COMPUTER ENGINEERING AND COMPUTER SCIENCE

College of Engineering

Department Chair
Wayne Dick

Department Office
Engineering and Computer Sciences (ECS) - 552

Telephone
(562) 985-4285

Website
http://www.cecs.csulb.edu/

Faculty

Professors
Joel Carissimo
Michael Chelian
Sandra Cynar
Wayne Dick
Edward Evans
Sheila Foster (Emeritus, 2001)
Arthur Gittleman
Michael Hassul
Shui Lam
Dar-Biau Liu
Michael K. Mahoney
Carl Maltz (Emeritus, 2002)
Tracy Bradley Maples
Thinh Nguyen
Morton Schwartz (Emeritus, 2002)
Dennis Volper
Robert Wilson (Emeritus, 2002)

Associate Professors
Todd Ebert
Burkhard Englert
Darin Goldstein
Min He
Michael Hoffman
Tom Johnson
Alvaro Monge
Frank Murgolo

Assistant Professor
Colleen McCarthy

Undergraduate Advisors
Joel Carissimo
Tom Johnson

Graduate Advisor
Alvaro Monge

Administrative Support Coordinator
Robin Ikemi

View the CSU, Long Beach *Catalog* on-line at www.csulb.edu by clicking on "Academics" and then "CSULB Catalog."

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

Accreditation

The Bachelor of Science in Computer Engineering is accredited by the Engineering Accreditation Commission (EAC) and the Bachelor of Science in Computer Science by the Computing Accreditation Commission (CAC) of the Accreditation Board for Engineering and Technology (ABET), 111 Market Place, Suite 1050, Baltimore, MD 21202 – telephone: 410/ 347-7700; website: 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 Educational Objectives

All courses and programs in the Department of Computer Engineering and Computer Science are designed to meet the following objectives: Students will receive a comprehensive education in Computer Engineering and/or Computer Science, as well as the sciences and humanities, that will serve them in both their professional and personal lives. Students will be able to analyze and solve problems in Computer Engineering and/or Computer Science using modern techniques, skills, and tools. Students will be able to communicate effectively. Students will be able to design systems, components or processes that meet performance, cost, time, safety, and quality requirements. Students will understand their professional responsibilities, including remaining current in their field of study, and will be able to analyze the social and ethical implications of their work.

Undergraduate Degree Programs

The Department of Computer Engineering and Computer Science offers programs leading to a Bachelor of Science in Computer Engineering, or a Bachelor of Science in Computer Science, The goal of both programs is to prepare graduates for a wide variety of computer-related careers by integrating the theoretical foundations of the discipline with practical applications. The degree in Computer Engineering focuses on computer hardware (design, construction, and operation of computer systems) while the Computer Science degree places more emphasis on computer software (algorithms). The high school student planning to enter either program is advised to pursue a strong program in science and mathematics.

Bachelor of Science in Computer Engineering (code CECSBS02) (129 units)

The Bachelor of Science in Computer Engineering degree program has a two-part objective. The first is to provide students with a strong background in mathematics, physics, and engineering science. The curriculum includes courses in digital systems, embedded systems, integrated circuits design, including operating systems and software engineering. The second objective is to provide students with the skills necessary to be effective contributors in a quality-oriented, customer-focused environment. Courses throughout the program, 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.

Requirements

Lower Division: CECS 174, 201, 228, 261, 274, 277; MATH 122, 222; PHYS 151, 152 (or EE 210 and 210L).

Upper Division: CECS 301, 311, 326, 340, 346, 347, 360, 440, 443, 447, 460A, 460B; EE 380 (or MATH 380), 386; MATH 323, 370A; plus nine units of approved electives to be selected from CECS 406, 451, 474, 475, 497, EE 486, ENGR 310 (or ENGL 317).

FOUR YEAR PLAN TO COMPLETE THE BS IN COMPUTER ENGINEERING (CECSBS02)

129 Units Required — CECS Department

Semester 1		Semester 2	
General Education	3	Oral Communication or Comp	3
Comp or Oral Communication	3	University 100	1
MATH 122 Calculus I (GE-B2)	4	MATH 222 Intermediate Calc	4
CECS 174 Prog & Problem Sol I	3	PHYS 151 Mech & Heat (GE-B1b)	4
CECS 201 Digital Logic Design	3	CECS 274 Prog & Prob Solv I	3
TOTAL UNITS	16	TOTAL UNITS	15
Semester 3		**Semester 4**	
Critical Thinking	3	General Education	3
*PHYS 152 E&M (GE-B3) or **EE210+L Fund Elec Circuits	4	CECS 277 Prog & Prob Sol III	3
EE 380 or MATH 380 Prob & Stat	3	CECS 301 Digtal Logic Desn II	3
CECS 228 Discrete Structures	3	CECS 311 Data Acq/Proc/ Display	3
CECS 261 Computing with JAVA	3	CECS 340 Dis Event Sys & Mod	3
TOTAL UNITS	16	TOTAL UNITS	15
Semester 5		**Semester 6**	
General Education	3	GE Capstone course	3
General Education	3	MATH 323 Numerical Analysis	4
MATH 370A Applied Math I	3	CECS 347 Embedded Processors II	3
EE 386 Digital Signal Processing	3	CECS 360 IC Design Software	3
CECS 346 Embedded Processors I	3	General Education	3
CECS 326 Operating Systems	3		
TOTAL UNITS	18	TOTAL UNITS	16
Semester 7		**Semester 8**	
GE Capstone course	3	GE Capstone course	3
Major Electives	6	General Education	3
CECS 440 Computer Architecture	3	CECS 443 Software Engr	3
CECS 447 Embedded Process III	3	CECS 460B System-on-Chip Design II	3
CECS 460A System-on-Chip Desn I	3	Major Elective	3
TOTAL UNITS	18	TOTAL UNITS	15

Engineering students may waive six units of General Education
This program can be completed in 129 units only if the student completes PHYS 152 to meet GE requirement and waives Categories B.1.a and D.2.

