COMPUTER ENGINEERING AND COMPUTER SCIENCE

College of Engineering

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General Education Advising: Academic Advising - Horn Center

Minor and Certificate Advisor: Michael Chelian, Alvaro Mouge

Administrative Support Coordinator: Robin Ikemi

Administrative Support Assistant: Karyl Anthony

Students desiring detailed information should contact the department for referral to one of the faculty advisors.

Career Possibilities

Computer Engineer • Software Engineer • Systems Analyst • Hand-held Appliance Programmer • Web Application Developer • Mainframe Programmer • Applications Programmer • LAN/WAN Administrator • Systems Administrator • Computer Service Representative • Database Administrator • Technical Services Manager • Telecommunications Analyst (Some of these, and other careers, require additional education or experience. For more information, see www.careers.csulb.edu.)

ABET Accreditation

The Bachelor of Science in Computer Engineering is accredited by the Engineering Accreditation Commission and the the Bachelor of Science in Computer Science is accredited by the Computing Accreditation Commission of ABET, http://www.abet.org.

Advisory Board

The Department of Computer Engineering and Computer Science is supported by an Advisory Board composed of engineers, computer scientists, and business executives in the Southern California area. This liaison helps the department keep its curricula responsive to the needs of the community.

Undergraduate Degree Programs

The degree in Computer Engineering focuses on computer hardware (design, construction, and operation of computer systems). The Computer Science degree places more emphasis on computer software (databases and user development). The high school student planning to enter either program is advised to pursue a strong program in science and mathematics.

Students will receive a comprehensive education in computer engineering and/or computer science, as well as the sciences and humanities, and will be able to communicate effectively. They will be able to design systems, components or processes that meet performance, cost, time, safety, and quality requirements. They will understand professional responsibilities and will be able to analyze the social and ethical implications of their work.

Undergraduate Programs

Bachelor of Science in Computer Engineering (120 units)

This program provides students with a strong background in mathematics, physics, and engineering science. Courses, especially those in the junior and senior years, emphasize an open-ended, design-oriented approach to solving engineering problems. Teamwork, communication skills, and an interdisciplinary approach to problem solving are integrated into the senior computer engineering design courses.

Program Educational Objectives

After graduation and engaging in the profession of Computer Engineering for a few years, our graduates will have:

- become a part of California's high technology workforce, and made significant contributions to Computer Engineering through the research, design and development of a wide range of embedded systems and system-on-chip applications.
- helped further the state's economic growth by developing innovative ideas, and translating them into commercial products that benefit society.
- functioned effectively as team members and/or leaders in multidisciplinary and multicultural environments.
- recognized the societal and global context of their work and understood professional and ethical responsibilities.
- continued the pursuit of lifelong learning through such activities as graduate school, distance education, professional training and membership in professional societies and been able to adapt to new engineering tools.

Major Declaration

Freshmen admission to engineering majors is to a 'pre-major' status (i.e., Pre-Computer Engineering). Continuation in the major will be subject to meeting specific lower division course and GPA requirements at CSULB that indicate the student's ability to succeed and complete the major. Transfer applicants and CSULB students seeking admission into Computer Engineering must also

meet similar major specific requirements. To become fully admitted into the Computer Engineering major, all prospective students (i.e., pre-majors, undeclared, major changes) must have a minimum cumulative 2.5 GPA and complete the following lower-division courses with a minimum grade of "C" prior to earning 60 units:

Core Lower-Division Major Requirements:
MATH 122 (Calculus I), MATH 123 (Calculus II), PHYS 151 (Mechanics & Heat)

General Education Foundations Courses:
Written Communication, Oral Communication, and Critical Thinking

Degree Progress

Students must complete the following requirements within one calendar year of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. At the end of the year, students who have not met the requirements must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete.

First-Time Freshmen: A grade of "C" or better must be achieved in MATH 122 within one calendar year.

Transfer Students: A grade of "C" or better must be achieved in MATH 123 and PHYS 151 within one calendar year.

Requirements

Lower Division:

Take all of the following courses:

CECS 100 Critical Thinking in the Digital Information Age (3)
Prerequisite/Corequisite: ENGL 100 or its equivalent all with a grade of "C" or better.

CECS 105 Introduction to Computer Engineering and Computer Science (1)
Prerequisites: None.

CECS 174 Introduction to Programming and Problem Solving (3)
Prerequisite: CECS 100 and MATH 113 (or equivalent) all with a grade of "C" or better.

CECS 201 Computer Logic Design I (3)
Prerequisite: MATH 113 or equivalent all with a grade of "C" or better.

CECS 211 Principles of Computer Engineering I (3)
Prerequisite: MATH 122 with a grade of "C" or better.

CECS 228 Discrete Structures With Computing Applications I (3)
Prerequisites: CECS 174 and MATH 113 or equivalent all with a grade of "C" or better.

CECS 229 Discrete Structures With Computing Applications II (3)
Prerequisites: MATH 123 and CECS 228 both with a grade of "C" or better.

CECS 262 Introduction to Embedded System Programming (3)
Prerequisites: CECS 174 and CECS 201 all with a grade of "C" or better.

CECS 271 Introduction to Numerical Methods (3)
Prerequisites: CECS 174 and MATH 123 all with a grade of "C" or better.

CECS 274 Object Oriented Programming and Data Structures (3)
Prerequisite: CECS 174 with a grade of "C" or better.

CECS 282 C++ for Java Programmers (3)
Prerequisite: CECS 274 with a grade of "C" or better.

ENGR 101 Intro to the Engineering Profession (1)
Prerequisite/Corequisite: MATH 111 or MATH 113 or MATH 122.

ENGR 102 Academic Success Skill (1)
Prerequisite: ENGR 101 with a grade of "C" or better.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

Take one of the following choices:

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

or both of the following:

EE 210 Electro-Magnetic Foundations in EE (3)
Prerequisite: PHYS 151 with a grade of "C" or better. Corequisites: MATH 123, EE 210L.

EE 210L Electro-Magnetic Foundations in EE Lab (1)
Corequisite: EE 210.

A Science Elective – Take four units of approved elective to be selected from:

BIOL 200, PHYS 254 and PHYS 255, CHEM 111A

Upper Division:

Take all of the following courses:

CECS 301 Computer Logic Design II (3)
Prerequisites: CECS 174, CECS 201 all with a grade of "C" or better.

CECS 311 Principles of Computer Engineering II (3)
Prerequisites: CECS 201 and CECS 211 all with a grade of "C" or better.

CECS 326 Operating Systems (3)
Prerequisites: CECS 282 and either CECS 285 or CECS 346 all with a grade of "C" or better.

CECS 346 Microprocessors and Controllers I (3)
Prerequisites: CECS 211 and CECS 262 all with a grade of "C" or better.

CECS 347 Microprocessors and Controllers II (3)
Prerequisites: CECS 301, CECS 311, and CECS 346 all with a grade of "C" or better.

CECS 360 Integrated Circuit Design Software (3)
Prerequisites: CECS 301, CECS 346, MATH 123 or MATH 222 all with a grade of "C" or better.

CECS 440 Computer Architecture (3)
Prerequisites: CECS 346 with a grade of "C" or better.

CECS 447 Microprocessors and Controllers III (3)
Prerequisite: CECS 347 with a grade of "C" or better.

CECS 460 System on Chip Design (3)
Prerequisite: CECS 360 with a grade of "C" or better.

CECS 463 System on Chip Applications (3)
Prerequisite: CECS 360 with a grade of "C" or better.

CECS 490A Computer Engineering Senior Project I (3)
Prerequisites: CECS 347 with a grade of "C" or better, senior standing.

CECS 490B Computer Engineering Senior Project II (3)
Prerequisites: CECS 490A with a grade of "C" or better and consent of instructor.

EE 380 Probability, Statistics and Stochastic Modeling (3)
Prerequisites: MATH 123; (EE 202 or CECS 271 or CECS 274) all with a grade of "C" or better.

Take three units of approved elective to be selected from:
CECS 343, CECS 406, CECS 451, CECS 461, CECS

474, CECS 475, CECS 497; EE 386, EE 486; CE 406; ECON 300; CEM 310 (or ENGL 317); ENGR 350; MATH 370A.

A grade of "C" or better must be achieved in all required and elective courses. BIOL 200, CHEM 111A, CE 406; CEM 310; CECS 100, CECS 105, CECS 174, CECS 201, CECS 211, CECS 228, CECS 262, CECS 271, CECS 274, CECS 282, CECS 301, CECS 311, CECS 326, CECS 343, CECS 346, CECS 347, CECS 360, CECS 406, CECS 440, CECS 447, CECS 451, CECS 460, CECS 461, CECS 463, CECS 474, CECS 475, CECS 490A, CECS 490B, CECS 497; ECON 300; EE 210 and EE 210L, EE 380, EE 386, EE 486; ENGL 317; ENGR 101, ENGR 102, ENGR 350; MATH 122, MATH 123, MATH 224, MATH 247, MATH 370A; PHYS 151, PHYS 152, PHYS 254, PHYS 255.

