units of approved coursework, or
2. repeating no more than six units of coursework in which a “C” (2.0) or lower was earned, or
3. a combination of 1. and 2. not to exceed six units.

Requests to add courses to the Study Plan, repeat courses, or add courses to raise the overall grade point average must be approved by the Graduate Program Advisor and the Associate Vice President for Academic Programs (or designee) prior to registration. When a course is added or repeated, the original course remains on the Study Plan and on the student’s transcript, and both grades are used in calculating the student’s grade point average.

REPEATED COURSES, PROBATION AND DISQUALIFICATION

Repeated Courses

For master’s degree students, if a grade less than “C” (2.0) is received in a Study Plan course, the course must be repeated and passed with a grade of “C” (2.0) or better. A course may be repeated only once. If a course is repeated, both grades are included when computing the student’s

Study Plan and cumulative Cal State Fullerton grade point average. Repetition of a course carries no additional unit credit toward the degree; however, the additional units are included in the cumulative units shown on the Cal State Fullerton transcript.

In extenuating circumstances, the student may petition the Associate Vice President for Academic Affairs (or designee) to add another course to the approved program with the unit value equivalent to that of the course in which the unsatisfactory grade was received.

Probation

A student enrolled in a graduate degree program will be placed on academic probation if either the graduate GPA or the Study Plan GPA falls below 3.0. A graduate student may also be placed on probation for reasons other than graduate and/or Study Plan grade point average. This is known as administrative-academic probation. The reasons for this may include repeated withdrawal, failure to progress toward an educational objective, non-compliance with an academic requirement, failure to demonstrate a level of professional competence or fitness commensurate with the standards of the student's discipline, or inappropriate behavior as defined in the Student Bill of Rights and Responsibilities and in the Academic Dishonesty sections of this catalog (see "University Regulations").

Master's degree students will be allowed two semesters on academic probation before being subject to disqualification. Students will remain on administrative-academic probation contingent upon conditions required for their continuing in the program. The Graduate Studies Office maintains a list of students on probation and subject to disqualification.

Disqualification

The associate vice president, Graduate Programs and Research (or designee), in consultation with the student's Graduate Program Advisor, will disqualify a master's student who is on probation if the student does not, or cannot, raise the Study Plan and graduate grade point average to 3.0 by the completion of the second regular semester following the semester in which the grade point average fell below the minimum 3.0 standard.

If a student's grade point average becomes so low that it cannot be raised to 3.0 within the prescribed limits of coursework, the student will be disqualified from the graduate degree program.

Students placed on probation for reasons other than grade point average will be disqualified if:

1. the conditions for removal of administrative-academic probation are not met within the period specified;
2. the student becomes subject to academic probation while on administrative-academic probation; or
3. the student is removed from administrative-academic probation and subsequently becomes subject to administrative-academic probation for the same or similar reasons as originally placed on probation.

TRANSFER CREDIT POLICY

Graduate students may request to apply a limited amount of transfer coursework towards unit requirements for a graduate degree. The use of transfer coursework on a student's Study Plan is subject to the following provisions.

1. Each course being transferred must:
 - a. have been taken at an accredited college or university;
 - b. be acceptable for credit toward a graduate degree at the institution where the coursework was taken
 - c. have been completed with a grade of "B" (3.0) or better;
 - d. not have been used in meeting the requirements for another earned degree (either graduate or undergraduate); and
 - e. have been completed within the student's five-year time period which is required for completion of the requirements for the graduate degree at CSUF.

2. A minimum of 21 semester units required by the program must be taken in residence at California State University, Fullerton. Residence units are granted for courses taken at the University during regular sessions of fall and spring and any special session.