FIVE YEAR PLAN TO COMPLETE THE BS IN COMPUTER ENGINEERING (CECSBS02)

129 Units Required — CECS Department

Semester 1		Semester 2	
University 100	1	Oral Communication or Comp	3
Comp or Oral Communication	3	Math 222 Intermediate Calc	4
General Education	4	CECS 201 Digital Logic Desn	3
CECS 174 Prog & Problem Solv I	3	CECS 274 Prog & Prob Solv II	3
Math 122 Calculus I (GE-B1b)	3		
TOTAL UNITS	14	TOTAL UNITS	13
Semester 3		**Semester 4**	
Phys 151 Mech & Heat (GE-B1a)	4	Phys 152 E&M (GE-B3)	4
CECS 228 Discrete Structures	3	or **EE 210+L Fund of Elec Ckts	
CECS 277 Prog & Prob Solv III	3	Math 380 or EE 380 Prob & Statistics	3
Critical Thinking	3	CECS 261 Java	3
		CECS 340 Dis Event Sys Modeling	3
TOTAL UNITS	13	TOTAL UNITS	13
Semester 5		**Semester 6**	
General Education	3	GE Capstone course	3
Math 323 Intro to Num Methods	4	Math 370A Applied Math I	3
CECS 301 Digital Logic II	3	CECS 346 Embed Process I	3
CECS 311 Data Acq/Proc/Display	3	CECS 440 Comp Architecture	3
TOTAL UNITS	13	TOTAL UNITS	12
Semester 7		**Semester 8**	
General Education	3	GE Capstone course	3
CECS 326 Operating Systems	3	General Education	3
CECS 347 Embedded Proccess II	3	EE 386 Digital Signal Process	3
Major Elective	3	CECS 360 IC Desn Software	3
TOTAL UNITS	12	TOTAL UNITS	12
Semester 9		**Semester 10**	
General Education	3	GE Capstone course	3
CECS 447 Embedded Process III	3	General Education	3
CECS 460A System on Chip Desn I	3	CECS 443 Software Engr	3
Major Elective	3	CECS 460B System on Chip Design II	3
		Major Elective	3
TOTAL UNITS	12	TOTAL UNITS	15

Engineering students may waive six units of General Education.
This program can be completed in 129 units only if the student completes PHYS 152 to meet GE requirement and waives Categories B.1.a and D.2.

SIX YEAR PLAN TO COMPLETE THE BS IN COMPUTER ENGINEERING (CECSBS02)

129 Units Required — CECS Department

Semester 1		Semester 2	
University 100	1	Oral Communication or Comp	3
Comp or Oral Communication	3	Math 122 Calculus I (GE-B2)	4
General Education	3	CECS 201 Digital Logic Desn I	3
CECS 174 Prog & Prob Solv I	3	General Education	3
TOTAL UNITS	10	TOTAL UNITS	13
Semester 3		**Semester 4**	
Critical Thinking	3	Math 380 or EE 380 Prob & Statistics	3
CECS 274 Prog & Prob Solv II	3	CECS 228 Discrete Structures	3
Math 222 Intermediate Calculus	4	CECS 277 Prog & Prob Solv III	3
TOTAL UNITS	10	TOTAL UNITS	9
Semester 5		**Semester 6**	
Phys 151 Mech & Heat (GE-B1b)	4	Phys 152 E&M (GE-B3) or **EE 210+L Fund of Elec Ckts	4
CECS 261 Java	3		
CECS 340 Discrete Event Sys Modeling	3	CECS 311 Data Acq/Proc/ Display	3
		CECS 301 Digial Logic Desn II	3
TOTAL UNITS	10	TOTAL UNITS	10

**EE 210+L provides no GE credit.

Semester 7		Semester 8	
General Education	3	General Education	3
Math 323 Intro to Num Methods	4	CECS 326 Operating Systems	3
CECS 346 Embedded Processors I	3	CECS 347 Embed Process II	3
Math 370A Applied Math I	3	CECS 440 Computer Arch	3
TOTAL UNITS	13	TOTAL UNITS	12
Semester 9		**Semester 10**	
General Education	3	CECS 360 IC Software Design	3
EE 386 Digital Signal Processing	3	CECS 443 Software Engr	3
CECS 447 Embedded Process III	3	General Education	3
Major Elective	3	GE Capstone Course	
TOTAL UNITS	12	TOTAL UNITS	12
Semester 11		**Semester 12**	
GE Capstone class	3	GE Capstone course	3
CECS 460A System on Chip Desn I	3	CECS 460B System on Chip Design II	3
Major Elective	3	Major Elective	3
TOTAL UNITS	9	TOTAL UNITS	9

Engineering students may waive six units of General Education.
This program can be completed in 129 units only if the student completes PHYS 152 to meet the GE requirement and waives Categories B.1.a and D.2.

Bachelor of Science in Computer Science (code CECSBS01) (129 units)

The Bachelor of Science in Computer Science degree is designed to prepare graduates for a variety of professional careers in the computer field. The curriculum is designed to provide students with both breadth and depth in computer science. Breadth is achieved through a series of core courses that stress a balance between the theoretical and practical aspects of computer science. The topics covered in these courses include the following: the basics of programming languages, software design and analysis, data structures, algorithms, digital systems, computer organization, computer architecture, and operating systems. Extensive laboratory time is required for these courses, and design and analysis experiences are emphasized. Depth is achieved through courses (both required and elective) on advanced computer science topics. These courses provide students with in-depth knowledge of the material covered in the breadth portion of the curriculum.

Requirements

Lower Division: CECS 174, 201, 228, 261 or 381, 274, 277; MATH 122, 222, 247; PHYS 151, 152 (or EE 210 and 210L); four units of approved courses in science or with strong emphasis in quantitative methods.

Upper Division: CECS 323, 325, 326, 328, 340, 424, 440, 443; ENGR 350; MATH 380 (or EE 380); ENGR 310 or ENGL 317; One course selected from CECS 472, 474, 476; plus twelve units of approved electives to be selected as follows: three (3) units from CECS 471, 475, 481; and nine (9) units from MATH 323, CECS 405, 406, 419, 423, 426, 428, 444, 448, 449, 451, 455, 470, 473, 478, 497, and 472, 474, 476 if not taken as required course.