Bachelor of Science in Computer Science (120 units)

This degree is designed to prepare graduates for a variety of professional careers in the computer field. The curriculum is designed to provide a balance between the theoretical and practical aspects of computer science. Extensive laboratory time is required for these courses, and design and analysis experiences are emphasized.

Program Educational Objectives

Our students following graduation will be able

- to enter California's high technology workforce, and make significant contributions through the research, design and development of software and networked computer systems.
- to help further the state's economic growth by developing innovative ideas, and translating them into commercial products that benefit society.
- to function effectively as a team member and/or leader in multidisciplinary and multicultural environments.
- to recognize the societal and global context of their work and to understand professional and ethical responsibilities.
- to pursue lifelong learning through such activities as graduate school, distance education, professional training and membership in professional societies and to be able to adapt to new engineering tools.

Major Declaration

Freshmen admission to engineering majors is to a 'pre-major' status (i.e., Pre-Computer Science). Continuation in the major will be subject to meeting specific lower division course and GPA requirements at CSULB that indicate the student's ability to succeed and complete the major. Transfer applicants and CSULB students seeking admission into Computer Science must also meet similar major specific requirements. To become fully admitted into the Computer Science major, all prospective students (i.e., pre-majors, undeclared, major changes) must have a minimum cumulative 2.5 GPA and complete the following lower-division courses with a minimum grade of "C" prior to earning 60 units:

Core Lower-Division Major Requirements:
MATH 122 (Calculus I), MATH 123 (Calculus II), PHYS 151 (Mechanics & Heat)

General Education Foundations Courses:
Written Communication, Oral Communication, and Critical Thinking

Degree Progress

Students must complete the following requirements within one calendar year of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. At the end of the year, students who have not met the requirements must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete.

First-Time Freshmen: A grade of "C" or better must be achieved in MATH 122 within one calendar year.

Transfer Students: A grade of "C" or better must be achieved in MATH 123 and PHYS 151 within one calendar year.

Requirements

Lower Division:

Take all of the following courses:

CECS 100 Critical Thinking in the Digital Information Age (3)
Prerequisite/Corequisite: ENGL 100 or GE Composition (Area A1).

CECS 105 Introduction to Computer Engineering and Computer Science (1)
Prerequisites: None.

CECS 174 Introduction to Programming and Problem Solving (3)
Prerequisite: CECS 100 and MATH 113 (or equivalent) all with a grade of "C" or better.

CECS 201 Computer Logic Design I (3)
Prerequisite: MATH 113 or equivalent all with a grade of "C" or better.

CECS 228 Discrete Structures With Computing Applications I (3)
Prerequisites: CECS 174 and MATH 113 or equivalent all with a grade of "C" or better.

CECS 229 Discrete Structures with Computing Applications II (3)
Prerequisites: MATH 123 and CECS 228 both with a grade of "C" or better.

CECS 274 Object Oriented Programming and Data Structures (3)
Prerequisite: CECS 174 with a grade of "C" or better.

CECS 277 Object Oriented Application Development (3)
Prerequisite: CECS 274 with a grade of "C" or better.

CECS 282 C++ for Java Programmers (3)
Prerequisite: CECS 274 with a grade of "C" or better.

CECS 285 Computer Organization and Assembly Language Programming (3)
Prerequisites: CECS 201, CECS 274 all with a grade of "C" or better.

ENGR 101 Intro to the Engineering Profession (1)
Prerequisite/Corequisite: MATH 111 or MATH 113 or MATH 122.

ENGR 102 Academic Success Skills (1)
Prerequisite: ENGR 101 with a grade of "C" or better.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

Take a minimum of 12 units of approved science-electives to include a two-semester science sequence chosen from the following groups of courses:

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

or

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

EE 210 Electro-Magnetic Foundations in EE (3)
Prerequisite: PHYS 151 with a grade of "C" or better.
Corequisites: MATH 123, EE 210L.

EE 210L Electro-Magnetic Foundations in EE Lab (1)
Corequisite: EE 210.

or

CHEM 111A General Chemistry (5)
Prerequisites: A passing score on the Chemistry Placement Examination.
Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)
Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 117 or MATH 119A or MATH 122 all with a grade of "C" or better.

Remaining units to be chosen from the following:
BIOL 153, 200, 205, 207.

Upper Division:

Take all of the following courses:

CECS 323 Database Fundamentals (3)
Prerequisites: CECS 228 and (CECS 277 or CECS 282) all with a grade of "C" or better.

CECS 326 Operating Systems (3)
Prerequisites: CECS 282 and either CECS 285 or CECS 346 all with a grade of "C" or better.

CECS 327 Introduction to Networks and Distributed Computing (3)
Prerequisite: CECS 326 with a grade of "C" or better.

CECS 328 Data Structures and Algorithms (3)
Prerequisite: CECS 228 with a grade of "C" or better; Corequisite: CECS 277.

CECS 341 Computer Architecture and Organization (3)
Prerequisites: CECS 285 with a grade of "C" or better.

CECS 343 Introduction to Software Engineering (3)
Prerequisites: CECS 277 or CECS 282 all with a grade of "C" or better.

EE 380 Probability, Statistics and Stochastic Modeling (3)
Prerequisites: MATH 123; (EE 202 or CECS 271 or CECS 274) all with a grade of "C" or better.

ENGR 350 Computers, Ethics and Society (3)
Prerequisites: 3 units from GE Category A.1 (Writing) and 3 units from GE Category D (Social and Behavioral Science).

Take one course from the following:

CEM 310 Communications in Engineering Profession (3)
Prerequisites: ENGL 100, COMM 110 all with a grade of "C" or better and Senior standing.

ENGL 317 Technical Writing (3)
Prerequisites: GE Foundation requirements, upper-division standing, and a previous composition course, i.e., ENGL 100, ENGL 101, ENGL 102, ENGL 300, or equivalents.

Take three units of study in formal languages and computation to be chosen from the following courses:
CECS 424, CECS 444

Take 12 units of upper division courses chosen from:

Take three units of core electives chosen from the following: CECS 419, CECS 424, CECS 428, CECS 429, CECS 444, CECS 445, CECS 448, CECS 449, CECS 451, CECS 474, CECS 478, MATH 323

Take three units of applied electives to be chosen from the following: CECS 455, CECS 470, CECS 472, CECS 475, CECS 476

Take 6 units of a two-semester capstone senior project sequence chosen from the following groups of courses:
- CECS 491A and CECS 491B, or
- CECS 492A and CECS 492B, or
- CECS 493A and CECS 493B

A grade of "C" or better is required in the following courses:
BIOL 153, BIOL 200, BIOL 205, BIOL 207; CEM 310; CHEM 111A, CHEM 111B; CECS 100, CECS 105, CECS 174, CECS 201, CECS 228, CECS 274, CECS 277, CECS 282, CECS 285, CECS 323, CECS 326, CECS 327, CECS 328, CECS 341, CECS 343, CECS 491A, CECS 491B, CECS 492A, CECS 492B, CECS 493A, CECS 493B; EE 210 and EE 210L, EE 380; ENGL 317; ENGR 101, ENGR 102, ENGR 350; MATH 122, MATH 123, MATH 222, MATH 224, MATH 233, MATH 247, MATH 380; PHYS 151, PHYS 152.

Bachelor of Science in Engineering Technology

Technology and Engineering Education Option

For requirements, see the description in the Engineering Technology Programs section of this catalog.

Minor in Computer Science

Requirements

A minimum of 21 units.

Take all of the following:

CECS 174 Introduction to Programming and Problem Solving (3)
*"C" or better required.
Prerequisite: CECS 100 and MATH 113 (or equivalent) all with a grade of "C" or better.

CECS 228 Discrete Structures with Computing Applications (3)
*"C" or better required.
Prerequisites: CECS 174 and MATH 113 or equivalent all with a grade of "C" or better.

CECS 274 Object Oriented Programming and Data Structures (3)
*"C" or better required.
Prerequisite: CECS 174 all with a grade of "C" or better.

CECS 323 Database Fundamentals (3)
Prerequisites: CECS 228 and (CECS 277 or CECS 282) all with a grade of "C" or better.

Take one of the following courses:

CECS 277 Object Oriented Application Development (3)
*"C" or better required.

Prerequisite: CECS 274 with a grade of "C" or better.

CECS 282 C++ for Java Programmers

*"C" or better required.
Prerequisite: CECS 274 with a grade of "C" or better.

Take two courses selected from the following:
CECS 328, CECS 343, CECS 419, CECS 428, CECS 445, CECS 451, CECS 455, CECS 470, CECS 475, CECS 497

Minor in Web Technologies and Applications

Open to all majors except those seeking a B.S. Engineering Technology, Option in Technology and Engineering Education. The minor is conferred concurrently with the BS/BA degree.