STUDENT CLUBS

Students can enhance their technical knowledge by becoming a member of one or more of the following clubs and by attending their seminars, conferences or symposia, and subscribing to their technical magazines. Most are affiliated with local, regional, and national chapters, providing excellent opportunities for students to network with professionals in the field. Computer Engineering students may get involved in one or more of the following several student clubs:

The IEEE Computer Society
 The Institute of Electrical and Electronics Engineers (IEEE)
 Association for Computer Machinery (ACM)
 Society of Mexican American Engineers & Scientists (MAES)
 National Society of Black Engineers (NSBE)
 Society of Hispanic Professional Engineers (SHPE)
 Society of Women Engineers (SWE)
 Tau Beta Pi (TBP – National Engineering Honor Society)
 Upsilon Pi Epsilon (UPE - International Honors Society for the Computing and Information Disciplines)

COURSE DESCRIPTIONS

The core and elective courses included in the graduate curriculum are given below:

Computer Engineering (EGCP) Courses

EGCP 446 Advanced Digital Design using Verilog HDL

Prerequisite: EGCP 441

Fundamentals of Verilog programming, behavioral modeling using Verilog, structural modeling using Verilog, RTL design using Verilog, Shannon's decomposition, FPGA architecture, Digital design, synthesis and implementation using FPGA. (3 units)

EGCP 447 Introduction to Hardware Security and Trust

Prerequisite: EGCP 281

Hardware Trojan detection and isolation, physical and invasive attacks, side-channel attacks, physically unclonable functions, watermarking of Intellectual Property (IP) blocks, passive and active metering for prevention of piracy, access control. (3 units)

EGCP 456 Introduction to Logic Design in Nanotechnology

Prerequisites: EGCP 180 or EGEE 245

Promising novel nanoelectronic technologies and logic primitives for such technologies, applicable basic logic design technique, design models for spatial dimensions, applicable world-level data structures, multilevel circuit design, testability and observability, tolerance and reliable computing. (Same as EGEE 456) (3 units)

EGCP 461 Low Power Digital IC Design

Prerequisites: EGCP 180 or EGEE 245; EGEE 303

Importance of low power design; analysis of power dissipation in digital integrated circuits; circuit-level low-power techniques, logic-level low-power techniques, and system-level low-power techniques. (Same as EGEE 461) (3 units)

EGCP 463 Current Topics in Computer Engineering

Prerequisites: junior/senior standing in computer engineering and consent of instructor

Topics of contemporary interest from the perspective of current research and development in computer engineering. Lectures by guest professionals. (3 units)

EGCP 520 Advanced Computer Architecture

Prerequisite: EGCP 381

Performance analysis and evaluation, limitations of scalar pipelines, superpipelined, superscalar and VLIW processing, parallelism in programs, memory and I/O systems, out-of-order execution, branch prediction, register and memory data flow techniques, Tomasulo's algorithm, COTS hardware accelerators, CUDA, GPU programming architecture. (3 units)

EGCP 541 Mixed-Signal IC Design

Prerequisite: EGCP 441

IC design techniques for: Op-amps, phase-locked loops (PLL), high-speed RF circuits, high-speed broadband circuits, clock/data recovery (CDR) circuits, analog and optical signal processing circuits, CMOS digital camera technologies. (3 units)

EGCP 542 VLSI Testing and Design for Testability

Prerequisite: EGCP 441

Fault model, equivalence and dominance, combinational and sequential circuit test generation, design for testability (DFT), test compression, memory testing and diagnosis, boundary scan, testing analog circuits, mixed-signal testing strategies, logic and mixed signal built-in self-test (BIST). (3 units)

EGCP 543 Advanced Secure Hardware Design

Prerequisites: EGCP 441 and 447

Secure hardware design and implementation at multiple levels of abstraction, cryptographic hardware primitives, cryptographic modules, trusted platforms, reverse engineering of cryptographic modules using passive attacks, active attacks and cryptanalytic techniques, countermeasures against reverse engineering. (3 units)

EGCP 556 Advanced Nanoelectronics

Prerequisite: EGCP 456

Novel nanoelectronic devices, CAD Analysis of nanoelectronic devices, Advanced MOSFETs—SOI, FinFETs, SiGe, carbon nanotubes and ribbons, nanowires, quantum devices: RTD, tunnel FET, qubits, nanomemory, DRAM, flash, M/F RAM, spin torque devices. (3 units)

EGCP 597 Project

Prerequisite: Consent of graduate advisor and program coordinator. Classified graduate students only.

Project proposal must be approved prior to last day of class instruction of the preceding semester. (3 units)

EGCP 598 Thesis

Prerequisite: consent of graduate advisor and program coordinator. Classified graduate students only.