FOUR YEAR PLAN TO COMPLETE THE BS IN COMPUTER SCIENCE (CECSBS01)

129 Units Required — CECSDepartment

Semester 1		Semester 2	
General Education	3	Oral Communication or Comp	3
Comp or Oral Communication	3	University 100	1
Math 122 Calculus I (GE - B2)	4	CECS 228 Discrete Struct I	3
CECS 174 Prog & Problem Sol I	3	CECS 274 Prog & Prob Sol II	3
CECS 201 Digital Logic Design	3	Math 222 Intermediate Calc	4
TOTAL UNITS	16	TOTAL UNITS	14
Semester 3		**Semester 4**	
Critical Thinking	3	*Phys 152 E&M (GE - B3) OR EE210+L (No GE)	4
Phys 151 Mech & Heat (GE - B1b)	4	General Education	3
CECS 261 Java OR CECS 381 VB.NET	3	CECS 323 Database Fund	3
CECS 277 Prog & Problem Sol III	3	CECS 325 Comp Org and Asmb Lang	3
Math 380 OR EE 380 Prob & Stat	3	CECS 340 Dis Event Sys Model	3
TOTAL UNITS	16	TOTAL UNITS	16

Semester 5		Semester 6	
		GE Capstone course	3
GE Capstone course	3	General Education	3
General Education	3	Major Elective	3
Major Elective (Sci Course - GE B1a)	4	CECS 328 Discrete Struct II	3
CECS 326 Operating Systems	3	Math 247 Linear Algebra	3
Engl 317 OR Engr 310 (Communications)	3	Engr 350 Computers, Ethics	3
TOTAL UNITS	16	TOTAL UNITS	18

Semester 7		Semester 8	
GE Capstone course	3	General Education	6
General Education	3	Major Elective	3
Major Electives	6	CECS 443 Software Engr	3
CECS 424 Prog Languages	3	One of: CECS 472, 474, 476	3
CECS 440 Comp Architecture	3		
TOTAL UNITS	18	TOTAL UNITS	15

Engineering students may waive six units of General Education.
This program can be completed in 129 units only if the student completes PHYS 152 to meet the GE requirement and waives Categories B.1.a and D.2.

FIVE YEAR PLAN TO COMPLETE THE BS IN COMPUTER SCIENCE (CECSBS01)

129 Units Required — CECS Department

Semester 1		Semester 2	
University 100	1	Oral Communication or Comp	3
Comp or Oral Communication	3	Math 222 Intermed Calculus	4
General Education	3	CECS 201 Digital Logic Desn	3
Math 122 Calculus I (GE B.1)	4	CECS 274 Prog & Problem Sov II	3
CECS 174 Prog & Problem Solv I (KPE Activity class)	3 (1)		
TOTAL UNITS	14 - (15)	TOTAL UNITS	13

Semester 3		Semester 4	
		*PHYS 152 E&M (GE B3) OR EE210+L (No GE)	4
PHYS 151 Mech, Heat (GE B.1.b)	4	Critical Thinking	3
CECS 228 Discrete Structures I	3	CECS 261 Java OR CECS 381 VB.NET	3
CECS 277 Prog & Problem Solv III	3	CECS 340 Dis Event Sys Model	3
Math 380 OR EE 380 Prob, Stat	3		
TOTAL UNITS	13	TOTAL UNITS	13

Semester 5		Semester 6	
General Education	3	General Education	3
General Education	3	CECS 325 Comp Org and Asmb Lang	3
ENGL 317 OR ENGR 310 Communications	3	Math 247 Linear Algebra	3
CECS 323 Database Fund	3	Engr 350 Computers, Ethics	3
TOTAL UNITS	12	TOTAL UNITS	12

Semester 7		Semester 8	
General Education	3	GE Capstone course	3
Major Elective	3	Major Elective	3
Major Elective (Sci Course - GE B1a)	4	CECS 328 Discrete Structures II	3
CECS 326 Operating Systems	3	One of: CECS 472, 474, 476	3
TOTAL UNITS	13	TOTAL UNITS	12

Semester 9		Semester 10	
General Education	3	General Education	3
CECS 440 Computer Architecture	3	Major Electives	6
CECS 424 Prog Languages	3	CECS 443 Software Engr	3
GE Capstone Course	3	GE Capstone Course	3
TOTAL UNITS	12	TOTAL UNITS	15

Engineering students may waive six units of General Education
This program can be completed in 129 units only if the student completes PHYS 152 to meet the GE requirement and waives Categories B.1.a and D.2.

SIX YEAR PLAN TO COMPLETE THE BS IN COMPUTER SCIENCE (CECSBS01)

129 Units Required — CECS Department

Semester 1		Semester 2	
University 100	1	Oral Communication or Comp	3
General Education	3	Math 122 Calculus I (GE - B2)	4
Comp or Oral Communication	3	CECS 201 Digital Logic Desn	3
CECS 174 Prog & Problem Sol I (KPE Activity class)	3 (1)		
TOTAL UNITS	10-(11)	TOTAL UNITS	10

Semester 3		Semester 4	
Critical Thinking	3	CECS 228 Discrete Structures I	3
CECS 274 Prog & Problem Sol II	3	CECS 277 Prog & Prob Sol III	3
Math 222 Intermediate Calculus	4	Math 380 OR EE 380 Prob & Stat	3
TOTAL UNITS	10	TOTAL UNITS	9

Semester 5		Semester 6	
		Phy 152 E&M (GE-B3) OR *EE210+210L	4
Phy 151 Mech & Heat (GE - B1b)	4	Math 247 Linear Algebra	3
CECS 261 Java OR CECS 381 VB.NET	3	CECS 323 Database Fund	3
CECS 340 Dis Event Sys Model	3	Engl317 OR Engr310 Comm	3
TOTAL UNITS	10	TOTAL UNITS	13

*EE 210/210L does not count for GE

Semester 7		Semester 8	
GE Capstone course	3	GE Capstone course	3
General Education	3	CECS 326 Operating Systems	3
CECS 325 Comp Org and Asmb Lang	3	CECS 328 Discrete Struct II	3
Engr 350 Computers, Ethics	3		
TOTAL UNITS	12	TOTAL UNITS	9

Semester 9		Semester 10	
GE Capstone course	3	General Education	6
General Education	3	Major Elective	3
Major Elective (Sci Course - GE B1a)	4	One of: CECS 472, 474, 476	3
CECS 440 Computer Architecture	3		
TOTAL UNITS	13	TOTAL UNITS	12

Semester 11		Semester 12	
General Education	3	General Education	6
Major Elective	3	Major Elective	3
CECS 424 Prog Languages	3	CECS 443 Software Engr	3
TOTAL UNITS	9	TOTAL UNITS	12

Engineering students may waive six units of General Education
This program can be completed in 129 units only if the student completes PHYS 152 to meet the GE requirement and waives Categories B.1.a and D.2.