This minor will provide the technical skills not included in non-technical degrees, but required for success in a highly technical world. Students will gain an understanding of the system design process and learn to acquire and evaluate information from the internet and to communicate information via the internet including ethical issues encountered. In addition, students will learn to create a robust, useable, and accessible website.

Requirements

A minimum of 18 units as specified below.

Complete the 12 core units:

CECS 100 Critical Thinking in the Digital Information Age (3)
Prerequisite/Corequisite: ENGL 100 or GE Composition (Area A1).

CECS 110 Beginning Web Design (3)

*"C" or better required.
Prerequisites: None.

CECS 200 Intermediate Web Design (3)

*"C" or better required.
Prerequisite: CECS 110 with a grade of "C" or better.
Prerequisite/Corequisite: CECS 100.

CECS 300 Design of Dynamic Web Sites (3)
Prerequisite: CECS 200 with a grade of "C" or better.

Complete 6 units from the following list of electives:
ART 366; CECS 323, CECS 410, CECS 412, CECS 470; ENGR 350; ETEC 435; IS 380, IS 445, IS 484; MKTG 437; PSY 327

Minor in Computer Science Applications

This minor is not open to students majoring in Computer Science or Computer Engineering.

This minor is designed to prepare students to write small programs and to maintain and upgrade PC software and hardware as well as understand how to set up a local area network. In addition it prepares students to be able to design and implement web applications.

Requirements

Completion of 18 units.

Complete the 12 core units:

CECS 110 Beginning Web Design (3)

*"C" or better required.
Prerequisites: None.

CECS 174 Intro to Programming & Problem Solving (3)
Prerequisite: CECS 100 and MATH 113 (or equivalent) all with a grade of "C" or better.

CECS 200 Intermediate Web Design (3)
Prerequisite: CECS 110 with a grade of "C" or better.
Prerequisite/Corequisite: CECS 100.

CECS 410 Computers and Networks (3)
Prerequisite: Course design assumes familiarity with computers.

Complete 6 units from the following list of electives:
CECS 300, CECS 412; IS 300, IS 340, IS 343; ETEC 435.

Certificate in Web Technologies and Applications

Open to all majors except those with or seeking a B.S. Engineering Technology, Option in Technology and Engineering Education. The certificate is conferred as a post-baccalaureate certificate or concurrently with the BS/BA degree.

This certificate will prepare students to work with a variety of technologies including computers and related technologies and the proper setup and operation of equipment along with valuable troubleshooting skills. Students will gain an understanding of the system design process and learn to acquire and evaluate information from the internet and to communicate information via the internet including ethical issues. They will learn to create a robust, useable, and accessible website.

Please be aware that this program is not eligible for Financial Aid unless pursued concurrently with a degree program.

Requirements

A minimum of 24 units as specified below

Complete the 18 core units:

CECS 100 Critical Thinking in the Digital Information Age (3)
Prerequisite/Corequisite: ENGL 100 or GE Composition (Area A1)

CECS 110 Beginning Web Design (3)

*"C" or better required.
Prerequisites: None.

CECS 200 Intermediate Web Design (3)

*"C" or better required.
Prerequisite: CECS 110 with a grade of "C" or better.
Prerequisite/Corequisite: CECS 100.

CECS 300 Design of Dynamic Web Sites (3)
Prerequisite: CECS 200 with a grade of "C" or better.

CECS 410 Computers and Networks (3)
Prerequisite: Course design assumes familiarity with computers.

CECS 412 Intro to Computer Network Architectures (3)
Prerequisite: Familiarity with computers.

Complete 6 units from the following list of electives:
ART 366; CECS 323, CECS 470; ENGR 350; ETEC 435; IS 380, IS 445, IS 484; MKTG 437; PSY 327

Graduate Programs

Mission

The mission of the graduate program in Computer engineering and Computer Science at CSULB is to provide a high-quality educational experience and the technical specialization required to become successful leaders in industry. The program also prepares the students to pursue advanced degrees if they so desire. The graduate program involves advanced courses in analysis and design in computer software and hardware. The students may choose to do a thesis or take a comprehensive examination as the culmination of their program.

Program Objectives

Graduates of the MS program will:

1. have technical competency in their field of study.
2. have technical knowledge and skills needed to conduct independent and/or innovative research.
3. keep current with state of the art technologies and advancements in their area.

Master of Science in Computer Science

Admission Procedures

To be considered for admission the graduate applicant must have earned a bachelor's degree in computer engineering, computer science or sufficient background in computer engineering or computer science from a college or university with a minimum grade point average (GPA) of 2.7 in the last 60 semester or 90 quarter upper division major units attempted. The general Graduate Record Examination (GRE) is strongly recommended.

Option in Computer Engineering

This option offers advanced study in the theory, analysis, design and applications of both computer hardware and software.

Prerequisites

1. A bachelor's degree in computer engineering, computer science or sufficient background in computer engineering from a college or university with a minimum grade point average (GPA) of 2.7 in the last 60 semester units or 90 quarter upper division major units attempted.

2. The general Graduate Record Examination (GRE) is strongly recommended.

Requirements

Students must complete a minimum of 30 graduate and approved upper-division course units including the following:

1. At least 21 units at the graduate level of instruction;
2. 12 units of required courses consisting of:
   A. CECS 460 System on Chip Design (3)
      Prerequisite: CECS 360 with a grade of "C" or better..
   B. CECS 530 Advanced Computer Architecture I (3)
      *"C" or better required.
      Prerequisite: CECS 341 or CECS 440 with a grade of "C" or better.
   C. One course from the following:
      CECS 531 Advanced Computer Architecture II (3)
      Prerequisite: CECS 530 with a grade of "C" or better.
      CECS 546 Fault Tolerant Computing Systems (3)
      Prerequisite: CECS 341 or CECS 440 with a grade of C or better.
   D. One course from the following:
      CECS 526 Advanced Operating Systems (3)
      Prerequisites: CECS 228 and CECS 326 all with a grade of "C" or better.
      CECS 528 Advanced Analysis of Algorithms (3)
      Prerequisites: CECS 328, MATH 380 or EE 380 all with a grade of "C" or better.
3. All students must complete one of the following:
   A. Comprehensive examination
   B. Project with oral presentation, which requires 3 units of CECS 697, an oral defense, and submission of a formal written report of the project to be approved by a committee of 3 faculty members that includes the supervising faculty of the project.
      To be eligible for the option a student must:
      a) have advanced to candidacy,
      b) have maintained a GPA of 3.3 or above in the MSCS coursework,
      c) have been nominated by a faculty member to undertake a project under that faculty member's supervision, and
      d) have had a project proposal approved by the CECS Graduate Curriculum Committee.
   C. Thesis with oral defense, which requires a total of 6 units. At least 3 of the units must be taken from CECS 698 and the remaining units may be taken from either CECS 697 or CECS 698. To be eligible for the option a student must:
      a) have advanced to candidacy,
      b) have maintained a GPA of 3.3 or above in the MSCS coursework,
      c) have been nominated by a faculty member to undertake a thesis under that faculty member's supervision, and
      d) have had a thesis proposal approved by the CECS Graduate Curriculum Committee.

Option in Computer Science

This option offers advanced study in software development and engineering, networking, operating systems, distributed computing, artificial intelligence, security, and analysis of algorithms.

Prerequisites

1. A bachelor's degree in computer science, computer engineering or sufficient background in computer science from a college or university with a minimum grade point average (GPA) of 2.7 in the last 60 semester or 90 quarter upper division major units attempted.
2. The general Graduate Record Examination (GRE) is strongly recommended.

Requirements

Students must complete a minimum of 30 graduate and approved upper-division course units including the following:

1. At least 21 units at the graduate level of instruction;
2. 12 units of required courses consisting of:
   A. CECS 528 Advanced Analysis of Algorithms (3)
      Prerequisites: CECS 328, MATH 380 or EE 380 all with a grade of "C" or better.
   B. One course from the following:
      CECS 526 Advanced Operating Systems (3)
      Prerequisites: CECS 228 and CECS 326 with a grade of "C" or better.
      CECS 530 Advanced Computer Architecture I (3)

Prerequisite: CECS 341 or CECS 440 with a grade of "C" or better.

C. Two courses from the following:
CECS 521, CECS 531, CECS 543, CECS 546, CECS 572, CECS 575

3. All students must complete one of the following:
A. Comprehensive examination
B. Project with oral presentation, which requires 3 units of CECS 697, an oral defense, and submission of a formal written report of the project to be approved by a committee of 3 faculty members that includes the supervising faculty of the project. To be eligible for the option a student must:
a) have advanced to candidacy,
b) have maintained a GPA of 3.3 or above in the MSCS coursework,
c) have been nominated by a faculty member to undertake a project under that faculty member's supervision, and
d) have had a project proposal approved by the CECS Graduate Curriculum Committee.
C. Thesis with oral defense which requires a total of 6 units. At least 3 of the units must be taken from CECS 698 and the remainig units may be taken from either CECS 697 or CECS 698. To be eligible for the option a student must:
a) have advanced to candidacy,
b) have maintained a GPA of 3.3 or above in the MSCS coursework,
c) have been nominated by a faculty member to undertake a thesis under that faculty member's supervision, and
d) have had a thesis proposal approved by the CECS Graduate Curriculum Committee.