Thesis proposal must be approved prior to last day of class instruction of the preceding semester. (6 units)

EGCP 599 Independent Graduate Research

Prerequisite: Application for independent study approved by the instructor and the Computer Engineering Program Coordinator. Independent study or research under the direction of a full-time faculty member. May be repeated for a maximum of 3 total units of credit. (1 - 3 units)

Computer Science (CPSC) Courses - Approved Electives

CPSC 411 Mobile Device Application Programming

Prerequisite: CPSC 301 or passing score on Examination in Programming Proficiency

Introduction to developing applications for mobile devices, including but not limited to runtime environments, development tools and debugging tools used in creating applications for mobile devices. Use emulators in lab. Students must provide their own mobile devices. (3 units)

CPSC 431 Database and Applications

Prerequisites: CPSC 332.

Database design and application development techniques for a real-world system. Topics include system analysis, requirement specifications, conceptual modeling, logic design, physical design and web interface development. Develop projects using contemporary database management system and web-based application development platform. (3 units)

CPSC 451 Advanced Operating Systems

Prerequisite: CPSC 351

Internal structures of a modern operating system. Specific topics include processes, process communication, file systems, networking and the I/O system. Programming assignments will utilize calls and other low-level interfaces. (3 units)

CPSC 452 Cryptography

Prerequisites: Examination in Programming Proficiency or CPSC 301 and MATH 270B

Introduction to cryptography and steganography. Encryption, cryptographic hashing, certificates, and signatures. Classical, symmetric-key, and public-key ciphers. Block modes of operation. Cryptanalysis including exhaustive search, man-in-the-middle, and birthday attacks. Programming projects involving implementation of cryptographic systems. (3 units)

CPSC 454 Cloud Computing and Security

Prerequisites: CPSC 351 and CPSC 353

Cloud computing and cloud security, distributed computing, computer clusters, grid computing, virtual machines and virtualization, cloud computing platforms and deployment models, cloud programming and software environments, vulnerabilities and risks of cloud computing, cloud infrastructure protection, data privacy and protection. (3 units)

CPSC 456 Network Security Fundamentals

Prerequisite: CPSC 351

Learn about vulnerabilities of network protocols, attacks targeting confidentiality, integrity and availability of data transmitted across networks, and methods for diagnosing and closing security gaps through hands-on exercises. (3 units)

CPSC 462 Software Design

Prerequisite: CPSC 362

Concepts of software modeling, software process and some tools. Object-oriented analysis and design and Unified process. Some computer-aided software engineering (CASE) tools will be recommended to use for doing homework assignments. (3 units)

CPSC 463 Software Testing

Prerequisite: CPSC 362

Software testing techniques, reporting problems effectively and planning testing projects. Students apply what they learned throughout the course to a sample application that is either commercially available or under development. (3 units)

CPSC 464: Software Architecture

Prerequisite: CPSC 362

Basic principles and practices of software design and architecture. High-level design, software architecture, documenting software architecture, software and architecture evaluation, software product lines, and some considerations beyond software architecture. (3 units)

CPSC 466 Software Process

Prerequisite: CPSC 362

Practical guidance for improving the software development and maintenance process. How to establish, maintain and improve software processes. Exposure to some common process models, such as CMM, CMMI, PSP and TSP. (3 units)

CPSC 471 Computer Communications

Prerequisite: CPSC 351

Introduction to digital data communications. Terminology, networks and their components, common-carrier services, telecommunication facilities, terminals, error control, multiplexing and concentration techniques. (3 units)

CPSC 473 Web Front-End Engineering for Internet Applications

Prerequisite: CPSC 332

Concepts and architecture of interactive web applications. Markup, stylesheets, templates and frameworks. Functional and object-oriented aspects of JavaScript. Model-view design patterns. Asynchronous events, WebSocket and real-time techniques. HTTP server architecture, web services and non-relational datastores. Workflow, staging and cloud deployment. (3 units)

CPSC 474 Parallel and Distributed Computing

Prerequisite: CPSC 473

Concepts of distributed computing; distributed memory and shared memory architectures; parallel programming techniques; inter-process communication and synchronization; programming for parallel architectures such as multi-core and GPU platforms; project involving distributed application development. (3 units)