FAQ Concerning Road Maps for Completion of Undergraduate Degrees

For each undergraduate major, the on-line Catalog shows plans for scheduling all required courses to complete the degree in four, five, or six years.

While CSULB will make every effort to schedule classes at the times shown in the plans, we cannot guarantee that courses will be available in specific semesters. It is possible that shortage or budget or of personnel will make it impossible to offer as many classes as we would wish.

The plans are not substitutes for working with an advisor. You are strongly encouraged to see an advisor when planning your program each term.

I am a freshman. Do I have to choose now whether to follow the four, five, or six-year plan?

No. Most freshmen take 12-15 units. You need at least 12 units to receive full financial aid. With experience, you will be able to judge how heavy a load you find comfortable. This will depend on your outside obligations, such as a job, and on your personal circumstances. In theory, each unit requires three hours a week, including preparing for class, attending class, and completing assignments. Use these guidelines to budget your time and plan an appropriate schedule.

Must I take the courses in the semesters shown on the plan?

The plan shows one possible way of completing all requirements for the degree. Consult your advisor about whether it is essential to take a given course in the semester shown. There are some rules to keep in mind:

1) You can take the General Education Foundation courses (Composition, Oral Communication, Critical Thinking, Mathematics) in any semester in the first 36 units of baccalaureate-level course work completed at CSULB.

2) You cannot take upper division courses until you have completed at least 30 units. (Exceptions can be made for students who already have completed advanced study in the subject.) You cannot take General Education Capstone courses until you have completed at least 60 units.

3) For some majors it is essential to complete courses in the correct sequence. You cannot take a more advanced course until you have completed the prerequisite course(s).

4) You must complete all requirements for admission to impacted majors within the first 60 units.

I have been told that I must take one or more pre-baccalaureate courses. How can I plan my program?

Your advisor at SOAR can help you identify which courses must be postponed. You must still complete the minimum number of baccalaureate units required for the degree.

You may be able to catch up by taking additional courses in later semesters or by taking classes in summer or winter session, or you may choose to spend an additional semester completing the program. You cannot begin the sequence of required courses for some majors until you are ready for baccalaureate-level Mathematics. See your major advisor to develop a plan for scheduling the required courses.

I didn't complete the exact list of courses shown. Can I still graduate on time?

The answer depends on your major and on what courses you have completed. The plans are not rigid requirements; they are only intended to provide guidance in planning a program. There are many reasons for students to follow a different pattern, such as changing the major, choosing to take fewer classes in a given semester, choosing to complete a minor or a second major. See your advisor for help in planning a program that will work for you.

If I follow the plan, will I have all requirements for graduation completed?

The plans include the specific courses required for the major. For some majors, there are restrictions on the choice of major electives. It is important that you select General Education courses to meet the required distribution pattern. You may need to take an additional General Education course to complete the minimum number of units required for each category. This is likely to happen if you took three-unit courses in Category B, Physical Universe.

Bachelor of Science in Engineering Technology

Technology and Engineering Education Option (code ET__BS15)

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

Minor in Computer Science (code CECSUM01)

The minor in Computer Science is designed to prepare students in other majors for careers in a wide variety of fields which require computer science expertise.

Requirements

A minimum of 24 units. CECS 174, 201, 228, 274, 277, 325 and two courses to be selected from CECS 323, 326, 328, 340, 423, 443, 449, 470, 474, 475, ENGR 350.

Minor in Web and Technology Literacy (code ET__UM01)

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

Minor in Computer Science Applications (code ET__UM02)

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

Certificate in Web and Technology Literacy (code ET__CT03)

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

Master of Science in Computer Science

The Master of Science in Computer Science is offered by the Department of Computer Engineering and Computer Science, College of Engineering. Two options are offered:

1. Option in Computer Engineering
2. Option in Computer Science

The Option in Computer Engineering offers advanced study in the theory, analysis, design and applications of both computer hardware and software. The Option in Computer Science offers advanced study in modeling software systems, operating systems, compiler construction, and analysis of algorithms.

Admission Procedures

To be considered for admission the graduate applicant must have earned a bachelor's degree from an accredited institution, have been in good standing at the last institution attended, and have a grade point average (GPA) of at least 2.7 for the last 60 semester units (90 quarter units) attempted. The general Graduate Record Examination (GRE) is required. There is no separate department application, but applicants should submit a second set of transcripts to the department.

Option in Computer Engineering (code CEC-SMS02)

Prerequisites

1. A bachelor's degree in computer science, engineering, or other appropriate discipline from an accredited college or university, with a minimum grade point average (GPA) of 2.7 in the last 60 semester units attempted.
2. Credit in the following courses or their equivalents: CECS 274, 301, 326, 340, 346, 347, 360, 440, 443, and MATH 370A.
3. Students must consult with the program graduate advisor prior to enrolling in any course for the program.

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. CECS 460A, 460B, 530, and either 531 or 546;
3. One course from the Computer Engineering Fundamental Areas;
4. One additional course from the MSCS Application Courses;
5. All students must complete either:

   A. a comprehensive examination, or

   B. a thesis with oral defense which requires a total of 6 units of CECS 697 or 698, of which at least 4 units must be CECS 698.