Advancement to Candidacy for Both Options

Students applying for advancement to candidacy must:
1. have completed all undergraduate deficiencies with grades of "C" or better;
2. have attained an overall grade point average (GPA) of 3.0;
3. have completed at least 12 units of required courses applicable to the degree with a GPA of at least 3.0 for the completed units;
4. have fulfilled the Graduation Writing Assessment Requirement (GWAR);
5. and have their plans of studies approved by the CECS department graduate advisor.

Computer Engineering and Computer Science Courses (CECS)

LOWER DIVISION

100. Critical Thinking in the Digital Information Age (3)

Prerequisite/Corequisite: ENGL 100 or GE Composition (Area A1).

Help students develop critical thinking skills using technical software. Main topics include: identifying engineering issues for investigation, developing planning and problem solving strategies, locating pertinent information and examples, critically analyzing these sources, forming and testing hypotheses, synthesizing and organizing results for effective communication, and developing transferable problem solving skills.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

105. Introduction to Computer Engineering and Computer Science (1)

Introduction to the fields of computer engineering and computer science. Current and future trends and challenges in various fields of computing. Social, ethical and economical issues related to computing technology. Exploration of career and professional development opportunities.

(Lecture 1 hour) Letter grade only (A-F).

110. Beginning Web Design (3)

Introduction to HTML and CSS using modern tools, following the W3C guidelines for coding. Web sites designed with usability and accessibility principles implemented. Overview of graphics, video, sound, JavaScript and Dreamweaver.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

174. Introduction to Programming and Problem Solving (3)

Prerequisite: CECS 100 and MATH 113 (or equivalent) all with a grade of "C" or better.

Introduction to basic concepts of computer science and fundamental techniques for solving problems using the Java programming language. Structured problem solving, object-oriented programming, programming style. Applications to numerical and non-numerical problems.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

200. Intermediate Web Design (3)

Prerequisite: CECS 110 with a grade of "C" or better.
Prerequisite/Corequisite: CECS 100.

Intermediate HTML and CSS using Dreamweaver, following the W3C guidelines for coding. Web sites designed with usability and accessibility principles implemented.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

201. Computer Logic Design I (3)

Prerequisite: MATH 113 or equivalent all with a grade of "C" or better.

Basic topics in combinational and sequential switching circuits with applications to the design of digital devices. Introduction to Electronic Design Automation (EDA) tools. Laboratory projects with Field Programmable Gate Arrays (FPGA).

(Lecture 2 hours, lab 3 hours) Letter grade only (A-F).

202. The Digital Information Age (3)

Prerequisite: GE Foundation requirements.

The introduction and use of common-place digital and electronic devices and how this technology affects our society. Topics include advances in 3D imaging, 3D printing, Processors, Memory, Security and Privacy.

(Lecture 3 hours) Letter grade only (A-F).

211. Principles of Computer Engineering I (3)

Prerequisite: MATH 122 with a grade of "C" or better.

Basic principles of analysis and design of computer-based circuits. Application of transistors, logic families, digital, devices in computer and embedded processor interfacing, importance of phasors and the complex plane. Basic DC/AC circuit fundamentals. Laboratory safety.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

228. Discrete Structures with Computing Applications (3)

Prerequisites: CECS 174 and MATH 113 or equivalent all with a grade of "C" or better.

An introduction to discrete mathematics with applications towards computing. Topics include sets, functions, logic, relations, graphs, trees, recursion, combinatorics, and mathematical reasoning.

Letter grade only (A-F). (Lecture 2 hours, laboratory/problem session 3 hours)

229. Discrete Structures with Computing Applications II (3)

Prerequisites: MATH 123 and CECS 228 both with a Grade of "C" or better

This is the second course in a two-course sequence in computing applications of discrete structures. Topics include applications of computer arithmetic and matrices in computer systems. Programming assignments in Python will be provided.

Letter grade only (A-F). (Lecture 2 hours, Laboratory 3 hours)

262. Introduction to Embedded System Programming (3)

Prerequisites: CECS 174 and CECS 201 all with a grade of "C" or better.

Introduction to embedded system architecture, memory organization and programming using C. Interfacing with external I/O devices, Use of internal special function registers. Development tools and extended C instructions unique to embedded systems. Course will be taught using an embedded processor development board.

(Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

271. Introduction to Numerical Methods (3)

Prerequisites: CECS 174 and MATH 123 all with a grade of "C" or better.

Matrix computations. Linear algebra fundamentals. Numerical methods for algebraic equations. Systems of linear equations. Curve fitting. Least squares. Interpolation. Fourier transform. Frequency domain concepts. Numerical integration and differentiation. Ordinary differential equations. Use of MATLAB or equivalent for algorithm implementation.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

274. Object Oriented Programming and Data Structures (3)

Prerequisite: CECS 174 with a grade of "C" or better.

Disciplined methods of design, coding and testing using the Java programming language. Data abstraction, object-oriented design. Introduction to data structures (linked lists, stacks, queues and trees.) Recursion. Sorting and searching.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

277. Object Oriented Application Development (3)

Prerequisite: CECS 274 with a grade of "C" or better.

Advanced introduction to the fundamentals of computer science and software engineering methodology. Advanced programming techniques and design methodology typically used in large programming projects using the Java programming language.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

282. C++ for Java Programmers (3)

Prerequisite: CECS 274 with a grade of "C" or better.

Structured and Object Oriented Programming in C++. Common features and differences between Java and C++. Pointers, references, and memory management, stream I/O, classes, operator overloading, exception handling, STL.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

285. Computer Organization and Assembly Language Programming (3)

Prerequisites: CECS 201, CECS 274 all with a grade of "C" or better.

Study of computer organization and assembly language programming using embedded processor based systems to solve practical problems. Laboratory projects using embedded system software development and hardware simulation tools. Hands-on projects using hardware prototyping boards.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

UPPER DIVISION

300. Design of Dynamic Web Sites (3)

Prerequisite: CECS 200 with a grade of "C" or better.

Dynamic Web design using modern tools. Creation of domains, using hosting services and content management systems. Website portability, usability and accessibility.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

301. Computer Logic Design II (3)

Prerequisites: CECS 174, CECS 201 all with a grade of "C" or better.

Sequential logic emphasizing Finite State Machine design & analysis, timing analysis of sequential logic, Introduction to Data Path, Control and Memory. Use of Electronic Design Automation (EDA) tools for design, simulation, verification. Laboratory projects with Field Programmable Gate Arrays (FPGA's).

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

311. Principles of Computer Engineering II (3)

Prerequisites: CECS 201 and CECS 211 all with a grade of "C" or better.

Embedded system components. Bipolar and MOS devices and switching circuits. Embedded systems signal processing with operational amplifiers. Digital/analog interfacing including A/D and D/A converters. Schematic capture, analysis and implementation of embedded signal processing algorithms. Fundamentals of digital communication.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

323. Database Fundamentals (3)

Prerequisites: CECS 228 and (CECS 277 or CECS 282) all with a grade of C or better.

Fundamental topics on database management. Topics include entity-relationship models, database design, data definition language, the relational model, data manipulation language, database application programming and normalization.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

326. Operating Systems (3)

Prerequisites: CECS 282 and either CECS 285 or CECS 346 all with a grade of "C" or better.

The structure and functions of operating systems. Interrupt handling, processes and interprocess communication, memory management, resource scheduling, information sharing and protection. Project implementation in C/C++.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

327. Introduction to Networks and Distributed Computing (3)

Prerequisite: CECS 326 with a grade of "C" or better.

Introduction to Distributed Computing and Inter-process Communication. Networking Protocols, Client Server Paradigm, Peer-to-Peer Networking, Sockets and Sockets API, Distributed Objects, Cloud Computing.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

328. Data Structures and Algorithms (3)

Prerequisite: CECS 228 with a grade of "C" or better.
Corequisite: CECS 277.

A broad view of data structures and the structure-preserving operations on them. Abstract data types, algorithms, complexity. Programming projects to exemplify these concepts.

341. Computer Architecture and Organization (3)

Prerequisites: CECS 285 with a grade of "C" or better.

Review of logic design. Instruction set architecture. Arithmetic logic units. Data path and control. Pipelining and performance. Memory system organization and design. Virtual memory and paging. I/O interfacing. Vector and array processing. Distributed computing and supercomputing. Contemporary computer designs.

(Lecture 2 hours, laboratory, 3 hours) Letter grade only (A-F).

343. Introduction to Software Engineering (3)

Prerequisites: CECS 277 or CECS 282 all with a grade of "C" or better.