CPSC 476 Web Back-End Engineering for Enterprise Applications

Prerequisite: CPSC 223J or CPSC 223N, and CPSC 332

Concepts and architecture of enterprise applications, components, services and communication technologies. Dependency injection, application tiers, remote objects, distributed transactions, message queues, web services and object-relational mapping. Enterprise application development in Java with build tools, containers and applications servers. (3 units)

CPSC 477 Introduction to Grid Computing

Prerequisite: CPSC 351

Introduction to grid computing concepts and technologies, and their applications to solving computationally intensive, real-world problems. Topics include designing grid operating systems. Load balancing, distributed hash tables, locking, remote procedure calls, cycle-scavenging, fault tolerance and security. (3 units)

CPSC 481 Artificial Intelligence

Prerequisite: CPSC 335

Use of computers to simulate human intelligence. Topics include production systems, pattern recognition, problem solving, searching game trees, knowledge representation and logical reasoning. Programming in AI environments. (3 units)

CPSC 483 Data Mining and Pattern Recognition

Prerequisite: CPSC 335

Classification techniques, discriminant functions, training algorithms, potential function theory, supervised and unsupervised learning, feature selection, clustering techniques, multidimensional rotations and rank ordering relations. (3 units)

CPSC 484 Principles of Computer Graphics

Prerequisites: CPSC 301 or passing score on Examination in Programming Proficiency and MATH 150B, 270B

Examine and analyze of computer graphics; software structures, display processor organization, graphical input/output devices, display files. Algorithmic techniques for clipping, windowing, character generation and viewpoint transformation. (3 units)

CPSC 486 Game Programming

Prerequisite: CPSC 386, 484

Survey of data structures and algorithms used for real-time rendering and computer game programming. Build upon existing mathematics and programming knowledge to create interactive graphics programs. (3 units)

CPSC 489 Game Development Project

Prerequisite: CPSC 486

Individually or in teams, student design, plan and build a computer game. (3 units)

CPSC 531 Advanced Database Management

Prerequisite: CPSC 431

Implementation techniques for query analysis, data allocation, concurrency control, data structures, and distributed databases. New database models and recent developments in database technology. Student projects directed to specific design problems. (3 units)

CPSC 541 Systems and Software Standards and Requirements

Prerequisite: CPSC 362 or equivalent work experience

SESC framework and the IEEE Software Engineering Standards. -Establishing the following standards: Software Life Cycle Processes, Work Product Standards, Process Standards, Requirement Analysis and Management and System Integration. Introduces CMMI framework; discuss number of practical lessons.- (3 units)

CPSC 542 Software Verification and Validation

Prerequisite: CPSC 362

Theory and practice of software verification and validation (V&V), including software integrity levels, minimum V&V tasks, walkthroughs, inspections and clean room. Topics include: white-box and black-box testing, boundary value analysis, equivalence class partitioning, unit testing, functional testing and test plans.- (3 units)

CPSC 543 Software Maintenance

Prerequisite: CPSC 362

Theory and practice of maintaining large-scale software. Maintenance framework, process, measures, and process management. Topics include fundamentals of software change and its implications, maintenance process models, reusability for maintenance, reverse engineering, maintenance testing, software configuration management and tools in maintenance. (3 units)

CPSC 544 Advanced Software Process

Prerequisite: CPSC 362

Advanced guidance for defining and improving the software development process. Concepts of software maturity framework, principles of process improvement and software process assessment. Current topics such as CMMI and SCAMPI. (3 units)

CPSC 545 Software Design and Architecture

Prerequisite: CPSC 362

Advanced software design and architecture principles focusing a software engineering approach to the development process. Topics include architecture business cycle, quality attributes, attribute-driven design method, architectural styles, design patterns, software product lines and component-based design. (3 units)

CPSC 546 Modern Software Management

Prerequisite: CPSC 362 or equivalent work experience

Modern project management methodologies and techniques. Software development process. Planning, estimating, organizing, directing, monitoring, controlling software projects and

managing risks. Other related software management issues, such as infrastructure, quality software development, project and product metrics, and external factors. (3 units)

CPSC 547 Software Measurement

Prerequisite: CPSC 362

Current software measurement practices. Topics include: establishing an effective software metrics program; measuring software product, project and process; applying Statistical Process Control and other statistical techniques. High maturity concepts defined in CMMI model will be discussed. Stresses a practitioner-based approach. (3 units)