Option in Computer Science (code CECSMS01)

Prerequisites

1. A bachelor's degree in computer science, engineering, or other appropriate discipline from an accredited college or university, with a minimum grade point average (GPA) of 2.7 in the last 60 semester units attempted.
2. Credit in the following courses or their equivalents: One year of instruction in an object-oriented programming language, CECS 228, 323 (or 421), 325, 326, 328, 440, 443, MATH 380, and either 419, 424, or 444.
3. Students must consult with the program graduate advisor prior to enrolling in any course for the program.

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. CECS 528;
3. One course from the Computer Science Fundamental Areas;
4. Two courses from the MSCS Application courses;
5. All students must complete either:

   A. a comprehensive examination, or

   B. a thesis with oral defense which requires a total of 6 units of CECS 697 or 698, of which at least 4 units must be CECS 698.

Advancement to Candidacy

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 applicable to the degree with a GPA of at least 3.0;
4. have passed the University Writing Proficiency Examination;
5. and have their program of studies approved by the CECS department graduate advisor.

Courses (CECS)

Lower Division

101. The Digital Information Age (3)
Prerequisite: Category B2 General Education course. An introduction to commonplace digital information systems for non-majors. Information sources. Digital logic. Computer hardware and software. The Internet and the World Wide Web. (Lecture 3 hours.)

110. Introduction to the Internet (3)
Prerequisite: Some computer experience. Provides a general overview of computer systems, networking, and the Internet. World-Wide Web, email, telnet, ftp, newsgroups, finding information on the Internet, and basic Web page creation. Considers legal, ethical, privacy and security issues on the Internet. (Lecture 2 hours, laboratory 3 hours.)

126. Introduction to the UNIX Operating System (3)
Prerequisite: Consent of instructor. UNIX operating system's user interface. File and directory commands, editor commands, communication commands and other UNIX utilities. UNIX access permissions and security, I/O redirection, pipes, metacharacters, and full-screen editing with vi. Electronic communication, simple shell programming, and using the Xwindow System. (Lecture 2 hours, laboratory 3 hours.)

174. Programming and Problem Solving I (3)
Prerequisite: MATH 117 (or equivalent.) Introduction to the basic concepts of computer science and the fundamental techniques for solving problems using the C++ programming language. Structured problem solving, object-oriented programming, programming style. Applications to numerical and non-numerical problems. Not open to students with credit in CECS 175. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

200. Introduction to Web Design (3)
Prerequisite: Some computer experience. Introductory web page design using modern tools. Development of web pages from layout to posting on the Internet. Web security and ethics. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

201. Computer Logic Design I (3)
Prerequisite: MATH 117 (or equivalent). Basic topics in combinational and sequential switching circuits with applications to the design of digital devices. Laboratory projects with Small Scale Integration (SSI) implementations using Computer Aided Design (CAD). (Lecture 2 hours, lab 3 hours.) Letter grade only (A-F).

228. Discrete Structures with Computer Science Applications I (3)
Prerequisites: CECS 174 and MATH 122. The specification, development and analysis of algorithms. Sets, relations and functions. Logic and mathematical structures used in computer science. Introduction to combinatorics. Programming projects to exemplify these concepts. (Lecture 2 hours, laboratory/problem session 3 hours.) Letter grade only (A-F).

261. Computing with Java (3)
Prerequisite: CECS 174. Comparison of basic Java constructs to similar constructs in C++. Object-oriented programming in Java. Applets and graphical user interfaces. Mouse, key, and window events. Exception handling and files. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

271. Introduction to Numerical Methods (3)
Prerequisites: CECS 174 and MATH 123. An introduction to numerical methods and the FORTRAN programming language. Analysis of computational errors; iterative methods for finding roots and for solving systems of equations. Numerical techniques for evaluating integrals, determining derivatives, and solving ordinary differential equations. FORTRAN programming projects will be assigned. Not open to students with credit in CECS 342. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

274. Programming and Problem Solving II (3)
Prerequisite: CECS 174; Prerequisite/Corequisite: CECS 201. Disciplined methods of design, coding and testing using the C++ programming language. Data abstraction, object-oriented design. Introduction to data structures (linked lists, stacks, queues and trees.) Recursion. Sorting and searching. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

277. Programming and Problem Solving III (3)
Prerequisite: CECS 274. 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 C++ programming language. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

Upper Division

300. Web Authoring (3)
Prerequisite: CECS 200. Web page design using modern tools. Design and development of web pages from layout to posting on the Internet. Website usability, accessibility, security, and ethics. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

301. Computer Logic Design II (3)
Prerequisite: CECS 174. Prerequisite/Corequisite: CECS 311 or EE 331. Sequential logic, programmable logic design, basic Arithmetic Logic Unit (ALU) design and memory devices. Laboratory projects with Medium Scale to Very Large Scale Integration (MSI to VLSI) implementations and Computer Aided Design (CAD). (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

310E. Computer-Based Learning Resources (3)
Prerequisite: Some Internet experience. Explore and learn to use the many existing web-based education tools that focus on teaching technology. Evaluation of resources for age appropriateness and gender preferences. Students will develop a web-based tool to teach a technical subject of their choice. Field work required. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

311. Data Acquisition, Processing, and Display (3)
Prerequisites: CECS 201, EE 210 and 210L or PHYS 152. Hardware and software used to acquire, process, and display real-time signals. Transducers. Amplifiers. Buffers and isolators. Interrupt generators. Analog–to-digital and digital-analog converters. Display hardware. Software packages for electronics simulation and data acquisition. Sources of noise in digital systems. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

323. Database Fundamentals (3)
Prerequisites: CECS 228, 274, MATH 222. 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. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

325. Computer Organization and Assembly Language Programming (3)
Prerequisites: CECS 201 and 274. Basic computer organization, representation of information and instruction, addressing techniques, input/output, assembly language programming, macros and macro processing. Introduction to software systems, including assemblers, linkage editors and loaders. Programming assignments in assembly language. (Lecture 2 hours, lab 3 hours.) Letter grade only (A-F).

326. Operating Systems (3)
Prerequisites: CECS 277 and 325 (or 346). 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 3 hours, laboratory 3 hours.) Letter grade only (A-F).