Principles of software engineering, UML, modeling large software systems, requirements elicitation, object oriented analysis and design using UML, introduction to design patterns, implementation of large systems, software testing, project management, the software lifecycle. Semester long programming project.

Letter grade only (A-F). (Lecture 2 hours, lab 3 hours)

346. Microprocessors and Controllers I (3)

Prerequisites: CECS 211 and CECS 262 all with a grade of "C" or better.

Intro microprocessor/controller, embedded programming and design. Basic computer organization, representation of information and instruction, addressing techniques, input/output, assembly language programming. Introduction to assemblers, linkage editors and loaders. Study of the 8051. Design of microprocessor-based systems.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

347. Microprocessors and Controllers II (3)

Prerequisites: CECS 301, CECS 311, and CECS 346 all with a grade of "C" or better.

Study of embedded processor applications and interfacing. Embedded systems design, control of external devices, embedded programming in C and assembly. A/D and D/A converters, digital signal processing, motor and LCD controllers. Laboratory implementation of embedded designs and hardware-assisted debugging.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

360. Integrated Circuit Design Software (3)

Prerequisites: CECS 301, CECS 346, MATH 123 or MATH 222 all with a grade of "C" or better.

Introduction to Computer Aided Design tools used in the design and fabrication of integrated circuits. Discussion of the IC fabrication process, the layout and routing of basic gates, transistor level design of gates, synthesis and RTL level design, floor planning, and IC development costs.

(Lecture 2 hours, lab 3 hours) Letter grade only (A-F).

406. Selected Topics in Computer Science (3)

Prerequisite: Senior standing in the computer science major.

Each offering is based upon an area of computer science and technology in which recent advances have been made.

Letter grade only (A-F). May be repeated to a maximum of 6 units with different topics in different semesters. Topics announced in the *Schedule of Classes*. (Lecture 2 hours, laboratory 3 hours)

410. Computers and Networks (3)

Prerequisite: Course design assumes familiarity with computers.

Gain practical, hands-on experience in installing hardware and software on a PC. Learn what a computer network is and how it is similar to the telephone network. Learn the parts that make up a computer and a network.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

412. Introduction to Computer Network Architectures (3)

Prerequisite: Familiarity with computers

Beginning course in computer networking designed to provide a grasp of network architectures through lecture/hands-on laboratory assignments. Overview of networking concepts and design essentials. Networking media and NICs. Network communications/protocols focusing on TCP/IP. Local area networks. Networking administration. Networking problems.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

419./519. Theory of Computation (3)

Prerequisite: CECS 328 with a grade of "C" or better.

Finite Automata and regular expressions. Pushdown automata and context-free languages. Turing machines and computability. Computational complexity.

Letter grade only (A-F). Additional projects required for CECS 519. (Lecture-problems 3 hours)

424. Organization of Programming Languages (3)

Prerequisites: CECS 326 and CECS 328 all with a grade of "C" or better.

Understanding the variety of programming languages and the design trade-offs between current programming language paradigms. Comparison of programming languages in their design, implementation, and run-time supports. Includes programming projects.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

428. Analysis of Algorithms (3)

Prerequisite: CECS 328 with a grade of "C" or better.

Applications of standard combinatorial techniques to applied programming problems. Rigorous analysis of correctness/complexity of algorithms. Advanced graph algorithms are emphasized. Topics include shortest paths on graphs, sorting, string matching, union find problem, divide-and-conquer technique, and weighted-edge problem.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

429./529. Search Engine Technology (3)

Prerequisites: CECS 323 and CECS 328, MATH 380 or EE 380 all with a grade of "C" or better.

Models, algorithms, and evaluation of the retrieval of information from a collection of documents. Document preprocessing. Indexing and searching. Retrieval evaluation. Search engines.

Additional projects required for CECS 529. (Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

440. Computer Architecture (3)

Prerequisites: CECS 346 with a grade of "C" or better.

Review of logic design. Register transfer and micro-operations. Basic computer organization. Central processor organization. Microprogram control organization. Arithmetic processor design. Arithmetic algorithms. Input-output organization. Memory organization.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

444. Compiler Construction (3)

Prerequisites: CECS 285 and CECS 328 all with a grade of "C" or better.

Syntax directed compiler study. Organization of a compiler and overall design: parsing, semantic analysis, optimization and code generation.

(Lecture 3 hours, laboratory 3 hours) Letter grade only (A-F).

445. Software Design and Architecture (3)

Prerequisites: CECS 343 with a grade of "C" or better and senior standing .

In-depth look at software design, design patterns, frameworks, architectures and middleware architectures. Component based design including COM, Corba, and .Net. Fundamentals of software metrics, measuring software qualities. Basics of software evolution, reengineering, and reverse engineering. A semester long team project.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

447. Microprocessors and Controllers III (3)

Prerequisite: CECS 347 with a grade of "C" or better.

Embedded system applications and techniques. Real-time multi-tasking systems, schedulers, kernels, and operating systems for embedded processors. Advanced I/O technologies - CAN, I2C, Ethernet. Embedded Internet applications. Polling vs. interrupt handling. Lab implementation of embedded designs and hardware-assisted debugging.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

448. User Interface Design (3)

Prerequisite: CECS 343 with a grade of "C" or better or consent of instructor.

Evaluation, design and programming of user interface systems. Fundamentals of human cognition, system characteristics, and the interaction between humans and systems. Usability methods and user/task-centered design. Tools for designing and building user interfaces, with emphasis on rapid applications development.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

449. Computer Graphics (3)

Prerequisites: MATH 247, CECS 282 and CECS 328 all with a grade of "C" or better.

Introduction to the theory and practice of computer graphics, Graphics systems, 2-D and 3-D modeling, transformations, viewing transformations, projections, rendering techniques.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

451. Artificial Intelligence (3)

Prerequisites: CECS 277 and CECS 328 all with a grade of "C" or better.

Introduction to the history and implementation of artificial intelligence agents. Topics include search, constraint satisfaction, game-playing, logical agents, belief networks, optimal sequential decision systems. Project implementation.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

453. Mobile Application Development (3)

Prerequisite: CECS 328 with a grade of "C" or better or consent of the instructor.

Languages and application programming interfaces for mobile device platforms. Development of thick and thin client applications for mobile devices.

Letter grade only (A-F). (Lecture 2 hours, Laboratory 3 hours)

455. Introduction to Game Programming (3)

Prerequisite: CECS 328 with a grade of "C" or better or consent of instructor.

Introduction to game programming and graphics. “Slow” games. Real-time games with no adversary. Adversarial real-time games in 2-D.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

460. System on Chip Design (3)

Prerequisite: CECS 360 with a grade of "C" or better.

Complete System on Chip (SOC) design flow from design specification to working SOC. Creation of RTL level modules designed for reuse, integration of Intellectual Property (IP) for RTL and physical level IP, IC verification, creation of self-checking test benches for designs.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

461./561. Hardware/Software Co-design (3)

Prerequisite: CECS 341 or CECS 440 all with a grade of "C" or better.

Introduction to top-down methods for hardware/software system-on-chip co-design. Design flow – system specification, software implementation, hardware synthesis, system design, and verification. Process optimization with various design decisions emphasized. Projects/case studies using system-level design methods and tools.

Additional projects required for CECS 561. (Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

463. System on Chip (SOC) Applications (3)

Prerequisite: CECS 360 with a grade of "C" or better.

System on Chip (SOC) design applications. Study of a variety of signal processing SOC designs and ASIC algorithms. Class projects emphasizing hardware/software integration with use of FPGA/CPLD devices. Design reviews, specification, team design implementation with project planning and tracking for system level design applications.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

470. Web Programming and Accessibility (3)

Prerequisites: CECS 323 and CECS 343 all with a grade of "C" or better.

Introduction to World-Wide Web development. Accessibility issues. Web architecture, standards, and programming, emphasizing XML technologies and cascading style sheets. Visual design principles and information architecture. Client-side and server-side programming and protocols. Development for adaptive technologies and mobile devices.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

472. Computer Network Programming (3)

Prerequisites: CECS 326 all with a grade of "C" or better.

Fundamentals of computer network programming. Client-server programming. Concepts of computer network programming including the RPC Procedure Call, CORBA, multicasts, and broadcasts.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

474. Computer Network Interoperability (3)

Prerequisite: CECS 326 with a grade of "C" or better.

Overview of computer network theory and practice from a systems perspective. Topics include network infrastructure, local area network (LAN) protocols, wide area network (WAN) protocols, switching technologies, Internet Protocol (IP), Transmission Control Protocol (TCP), network security, and network configuration, design, and performance.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

475. Application Programming Using .NET (3)

Prerequisite: CECS 343 with a grade of "C" or better.

Introduction to enterprise application development utilizing the .NET environment. Topics include object-oriented design, events, databases, multithreading, web server applications, web services and cloud computing. Individual projects as well as a team project required.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

476. System and Network Administration (3)

Prerequisites: CECS 326 with a grade of "C" or better.