CPSC 551 Operating Systems Design

Prerequisite: CPSC 351

Design and evaluation techniques for controlling automatic resource allocation, providing efficient programming environments and appropriate user access to the system, and sharing the problem solving facilities. (3 units)

CPSC 558 Advanced Computer Networking

Prerequisite: CPSC 471

System-oriented view of computer network design, protocol implementation, networking, high-speed networking, network management, computer network performance issues. (3 units)

CPSC 566 Advanced Computer Graphics

Prerequisite: CPSC 484

Three-dimensional: reflection models, shading techniques, rendering process, parametric representation, ray tracing, radiosity, texture, anti-aliasing, animation, color science. (3 units)

CPSC 583 Expert Systems Design Theory

Prerequisite: CPSC 481

Knowledge representation and search strategies for expert systems; logic programming; expert system tools; project. (3 units)

CPSC 585 Artificial Neural Networks

Prerequisite: CPSC 481

Principles of neural networks; neural networks paradigms, software implementations, applications, comparison with statistical methods, use of fuzzy logic; project. (3 units)

Electrical Engineering (EGEE) Courses - Approved Electives

EGEE 404 Introduction to Microprocessors and Microcomputers

Prerequisite: EGEE 245L, EGEE 280; or graduate standing.

Hardware and software concepts in microprocessors, processor family chips, system architecture, CPU, input/output devices, interrupts and DMA, memory (ROM, RAM), electrical and timing characteristics, assembly language programming. (3 units)

EGEE 406 - Design Applications with Microcontroller and FPGA

Prerequisites: EGEE 245, EGEE 245L, EGEE 280; or graduate standing.

Digital system application design using microcontrollers, FPGAs and CPLDs including programming hardware interfacing, A/D conversion, CLB, logic arrays, interconnections, testing and simulations. (3 units)

EGEE 410 Electro-Optical Systems

Prerequisite: EGEE 311

Introduction to electro-optics; optical radiation characteristics and sources; geometrical and physical optics; lasers and electro-optical modulation; quantum and thermal optical radiation detectors; detector performance analysis; electro-optical systems modeling and analysis; application examples. (3 units)

EGEE 416 Feedback Control Systems

Prerequisite: EGEE 409

Feedback control system characteristics; stability in the frequency and time domains; analysis and design of continuous-time systems using root-locus, Bode and Nyquist plots, Nichols chart and applications. (3 units)

EGEE 424 Computer Simulation of Continuous Systems

Prerequisites: CPSC 120; EGEE 215 and 308

Using digital computer for simulation of physical systems modeled by ordinary differential equations; problem formulation, in-depth analysis of two integration methods, and the use of a general purpose system simulation program such as CSSL. (3 units)

EGEE 443 Electronic Communication Systems

Prerequisites: EGEE 310 and 323 or equivalent

Principles of amplitude, angular and pulse modulation, representative communication systems, the effects of noise on system performance. (3 units)

EGEE 455 Microelectronics and Nano Devices

Prerequisites: EGEE 303 and 311

Quantum mechanical principles, crystal structure, energy band, carrier transport, carrier generation and recombination, p-n junction, bipolar transistor, MOSFET, MEFET and related devices, basic microwave and optoelectronic technology, crystal growth and fabrication, introduction to nano structure, nano devices and technology. (3 units)

EGEE 460 Introduction to Cellular Mobile Communications Systems

Prerequisite: EGEE 443 Introduction to wireless mobile telecommunications, description and analysis of cellular radio systems, co-channel interference reduction, channel capacity and digital cellular systems. (3 units)

EGEE 465 Introduction to VLSI Design

Prerequisites: EGEE 245 and 303

Computer-aided design of VLSI circuits. MOS device structure, design rules, layout examples, CMOS standard cells. Speed power trade off, scaling, device and circuit simulation. VLSI design software tools. Routing method system design, Design Project. Chip fabrication through MOSIS service, testing. (3 units)

EGEE 480 Optical Engineering and Communications

Prerequisites: EGEE 311 and PHYS 227

Optics review, lightwave fundamentals, integrated optic waveguides, first design of fiber optic system, analog and digital modulation, digital fiber optic system design, baseband coding, digital video transmission in optical fiber, optical emitters and receivers, coherent optical communication, measurements in fiber optic telecommunication. (3 units)