328. Discrete Structures with Computer Science Applications II (3)
Prerequisite: CECS 228. 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. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

340. Discrete Event Systems Modeling and Simulation (3)
Prerequisites: CECS 201, 228 and 274. Modeling and simulation of discrete event systems specific to computer science and computer engineering including networks, queuing systems, digital logic, and computer architecture. The use of general purpose and specialized languages for these systems will be explored. Various methods for system input data (stochastic and deterministic) will be explored. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

346. Microprocessors and Controllers I (3)
Prerequisites: CECS 274 and 311. Introduction to microprocessor, micro controller and embedded system programming and design. Basic computer organization, representation of information and instruction, addressing techniques, input/output, assembly language programming. Introduction to software systems, including assemblers, linkage editors and loaders. Review of microprocessors and micro controllers with an in-depth study of the 8051 microprocessor. Design of microprocessor-based systems to solve practical problems. Laboratory projects using CAD implementations and hardware design tools for simulation of designs. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

347. Microprocessors and Controllers II (3)
Prerequisites: CECS 301 and 346. 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, 325 (or 346), MATH 123 or 222. 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).

381. GUI Programming (3)
Prerequisite: CECS 174. Introduction to programming in a graphical user interface (GUI) environment. Menus, dialog boxes, forms, textboxes, toolbars and other controls. Properties, methods and events of objects. Program control statements including if, case, while, loop, and do. System objects including the mouse, screen and printer. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

401E. Programming Robots – for Teachers and Parents (3)
Prerequisite: Some programming experience. Learn how to inspire interest in engineering and computer science among children ages 9 through 16. Using robotic kits, gain hands-on experience in problem solving and computer programming while constructing and programming unique robot inventions. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*405. Special Topics in Computer Science (3)
Prerequisite: Senior standing in computer science major. Selected topics from recent advances in computer science and technology. Course content will vary from year to year. (Lecture-problems 3 hours.) May be repeated to a maximum of 6 units with different topics. Letter grade only (A-F).

*406. Special 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. Repeatable to a maximum of 6 units with different topics in different semesters. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*410E. 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).

*419. Theory of Computation (3)
Prerequisite: CECS 328. Finite automata and regular expressions. Pushdown automata and context-free languages. Turing machines and computability. Computational complexity. (Lecture-problems 3 hours.) Letter grade only (A-F).

*423. Database Applications (3)
Prerequisite: CECS 323 (or 421). Preparation for work on commercial database systems. Advanced modeling and analysis, data definition, constraints, retrieval, manipulation, security and usability. Commercial development tools, distributed/multi-tier environments and integration of databases with intranets and internets. Projects may include cooperation with students from other departments. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*424. Organization of Programming Languages (3)
Prerequisites: CECS 326 and 328. 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).

*426. Topics in Operating Systems (3)
Prerequisite: CECS 326. Advanced operating system analysis and design. Topics of current interest. Project implementation (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*428. Analysis of Algorithms (3)
Prerequisite: CECS 328. Applications of standard combinatorial techniques to applied programming problems. Rigorous analysis of the correctness and 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).

440. Computer Architecture (3)
Prerequisites: CECS 340 and 325 (or 346). 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).

443. Software Engineering (3)
Prerequisite: CECS 326. Software life cycle. Functional decomposition, data flow and object-oriented development. Reusability and portability. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*444. Compiler Construction (3)
Prerequisites: CECS 325 and 328. 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).

447. Microprocessors and Controllers III (3)
Prerequisite: CECS 347. Embedded system applications and techniques. Real-time multi-tasking systems, schedulers, kernels, and operating systems for embedded processors. Advanced I/O technologies include CAM, I^2C, Ethernet. Embedded Internet applications. Polling versus interrupt handling. Laboratory implementation of embedded designs and hardware-assisted debugging. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*448. User Interface Design (3)
Prerequisites: CECS 323 (or 421), and any one of CECS 471, 475, 481. 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 261 and 274. Basic software and hardware of 2-D computer graphics. Applications. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*451. Artificial Intelligence (3)
Prerequisites: CECS 228, 274, MATH 380 or EE 380. 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).

455. Introduction to Game Programming (3)
Prerequisite: CECS 328 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).

460A. System on Chip Design I (3)
Prerequisite: CECS 360 or 440. A complete System on a Chip (SOC) design flow beginning with a design specification and ending with a working SOC. Creation of RTL level modules designed for reuse, integration of Intellectual Property (IP) for both RTL level and physical level IP, IC verification, and the creation of self-checking test benches for SOC designs. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*460B. System on Chip Design II (3)
Prerequisite: CECS 460A. System on a Chip (SOC) design applications. A variety of SOC designs will be built as class project which involve both the hardware and software aspect of a SOC along with hardware/software integration problems. Design reviews, design specification and team design implementation will be stressed along with project planning and tracking mechanisms for system level design problems. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*470. World–Wide Web Development (3)
Prerequisites: CECS 277 and 323 (or 421). Introduction to commercial practice in World-Wide Web site development. Web server and client software and the underlying networking technologies and protocols. Page and site design and programming using contemporary development tools and languages. Typography, graphics, database integration, usability, ethics and future directions. Projects will include site development for an actual client and may include cooperation with students from other departments. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*471. Internet Applications Using Java (3)
rerequisites: CECS 261 and 277. Threads, images, and animation. User interface component libraries. Streams, readers and writers. Client-server applications. Java beans. Internationalization. Introduction to remote method invocation, Java database connectivity, and multimedia applications. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*472. Computer Network Programming (3)
Prerequisites: CECS 326 and 328. Fundamentals of client-server programming. Concepts of computer network programming including RPC and CORBA. Introduction to the principles of TCP and routing. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*473. Enterprise Web Applications (3)
Prerequisites: CECS 323 (or 421), 470, and any one of CECS 471, 475, 481. Web commerce, high-availability Web sites, and information architecture. Advanced client side and server side scripting, advanced searching and indexing, application servers. Legal and business aspects. Projects may include cooperation with students from other departments. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*474. Computer Network Interoperability (3)
Prerequisite: CECS 326. An 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. Object-Oriented Programming and C++ (3)
Prerequisite: CECS 277. An overview of object-oriented programming, data abstraction, and the C++ language. Classes, constructors, destructors, function and operator overloading, inheritance, polymorphism, input/output, standard template library (STL), templates, Visual C++, Microsoft Foundation Class (MFC), and object-oriented design. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

*476. System and Network Administration (3)
Prerequisites: CECS 326 and 328. 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)
Prerequisites: CECS 323, 328, and one course selected from 472, 474, 476. 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).