Introduction to the management and administration of Unix systems and TCP/IP networks. Managing users, local and network file systems, electronic mail, print queues. Establishing and managing a network.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

478. Introduction to Computer Security (3)

Prerequisite: CECS 328 with a grade of "C" or better.

Controlling the risk of computer security. Security threats and vulnerabilities in the development and use of computer systems. Tools and controls that can reduce or block these threats. Law, privacy and ethics.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

490A. Computer Engineering Senior Project I (3)

Prerequisites: CECS 347 with a grade of "C" or better, senior standing.

The first in a two-course capstone senior project in computer engineering that fulfills GE integrative learning. Students work in teams to define a problem, complete a design and provide both a written report and a multimedia presentation at the end of the semester.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

490B. Computer Engineering Senior Project II (3)

Prerequisites: CECS 490A, with a grade of "C" or better and consent of instructor.

Second of a two-semester capstone senior project in computer engineering that fulfills GE integrative learning. Student teams will build, program and verify operation of project started in prior design course. Student teams must submit a written report, give an oral multimedia presentation and provide a working demonstration.

(Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

491A. Software Engineering Project I (3)

Prerequisites: ENGR 350 and CECS 343 all with a grade "C" or better.

First course in a two-course capstone design sequence that fulfills integrative learning. Design of a commercial grade software application including requirements analysis, functional, architectural and detailed design, emphasizing written communication, teamwork and the Object-Oriented Methodology.

Letter grade only (A-F), (Lecture 2 hours, laboratory 3 hours)

491B. Software Engineering Project II (3)

Prerequisite: CECS 491A with a grade "C" or better.

Second course in a two-course capstone design sequence that fulfills integrative learning. Implementation, testing, packaging and deployment of the system designed in CECS 491A emphasizing written communication, teamwork and the Object-Oriented Methodology.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

492A. Distributed and Cloud Computing Project I (3)

Prerequisites: ENGR 350, CECS 327 and CECS 343 all with a grade "C" or better.

First course in a two-course capstone design sequence. Design of a distributed or cloud computing application. Design experience, including detailed requirement analysis, design decisions, teamwork, written reports and oral presentation.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

492B. Distributed and Cloud Computing Project II (3)

Prerequisite: CECS 492A with a grade "C" or better.

Second course in a two-course capstone design sequence. Implementation of a distributed or cloud computing application. Implementation experience, including detailed documentation, testing and evaluation of the implementation, teamwork, written reports and oral presentation.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

493A. Database Web Application Project I (3)

Prerequisites: CECS 323 and CECS 343 all with a grade "C" or better.

Corequisite: ENGR 350.

First of a two-course capstone senior project in computer science that fulfills GE integrative learning. Propose, design, and prototype a data-intensive web application. Object-oriented modeling, analysis and software engineering. Teamwork, written report and oral presentation required.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

493B. Database Web Application Project II (3)

Prerequisite: CECS 493A with a grade "C" or better .

Second of a two-course capstone senior project in computer science that fulfills GE integrative learning. Design, implement, test and deploy a data-intensive web application. Requires object oriented and test-driven development. Teamwork, written report and oral presentation required.

Letter grade only (A-F). (Lecture 2 hours, laboratory 3 hours)

495. Computational Physiology (3)

Prerequisite: EE 380 with a grade of "C" or better

This course will introduce students to cardiovascular (heart) and cerebrovascular (brain) systems and signals, and the computational methods to analyze related signals, and detect/predict a physiological event of interest.

Same course as: EE 495. Not open for credit to students with credit in EE 495.

Letter Grade only (A-F). (Lecture 2 hours, Laboratory 3 hours).

496. Computer Science Problem Solving (1)

Prerequisites: CECS 274 with a grade of "C" or better and consent of instructor.

Problem solving in Computer Science. Theory necessary to solve computer science problems and the solutions to the problems. Problems studied will involve applications of graph theory, data structures, recursion, and algorithms.

(Lecture 1 hour) May be repeated to a maximum of 6 units in different semesters. Letter grade only (A-F).

497. Directed Studies (1–3)

Prerequisite: Consent of instructor.

Assigned study in topics in current computer literature or computer-related projects with a final report.

May be repeated to a maximum of 6 units with written consent of the Department Chair.

GRADUATE LEVEL

519./419. Theory of Computation (3)

Prerequisite: CECS 328 with a grade of "C" or better.

Finite Automata and regular expressions. Pushdown automata and context-free languages. Turing machines and computability. Computational complexity.

Additional projects required for CECS 519. (Lecture-problems 3 hours) Letter grade only (A-F).

521./621. Database Architecture (3)

Prerequisites: CECS 328 and CECS 323 or CECS 421 all with a grade of "C" or better.

Relational database design theory-a rigorous approach. Security, recovery, transaction management, distributed databases and query optimization.

Master's students register in CECS 521 or CECS 621; Ph.D. students register in CECS 621. Additional projects required for CECS 621. (Lecture-problems 3 hours) Letter grade only (A-F).

524./624. Advanced Topics in Programming Languages (3)

Prerequisite: CECS 424 with a grade of "C" or better.

Intensive study of languages of current interest which support object-oriented, client-server, and multimedia applications (e.g. JAVA).

Master's students register in CECS 524 or CECS 624; Ph.D. students register in CECS 624. Additional projects required for CECS 624. (Lecture-problems 3 hours) Letter grade only (A-F).

526./626. Advanced Operating Systems (3)

Prerequisites: CECS 228 and CECS 326 all with a grade of "C" or better.

Theoretical foundations of concepts applied in the design of operating systems. Control of concurrent processes, deadlocks, mutual exclusion, virtual memory, resource management and scheduling.

Master's students register in CECS 526 or CECS 626; Ph.D. students register in CECS 626. Additional projects required for CECS 626. (Lecture–problems 3 hours) Letter grade only (A-F).

528./628. Advanced Analysis of Algorithms (3)

Prerequisites: CECS 328, MATH 380 or EE 380 all with a grade of "C" or better.

Theoretical analysis of algorithms. Divide and conquer, dynamic programming and greedy algorithms; basic search and traversal techniques including search trees; sorting; matrix manipulations; NP–completeness.

Master's students register in CECS 528 or CECS 628; Ph.D. students register in CECS 628. Additional projects required for CECS 628. (Lecture–problems 3 hours) Letter grade only (A-F).

529./429. Search Engine Technology (3)

Prerequisites: CECS 323 and CECS 328, MATH 380 or EE 380 all with a grade of "C" or better.

Models, algorithms, and evaluation of the retrieval of information from a collection of documents. Document preprocessing. Indexing and searching. Retrieval evaluation. Search engines.

Additional projects required for CECS 529. (Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

530./630. Advanced Computer Architecture I (3)

Prerequisite: CECS 341 or CECS 440 all with a grade of "C" or better.

Fundamentals of computer architecture. Description of architecture and description languages. Basic computer design and central processor implementation. Memory hierarchy and input/output. Pipelining. Vector processor, multiprocessor systems and dataflow machines.

Master's students register in CECS 530 or CECS 630; Ph.D. students register in CECS 630. Additional projects required for CECS 630. (Lecture-problems 3 hours) Letter grade only (A-F).

531./631. Advanced Computer Architecture II (3)

Prerequisite: CECS 530 with a grade of "C" or better.

Advanced computer architecture with emphasis on parallel processing. Vector processors and multiprocessor systems. Dataflow computation. RISC/CISC. Hypercube. Parallel software. Applications in artificial intelligence, signal/image processing, neural network and optical computing.

Master's students register in CECS 531 or CECS 631; Ph.D. students register in CECS 631. Additional projects required for CECS 631. (Lecture–problems 3 hours) Letter grade only (A-F).

532. Memory Design and Implementation (3)

Prerequisite: CECS 341 or CECS 440 all with a grade of "C" or better.

Logic design and operation, physical design and operation, performance characteristics, design trade-offs, energy consumption of modern memory hierarchies, memory errors and error correction.

Letter grade only (A-F). (Lecture-problems 3 hours)

543./643. Advanced Software Engineering (3)

Prerequisite: CECS 343 all with a grade of "C" or better.

Study of software engineering as a broad, problem–solving discipline. Includes structured programming and software project management.

Master's students register in CECS 543 or CECS 643; Ph.D. students register in CECS 643. Additional projects required for CECS 643. (Lecture-problems 3 hours) Letter grade only (A-F).

544./644. Software Testing and Verification (3)

Prerequisite: CECS 543 with a grade of "C" or better.

Testing/verification techniques for software development including black box, white box, incremental, top-down and bottom-up, static and dynamic, performance, regression, thread, and stress testing. Object-oriented software testing with a hierarchical approach. Metrics for test, and verification will be introduced.

Master's students register in CECS 544 or CECS 644; Ph.D. students register in CECS 644. Additional projects required for CECS 644. (Lecture-problems 3 hours) Letter grade only (A-F).