EGEE 483 Introduction to Global Positioning Systems (GPS)

Corequisite: EGEE 409 or EGCP 371

Description of Global Positioning Systems (GPS) and Differential Global Positioning Systems (DGPS), GPS navigation, errors. Satellite signals and co-ordinate transform math. Modeling for position and velocity. Application to navigation. (3 units)

EGEE 510 Optics and Electromagnetics in Communications

Prerequisite: EGEE 480

Plane-wave propagation and reflection from multiple layers; two- and three-dimensional boundary value problems; waveguides and resonant cavities; radiation from apertures and antennas; electromagnetic properties of materials, gases and plasmas; significant coverage of engineering applications. (3 units)

EGEE 518 Digital Signal Processing

Prerequisite: EGEE 420

Discrete Fourier transform; fast Fourier transform; Chirp Z-transform; discrete time random signals; floating-point arithmetic; quantization; finite word length effect in digital filters; spectral analysis and power spectrum estimation. (3 units)

EGEE 522 Spread Spectrum Communications

Prerequisites: EGEE 443 and 580

Introduction to Spread Spectrum (SS) Systems. Performance analysis of coherent digital signaling schemes. Synchronization. Direct sequence, frequency hopping, time hopping and Hybrid Spread Spectrum Modulations. Binary shift register sequences. Code tracking loops. Performance of SS systems in a jamming environment, with forward error correction. (3 units)

EGEE 523A VLSI and Nano Technology and Devices

Prerequisite: EGEE 455 or equivalent

Silicon crystal, PN junction physics, oxide and interface physics, wafer fabrication technology; oxidation, diffusion, ion-implantation, epitaxy, photolithography, thin films process. Layout design principle for integrated circuits. Nano-electronic devices and technology. (3 units)

EGEE 523B CMOS VLSI Design

Prerequisites: EGEE 465 and EGEE 448 or equivalent.

Surface physics of MOS system, MOS device physics. Short channel effect; hot carrier effect, subthreshold conduction. CMOS fabrication process. Layout design rules. Scaling design and analysis of CMOS circuits. Standard cell method. CAD design and SPICE simulation. (3 units)

EGEE 526 Digital Control Systems

Prerequisite: EGEE 416

Analysis, design and implementation of digital control systems; Z-transform methods; frequency domain and state-space approach for discrete-time systems. (3 units)

EGEE 537 Satellite Communications

Prerequisite: EGEE 443

Satellite systems, link analysis, propagation effects, SNR/CNR calculations, modulation schemes, TDMA, FDMA, CDMA techniques. (3 units)

EGEE 557 Microprogramming and Embedded Microprocessors

Prerequisites: EGEE 412 and EGEE 448

Introduction to microprogramming concepts and applications to the control unit of a computer, microprogrammable control, arithmetic-logic unit, implementation of an embedded process on FPGA and interfacing with external memories. (3 units)

EGEE 558A Microprocessors and System Applications I

Prerequisites: EGEE 404 and 404L

Microprocessors and micro-computers, their related software systems, system design with microprocessors, applications in peripheral controllers, communication devices and multiprocessing systems. (3 units)

EGEE 558B Microprocessors and Systems Applications II

Prerequisite: EGEE 558A

Advanced microprocessor architecture and their applications to microcomputer networking; RISC VS CISC architectures, communication protocol, distributed-operating system, and local area networks. (3 units)

EGEE 559 Introduction to Robotics

Prerequisite: EGEE 416 or consent of instructor

Science of robotics from an electrical engineering standpoint, including modeling, task planning, control, sensing and robot intelligence. (3 units)

EGEE 580 Analysis of Random Signals

Prerequisites: EGEE 323 and 409 or equivalent

Random processes pertinent to communications, controls and other physical applications, Markov sequences and processes, the orthogonality principle. (3 units)

Disclaimer

This handbook is intended as a quick reference for graduate students who are pursuing the MS degree in computer engineering. It does not apply to those who are pursuing the integrated BS-MS degree in computer engineering. In case of any discrepancies between the contents of this handbook and those of College and/or University documents (University Catalog, for example), the contents of the latest version of the relevant College and/or University documents (as applicable) shall take precedence over the contents of this handbook.