*481. Event Driven Programming (3)
Prerequisite: CECS 326. A rigorous introduction to Graphical User Interface (GUI) programming as provided in a number of popular software development products. Topics include Windows API (Application Programming Interface) using C and C++, Visual Basic and other development tools. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

496. Computer Science Problem Solving (1)
Prerequisites: CECS 274 and consent of instructor. A study of problem solving in Computer Science. Discussion of the theory necessary to solve computer science problems as well as the solutions to the problems. Problems studied will involve applications of graph theory, data structures, recursion, and algorithms. The aim of the course is to enhance the student's problem solving ability. (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 permission of the Department Chair.

Graduate Level

521./621. Database Architecture (3)
Prerequisites: CECS 328 and 323 (or 421). (Master's students register in CECS 521 or 621; Ph.D. students register in CECS 621.) Relational database design theory-a rigorous approach. Security, recovery, transaction management, distributed databases and query optimization. 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 and 471. (Master's students register in CECS 524 or 624; Ph.D. students register in CECS 624.) Intensive study of languages of current interest which support object-oriented, client-server, and multimedia applications (e.g. JAVA). 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 326. (Master's students register in CECS 526 or 626; Ph.D. students register in CECS 626.) Theoretical foundations of concepts applied in the design of operating systems. Control of concurrent processes, deadlocks, mutual exclusion, virtual memory, resource management and scheduling. Additional projects required for CECS 626. (Lecture–problems 3 hours.) Letter grade only (A-F).

528./628. Advanced Analysis of Algorithms (3)
Prerequisite: CECS 328 and MATH 380. (Master's students register in CECS 528 or 628; Ph.D. students register in CECS 628.) 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. Additional projects required for CECS 628. (Lecture–problems 3 hours.) Letter grade only (A-F).

530./630. Advanced Computer Architecture I (3)
Prerequisite: CECS 440. (Master's students register in CECS 530 or 630; Ph.D. students register in CECS 630.) 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. Additional projects required for CECS 630. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

531./631. Advanced Computer Architecture II (3)
Prerequisite: CECS 530. (Master's students register in CECS 531 or 631; Ph.D. students register in CECS 631.) 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. Additional projects required for CECS 631. (Lecture–problems 3 hours.) Letter grade only (A-F).

543./643. Advanced Software Engineering (3)
Prerequisite: CECS 443. (Master's students register in CECS 543 or 643; Ph.D. students register in CECS 643.) Study of software engineering as a broad, problem–solving discipline. Includes structured programming and software project management. Additional projects required for CECS 643. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

544./644. Software Testing and Verification (3)
Prerequisite: CECS 543. 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. Additional projects required for CECS 644. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

545./645. Software Architecture (3)
Prerequisite: CECS 543. Topics include 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 architectures, and heterogeneous architecture. Component-based design patterns and some case studies. Additional projects required for CECS 645. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

546./646. Fault Tolerant Computing Systems (3)
Prerequisite: CECS 530. (Master's students register in CECS 546 or 646; Ph.D. students register in CECS 646.) 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. Additional projects required for CECS 646. (Lecture–problems 3 hours.) Letter grade only (A-F).

549./649. Advanced Computer Graphics (3)
Prerequisite: CECS 449. (Master's students register in CECS 549 or 649; Ph.D. students register in CECS 649.) 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. Additional projects required for CECS 649. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

551./651. Advanced Artificial Intelligence (3)
Prerequisite: CECS 451. (Master's students register in CECS 551 or 651; Ph.D. students register in CECS 651.) 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. Additional projects required for CECS 651. (Lecture-problems 3 hours.) Letter grade only (A-F).

552./652. Computer Simulation and Modeling (3)
Prerequisites: EE 380 (or MATH 380) and CECS 326. (Master's students register in CECS 552 or 652; Ph.D. students register in CECS 652.) Studies of general purpose and special simulation software. Model verification including graphical models Applications in various areas. 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. (Master's students register in CECS 553 or 653; Ph.D. students register in CECS 653.) 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. Additional projects required for CECS 653. (Lecture-problems 2 hours, laboratory 3 hours.) Letter grade only (A-F).

570./670. Concurrent Parallel Programming (3)
Prerequisite: CECS 428 or 440. (Master's students register in CECS 570 or 670; Ph.D. students register in CECS 670.) An introduction to concurrent and parallel programming for multiprocessing as well as 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. 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. (Master's students register in CECS 572 or 672; Ph.D. students register in CECS 672.) 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. Additional projects required for CECS 672. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

575./675. Object–Oriented Analysis and Design (3)
Prerequisite: CECS 475 and either CECS 443 or 543. (Master's students register in CECS 575 or 675; Ph.D. students register in CECS 675.) An object–oriented approach to software development based on modeling objects from the real world and then using the model to build a language–independent design organized around those objects. Object–oriented methodology from problem statement through analysis, system design, and object design. Implementation of object–oriented designs in various target environments. Case studies. Additional projects required for CECS 675. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

590./690. Special Topics in Computer Science (3)
Prerequisites: Graduate standing and consent of instructor. (Master's students register in CECS 590 or 690; Ph.D. students register in CECS 690.) Each offering is based on an area in computer science and technology in which recent advances have been made. Additional projects required for CECS 690. (Lecture-problems 3 hours.) May be repeated to a maximum of 6 units with consent of department. Letter grade only (A-F).