545./645. Software Architecture (3)

Prerequisite: CECS 543 with a grade of "C" or better.

Includes architectural styles, pipes and filters, data abstraction and object-oriented organization, event-based, implicit invocation, layered systems, repositories, interpreters, process control, distributed processes, domain-specific software & heterogeneous architectures. Component-based design patterns & case studies.

Master's students register in CECS 545 or CECS 645; Ph.D. students register in CECS 645. Additional projects required for CECS 645. (Lecture-problems 3 hours) Letter grade only (A-F).

546./646. Fault Tolerant Computing Systems (3)

Prerequisite: CECS 341 or CECS 440 with a grade of "C" or better.

Fault tolerant techniques are studied as tools to assure the reliability and continuous availability of computing systems. Case studies of modern fault tolerant systems reviewed. Software fault tolerant systems studied as alternatives to verification and validation approaches to software reliability.

Master's students register in CECS 546 or CECS 646; Ph.D. students register in CECS 646. Additional projects required for CECS 646. (Lecture–problems 3 hours) Letter grade only (A-F).

547./647. Software Maintenance, Reengineering and Reuse (3)

Prerequisite: CECS 343 or equivalent with a grade of "C" or better.

Introduction to software maintenance, defect management, corrective, adaptive and perfective maintenance. Evolution of legacy software systems. Program comprehension techniques, reverse engineering, restructuring, refactoring of software systems. Software re-engineering, data reverse engineering. Software reuse. Impact analysis, regression testing.

Master's students register in CECS 547 or CECS 647; Ph.D. students register in CECS 647. Additional projects required for CECS 647. (Lecture-problems 3 hours) Letter grade only (A-F).

549./649. Advanced Computer Graphics (3)

Prerequisite: CECS 449 with a grade of "C" or better.

Three-dimensional representations, transformations and viewing. Color models and modeling methods. Hidden-line and hidden-surface removal. Lighting and shading. Visual realism. Topics of current interest.

Master's students register in CECS 549 or CECS 649; Ph.D. students register in CECS 649. Additional projects required for CECS 649. (Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

550./650. Pattern Recognition Using Artificial Intelligence (3)

Prerequisite: CECS 451 with a grade of "C" or better or consent of instructor.

General concepts of pattern recognition and trainable classifiers, decision theory, supervised learning, non-parametric techniques, rule-based systems and neural networks.

Master's students register in CECS 550; Ph.D. students register in CECS 650. Additional projects required for CECS 650. (Lecture-problems 2 hours, laboratory 3 hours) Not open for credit to students with credit in CECS 750. Letter grade only (A-F).

551./651. Advanced Artificial Intelligence (3)

Prerequisite: CECS 451 with a grade of "C" or better.

Advanced concepts in artificial intelligence. Topics include knowledge acquisition and representation, fuzzy logic, logical reasoning, multi-sensor integration, Dempster-Shafer's theory of evidential reasoning, real-time expert systems and neural networks.

Master's students register in CECS 551 or CECS 651; Ph.D. students register in CECS 651.Additional projects required for CECS 651. (Lecture-problems 3 hours) Letter grade only (A-F).

552. Computer Simulation and Modeling (3)

Prerequisites: EE 380 (or MATH 380) and CECS 326 all with a grade of "C" or better.

Studies of general purpose and special simulation software. Model verification including graphical models Applications in various areas.

Master's students register in CECS 552 or CECS 652; Ph.D. students register in CECS 652. Additional projects required for CECS 652. (Lecture-problems 3 hours) Letter grade only (A-F).

553./653. Machine Vision (3)

Prerequisite: Graduate standing in engineering or computer science.

Discussion and laboratory implementation of current research in vision and image understanding. Topics include image formation, early processing, segmentation, relational structures in 2-D and 3-D, motion, stereo, 3-D reconstruction, morphological methods and computer architecture for machine vision.

Master's students register in CECS 553 or CECS 653; Ph.D. students register in CECS 653. Additional projects required for CECS 653. (Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

561./461. Hardware/Software Co-design (3)

Prerequisite: CECS 341 or CECS 440 all with a grade of "C" or better.

Introduction to top-down methods for hardware/software system-on-chip co-design. Design flow – system specification, software implementation, hardware synthesis, system design, and verification. Process optimization with various design decisions emphasized. Projects/case studies using system-level design methods and tools.

Additional projects required for CECS 561. (Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

570./670. Concurrent Parallel Programming (3)

Prerequisite: CECS 328, or CECS 341, or CECS 440 all with a grade of "C" or better.

Introduction to concurrent and parallel programming for multiprocessing and distributed systems. Computational models and paradigms. Parallel programming languages and programming tools. Portable parallel programming and mapping techniques. Heterogeneous concurrent programming. Concurrent programming on local networks on workstations and personal computers.

Master's students register in CECS 570 or CECS 670; Ph.D. students register in CECS 670. Additional projects required for CECS 670. (Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

572./672. Advanced Computer Networking (3)

Prerequisite: CECS 474 with a grade of "C" or better

Advanced concepts in computer network theory and practice. Computer network design and standards for local area networks (LANs) and wide area networks (WANs). Computer network configuration and performance issues.

Master's students register in CECS 572 or CECS 672; Ph.D. students register in CECS 672. Additional projects required for CECS 672. (Lecture-problems 3 hours) Letter grade only (A-F).

574./674. Topics in Distributed Computer Systems (3)

Prerequisite: CECS 526 or CECS 572 or CECS 626 or CECS 672 all with a grade of "C" or better.

Network operating systems vs distributed operating systems, research and design issues of distributed operating systems, resources and resource management in distributed systems, communication security and user authentication.

Master's students register in CECS 574; Ph.D. students register in CECS 674. Additional projects required for CECS 674. (Lecture–problems 3 hours) Letter grade only (A-F). Not open for credit to students with credit in CECS 673 or CECS 773.

575./675. Object–Oriented Analysis and Design (3)

Prerequisites: CECS 475 and CECS 343 or CECS 543 all with a grade of "C" or better.

An object–oriented approach to software development based on modeling objects from the real world. Object–oriented methodology from problem statement through analysis, system design, and object design. Implementation of object–oriented designs in various target environments. Case studies.

Master's students register in CECS 575 or CECS 675; Ph.D. students register in CECS 675. Additional projects required for CECS 675.

(Lecture-problems 3 hours) Letter grade only (A-F).

579. Information Security (3)

Prerequisite: CECS 328 with a grade of "C" or better.

Course Description: Symmetric cryptosystems, stream ciphers, pseudorandom functions, message authentication codes (MACs), collision resistant hash functions, number theory and cryptographic hardness assumptions, public-key encryption (El-Gamaland RSA), digital signature schemes

Letter grade only (A-F). (Lecture-problems 3 hours)

590./690. Selected Topics in Computer Science (3)

Prerequisites: Graduate standing and consent of instructor.

Each offering is based on an area in computer science and technology in which recent advances have been made.

Letter grade only (A-F). May be repeated to a maximum of 6 units with consent of department. Topics announced in the *Schedule of Classes*. Master's students register in CECS 590 or CECS 690; Ph.D. students register in CECS 690. Additional projects required for CECS 690. (Lecture-problems 3 hours)

621./521. Database Architecture (3)

Prerequisites: CECS 328 and CECS 323 (or CECS 421) all with a grade of "C" or better.

Relational database design theory-a rigorous approach. Security, recovery, transaction management, distributed databases and query optimization.

Master's students register in CECS 521 or CECS 621; Ph.D. students register in CECS 621. Additional projects required for CECS 621. (Lecture-problems 3 hours) Letter grade only (A-F).

624./524. Advanced Topics in Programming Languages (3)

Prerequisite: CECS 424 with a grade of "C" or better.

Intensive study of languages of current interest which support object-oriented, client-server, and multimedia applications (e.g. JAVA).

Master's students register in CECS 524 or CECS 624; Ph.D. students register in CECS 624. Additional projects required for CECS 624. (Lecture-problems 3 hours) Letter grade only (A-F).

626./526. Advanced Operating Systems (3)

Prerequisites: CECS 228 and CECS 326 all with a grade of "C" or better.

Theoretical foundations of concepts applied in the design of operating systems. Control of concurrent processes, deadlocks, mutual exclusion, virtual memory, resource management and scheduling.

Master's students register in CECS 526 or CECS 626; Ph.D. students register in CECS 626. Additional projects required for CECS 626. (Lecture–problems 3 hours) Letter grade only (A-F).

628./528. Advanced Analysis of Algorithms (3)

Prerequisites: CECS 328, MATH 380 or EE 380 all with a grade of "C" or better.

Theoretical analysis of algorithms. Divide and conquer, dynamic programming and greedy algorithms; basic search and traversal techniques including search trees; sorting; matrix manipulations; NP–completeness.

Master's students register in CECS 528 or CECS 628; Ph.D. students register in CECS 628. Additional projects required for CECS 628. (Lecture–problems 3 hours) Letter grade only (A-F).

630./530. Advanced Computer Architecture I (3)

Prerequisite: CECS 341 or CECS 440 all with a grade of "C" or better.

Fundamentals of computer architecture. Description of architecture and description languages. Basic computer design and central processor implementation. Memory hierarchy and input/output. Pipelining. Vector processor, multiprocessor systems and dataflow machines.

Master's students register in CECS 530 or CECS 630; Ph.D. students register in CECS 630. Additional projects required for CECS 630. (Lecture-problems 3 hours) Letter grade only (A-F).

631./531. Advanced Computer Architecture II (3)

Prerequisite: CECS 530 with a grade of "C" or better.

Advanced computer architecture with emphasis on parallel processing. Vector processors and multiprocessor systems. Dataflow computation. RISC/CISC. Hypercube. Parallel software. Applications in artificial intelligence, signal/image processing, neural network and optical computing.

Master's students register in CECS 531 or CECS 631; Ph.D. students register in CECS 631. Additional projects required for CECS 631. (Lecture–problems 3 hours) Letter grade only (A-F).

643./543. Advanced Software Engineering (3)

Prerequisite: CECS 343 all with a grade of "C" or better.

Study of software engineering as a broad, problem–solving discipline. Includes structured programming and software project management.

Master's students register in CECS 543 or CECS 643; Ph.D. students register in CECS 643. Additional projects required for CECS 643.

(Lecture-problems 3 hours) Letter grade only (A-F).

644./544. Software Testing and Verification (3)

Prerequisite: CECS 543 with a grade of "C" or better.

Various types of software testing and verification techniques for software development including black box, white box, incremental, top-down and bottom-up, static and dynamic, performance, regression, thread, and stress testing. Discussion of object-oriented software testing with a hierarchical approach. Metrics in complexity for testing, test, and verification plan will be introduced. Automatic software testing and some case studies.

Master's students register in CECS 544 or CECS 644; Ph.D. students register in CECS 644. Additional projects required for CECS 644. (Lecture-problems 3 hours) Letter grade only (A-F).

645./545. Software Architecture (3)

Prerequisite: CECS 543 with a grade of "C" or better.

Includes architectural styles, pipes and filters, data abstraction and object-oriented organization, event-based, implicit invocation, layered systems, repositories, interpreters, process control, distributed processes, domain-specific software & heterogeneous architectures. Component-based design patterns & case studies.

Master's students register in CECS 545 or CECS 645; Ph.D. students register in CECS 645. Additional projects required for CECS 645. (Lecture-problems 3 hours) Letter grade only (A-F).

646./546. Fault Tolerant Computing Systems (3)

Prerequisite: CECS 341 or CECS 440 with a grade of "C" or better.

Fault tolerant techniques are studied as tools to assure the reliability and continuous availability of computing systems. Case studies of modern fault tolerant systems reviewed. Software fault tolerant systems studied as alternatives to verification and validation approaches to software reliability.

Master's students register in CECS 546 or CECS 646; Ph.D. students register in CECS 646. Additional projects required for CECS 646. (Lecture–problems 3 hours) Letter grade only (A-F).

647./547. Software Maintenance, Reengineering and Reuse (3)

Prerequisites: CECS 343 or equivalent all with a grade of "C" or better.

Introduction to software maintenance, defect management, corrective, adaptive and perfective maintenance. Evolution of legacy software systems. Program comprehension techniques, reverse engineering, restructuring, refactoring of software systems. Software re-engineering, data reverse engineering.

Master's students register in CECS 547 or CECS 647; Ph.D. students register in CECS 647. Additional projects required for CECS 647. (Lecture-problems 3 hours) Letter grade only (A-F).

649./549. Advanced Computer Graphics (3)

Prerequisite: CECS 449 with a grade of "C" or better.

Three-dimensional representations, transformations and viewing. Color models and modeling methods. Hidden-line and hidden-surface removal. Lighting and shading. Visual realism. Topics of current interest.

Master's students register in CECS 549 or CECS 649; Ph.D. students register in CECS 649. Additional projects required for CECS 649. (Lecture 2 hours, laboratory 3 hours) Letter grade only (A-F).

650./550. Pattern Recognition Using Artificial Intelligence (3)

Prerequisite: CECS 451 with a grade of "C" or better or consent of instructor.

General concepts of pattern recognition and trainable classifiers, decision theory, supervised learning, non-parametric techniques, rule-based systems and neural networks.

Master's students register in CECS 550; Ph.D. students register in CECS 650. Additional projects required for Ph.D. students. (Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

651./551. Advanced Artificial Intelligence (3)

Prerequisite: CECS 451 with a grade of "C" or better.

Advanced concepts in artificial intelligence. Topics include knowledge acquisition and representation, fuzzy logic, logical reasoning, multi-sensor integration, Dempster-Shafer's theory of evidential reasoning, real-time expert systems and neural networks.

Master's students register in CECS 551 or CECS 651; Ph.D. students register in CECS 651. Additional projects required for CECS 651. (Lecture-problems 3 hours) Letter grade only (A-F).

653./553. Machine Vision (3)

Prerequisite: Graduate standing in engineering or computer science.

Discussion and laboratory implementation of current research in vision and image understanding. Topics include image formation, early processing, segmentation, relational structures in 2-D and 3-D, motion, stereo, 3-D reconstruction, morphological methods and computer architecture for machine vision.

Master's students register in CECS 553 or CECS 653; Ph.D. students register in CECS 653. Additional projects required for CECS 653. (Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

670./570. Concurrent Parallel Programming (3)

Prerequisite: CECS 328, or CECS 341, or CECS 440 all with a grade of "C" or better.

Introduction to concurrent and parallel programming for multiprocessing and distributed systems. Computational models and paradigms. Parallel programming languages and programming tools. Portable parallel programming and mapping techniques. Heterogeneous concurrent programming. Concurrent programming on local networks on workstations and personal computers.

Master's students register in CECS 570 or CECS 670; Ph.D. students register in CECS 670. Additional projects required for CECS 670. (Lecture-problems 2 hours, laboratory 3 hours) Letter grade only (A-F).

672./572. Advanced Computer Networking (3)

Prerequisite: CECS 474 with a grade of "C" or better

Advanced concepts in computer network theory and practice. Computer network design and standards for local area networks (LANs) and wide area networks (WANs). Computer network configuration and performance issues.

Master's students register in CECS 572 or CECS 672; Ph.D. students register in CECS 672. Additional projects required for CECS 672.

(Lecture-problems 3 hours) Letter grade only (A-F).

674./574. Topics in Distributed Computer Systems (3)

Prerequisite: CECS 526 or CECS 572 or CECS 626 or CECS 672 all with a grade of "C" or better.

Network operating systems vs distributed operating systems, research and design issues of distributed operating systems, resources and resource management in distributed systems, communication security and user authentication.

Master's students register in CECS 574; Ph.D. students register in CECS 674. Additional projects required for CECS 674. (Lecture–problems 3 hours) Letter grade only (A-F). Not open for credit to students with credit in CECS 773.

675./575. Object–Oriented Analysis and Design (3)

Prerequisites: CECS 475 and CECS 343 or CECS 543 all with a grade of "C" or better.

An object–oriented approach to software development based on modeling objects from the real world. Object–oriented methodology from problem statement through analysis, system design, and object design. Implementation of object–oriented designs in various target environments. Case studies.

Master's students register in CECS 575 or CECS 675; Ph.D. students register in CECS 675. Additional projects required for CECS 675.

(Lecture-problems 3 hours) Letter grade only (A-F).

690./590. Selected Topics in Computer Science (3)

Prerequisites: Graduate standing and consent of instructor.

Each offering is based on an area in computer science and technology in which recent advances have been made.

Letter grade only (A-F). May be repeated to a maximum of 6 units with consent of department. Topics announced in the *Schedule of Classes*. Master's students register in CECS 590 or CECS 690; Ph.D. students register in CECS 690. Additional projects required for CECS 690. (Lecture-problems 3 hours)

694. Seminar in Computer Science (3)

Prerequisite: 6 units of 500- or 600-level CECS courses.

Intensive study of a broad selection of conceptual and theoretical problems in computer science. A written student research project and an oral presentation are required.

Letter grade only (A-F).

697. Directed Research (1-3)

Prerequisite: Classified Graduate standing.

Theoretical and experimental problems in computer science and engineering requiring extensive research. Advancement to candidacy and program GPA of at least 3.0 are required. Graduate advisor and project supervisor must be consulted prior to registration.

Independent Study. Letter grade only (A-F).

698. Thesis or Industrial Project (3-6)

Prerequisite: Advancement to Candidacy.

Planning, preparation, completion of thesis or equivalent industrial project report on a suitable topic in computer engineering and computer science following the library's prescribed format. Requires consultation with Graduate Advisor and submission of Agreement for Independent Study form each semester.

May be repeated to a maximum of 6 units in the same semester.