621./521. Database Architecture (3)
Prerequisites: CECS 328 and 323 (or 421). (Master's students register in CECS 521 or 621; Ph.D. students register in CECS 621.) Relational database design theory-a rigorous approach. Security, recovery, transaction management, distributed databases and query optimization. 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 and 471. (Master's students register in CECS 524 or 624; Ph.D. students register in CECS 624.) Intensive study of languages of current interest which support object-oriented, client-server, and multimedia applications (e.g. JAVA). 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 326. (Master's students register in CECS 526 or 626; Ph.D. students register in CECS 626.) Theoretical foundations of concepts applied in the design of operating systems. Control of concurrent processes, deadlocks, mutual exclusion, virtual memory, resource management and scheduling. Additional projects required for CECS 626. (Lecture–problems 3 hours.) Letter grade only (A-F).

628./528. Advanced Analysis of Algorithms (3)
Prerequisite: CECS 328 and MATH 380. (Master's students register in CECS 528 or 628; Ph.D. students register in CECS 628.) 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. Additional projects required for CECS 628. (Lecture–problems 3 hours.) Letter grade only (A-F).

630./530. Advanced Computer Architecture I (3)
Prerequisite: CECS 440. (Master's students register in CECS 530 or 630; Ph.D. students register in CECS 630.) 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. Additional projects required for CECS 630. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

631./531. Advanced Computer Architecture II (3)
Prerequisite: CECS 530. (Master's students register in CECS 531 or 631; Ph.D. students register in CECS 631.) 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. Additional projects required for CECS 631. (Lecture–problems 3 hours.) Letter grade only (A-F).

643./543. Advanced Software Engineering (3)
Prerequisite: CECS 443. (Master's students register in CECS 543 or 643; Ph.D. students register in CECS 643.) Study of software engineering as a broad, problem–solving discipline. Includes structured programming and software project management. Additional projects required for CECS 643. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

644./544. Software Testing and Verification (3)
Prerequisite: CECS 543. 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. Additional projects required for CECS 644. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

645./545. Software Architecture (3)
Prerequisite: CECS 543. Topics include 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 architectures, and heterogeneous architecture. Component-based design patterns and some case studies. Additional projects required for CECS 645. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

646./546. Fault Tolerant Computing Systems (3)
Prerequisite: CECS 530. (Master's students register in CECS 546 or 646; Ph.D. students register in CECS 646.) 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. Additional projects required for CECS 646. (Lecture–problems 3 hours.) Letter grade only (A-F).

649./549. Advanced Computer Graphics (3)
Prerequisite: CECS 449. (Master's students register in CECS 549 or 649; Ph.D. students register in CECS 649.) 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. Additional projects required for CECS 649. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

650./750. Pattern Recognition Using Artificial Intelligence (3)
Prerequisite: CECS 451 or consent of instructor. (Master's students register in CECS 650; Ph.D. students register in CECS 750.) General concepts of pattern recognition and trainable classifiers, decision theory, supervised learning, non-parametric techniques, rule-based systems and neural networks. 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. (Master's students register in CECS 551 or 651; Ph.D. students register in CECS 651.) 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. Additional projects required for CECS 651. (Lecture-problems 3 hours.) Letter grade only (A-F).

652./552. Computer Simulation and Modeling (3)
Prerequisites: EE 380 (or MATH 380) and CECS 326. (Master's students register in CECS 552 or 652; Ph.D. students register in CECS 652.) Studies of general purpose and special simulation software. Model verification including graphical models Applications in various areas. Additional projects required for CECS 652. (Lecture-problems 3 hours.) Letter grade only (A-F).

653./553. Machine Vision (3)
Prerequisite: Graduate standing in engineering or computer science. (Master's students register in CECS 553 or 653; Ph.D. students register in CECS 653.) 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. 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 428 or 440. (Master's students register in CECS 570 or 670; Ph.D. students register in CECS 670.) An introduction to concurrent and parallel programming for multiprocessing as well as 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. 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. (Master's students register in CECS 572 or 672; Ph.D. students register in CECS 672.) 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. Additional projects required for CECS 672. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

673./773. Topics in Distributed Computer Systems (3)
Prerequisite: CECS 572 or 672. (Master's students register in CECS 673; Ph.D. students register in CECS 773.) 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. Additional projects required for Ph.D. students. (Lecture–problems 3 hours.) Letter grade only (A-F).

675./575. Object–Oriented Analysis and Design (3)
Prerequisite: CECS 475 and either CECS 443 or 543. (Master's students register in CECS 575 or 675; Ph.D. students register in CECS 675.) An object–oriented approach to software development based on modeling objects from the real world and then using the model to build a language–independent design organized around those objects. Object–oriented methodology from problem statement through analysis, system design, and object design. Implementation of object–oriented designs in various target environments. Case studies. Additional projects required for CECS 675. (Lecture 2 hours, laboratory 3 hours.) Letter grade only (A-F).

690./590. Special Topics in Computer Science (3)
Prerequisites: Graduate standing and consent of instructor. (Master's students register in CECS 590 or 690; Ph.D. students register in CECS 690.) Each offering is based on an area in computer science and technology in which recent advances have been made. Additional projects required for CECS 690. (Lecture-problems 3 hours.) May be repeated to a maximum of 6 units with consent of department. Letter grade only (A-F).

694. Seminar in Computer Science (3)
Prerequisite: Six 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 intensive analysis. (Independent Study.) Letter grade only (A-F).

698. Thesis or Industrial Project (2-6)
Prerequisite: Advancement to Candidacy. Planning, preparation, and completion of a 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 department's Graduate Advisor and submission of an Agreement for Independent Study form each semester of enrollment. May be repeated to a total of 6 units.

750./650. Pattern Recognition Using Artificial Intelligence (3)
Prerequisite: CECS 451 or consent of instructor. (Master's students register in CECS 650; Ph.D. students register in CECS 750.) General concepts of pattern recognition and trainable classifiers, decision theory, supervised learning, non-parametric techniques, rule-based systems and neural networks. Additional projects required for Ph.D. students. (Lecture-problems 2 hours, laboratory 3 hours.) Letter grade only (A-F).

773./673. Topics in Distributed Computer Systems (3)
Prerequisite: CECS 572 or 672. (Master's students register in CECS 673; Ph.D. students register in CECS 773.) 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. Additional projects required for Ph.D. students. (Lecture–problems 3 hours.) Letter grade only (A-F).