LING 121 Syntax (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): LING 020. Survey of various approaches to syntax, including transformational. Syntactic structures of English and other languages are examined. Applications: English, foreign languages, philosophy, mathematics. **Kronenfeld, Waltz**

LING 131 Morphology (4) Lecture, 3 hours; seminar, 1 hour. Prerequisite(s): LING 020, LING 111 or LING 121. Studies word structure, the lexical component of language, allomorphy, types of morphemes, and inflexional and derivational morphology. Examines various theories of lexical/morphological organization in the brain. Examples are taken from English and other Indo-European languages.

LING 141 Phonology (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): LING 111. Introduction to the study of functional sound units in speech, including phonotactics, morphophonemics. Various theories are examined, including generative. Applications: speech correction, speech analysis, English, foreign languages. **Levin**

LING 151 Semantics (4) Lecture, 3 hours; extra reading, 1 hour; outside research, 1 hour; term paper, 1 hour. Prerequisite(s): LING 121. Introduces the study of meaning and its metalinguistic preliminaries. Explores lexical, sentence, and utterance meaning (including speech acts, text, and discourse). Provides a survey of theories of meaning, such as structural semantics and language as a semiotic system.

LING 160 (E-Z) Topics in Dynamic and Comparative Linguistics (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): LING 111; LING 121 or LING 141. Comparative analyses of language groups such as Spanish and Portuguese, Slavic languages, and Native American languages. E. Historical Linguistics; F. Dialectology; G. Language Change; I. Sociolinguistics.

LING 162 Language and the Brain (4) Lecture, 3 hours; extra reading, 3 hours. Prerequisite(s): LING 020. Introduces the study of language and the brain, including speech production and comprehension, neurolinguistics, and aphasiology. Explores language acquisition problems, links between language knowledge and language use, speech disorders, and aphasia types. Presents neurolinguistic case studies with evidence from split-brain patients and fMRI data.

LING 167 Structural/Descriptive Linguistics (4) Lecture, 3 hours; outside research, 3 hours. Prerequisite(s): LING 020 or consent of instructor. An overview, from the original sources, of the contribution of major figures and schools in linguistics from Saussure through early Chomsky. Cross-listed with ANTH 167. **Kronenfeld**

LING 190 Special Studies (1-5) To be taken with the consent of the chair of the Committee as a means of meeting special curricular problems. Course is repeatable.

LING 192 Tutorial Activities (1-2) Prerequisite(s): junior or senior standing and nomination by faculty. Enlarging understanding of linguistics through conducting tutorial sessions in introductory courses, under the supervision of faculty members responsible for the courses involved. Graded Satisfactory (S) or No Credit (NC). May be repeated for a maximum of three quarters.

LING 195 Senior Thesis (2-4) Thesis, 6-12 hours. Prerequisite(s): senior standing or consent of instructor. Independent research and preparation of a thesis completed under the supervision of a faculty member. Course is repeatable to a maximum of 12 units.

LING 195H Senior Honors Thesis (2-4) Thesis, 6-12 hours. Prerequisite(s): invitation by faculty to pursue honors work in Linguistics; senior standing or consent of instructor. Intensive study, research, and preparation of a thesis in consultation with a faculty member. Grades are deferred until presentation of the thesis at the end of the final quarter. Satisfactory (S) or No Credit (NC) grading is not available. To be taken during two or three successive quarters; course is repeatable to a maximum of 12 units.

Related Courses

Refer to departmental listings for course descriptions.

Anthropology
ANTH 120 (Language and Culture)
ANTH 123 (Linguistic Anthropology)
ANTH 165 (Cognitive Anthropology)
ANTH 259 (Anthropological Linguistics)

Education
EDUC 172 (Reading and Language Development)
EDUC 177A (Language Development in Content Areas)
EDUC 177B (Language Development in Content Areas)
EDUC 201A (Theories and Processes of Reading)

English
ENGL 112 (History of the English Language)

Languages and Literatures/French
FREN 104 (Phonetics)

Mathematics
MATH 144 (Introduction to Set Theory)

Philosophy
PHIL 125 (Intermediate Logic)
PHIL 126 (Advanced Logic)
PHIL 132 (Philosophy of Language)

Psychology
PSYC 110 (The Brain and Behavior)
PSYC 134 (Cognitive Processes)
PSYC 135 (Psycholinguistics)
PSYC 163 (Cognitive Development)

Spanish
SPN 105 (Phonology of the Spanish Language)
SPN 106 (Structure of the Spanish Language)
SPN 107 (Spanish in the United States)
SPN 207 (History of the Spanish Language)

Literatures and Languages

Subject abbreviation: LTLG

Graduate Course

LTLG 250 Colloquium in Literatures and Languages (1-2) Seminar, 1 hour. Lectures and discussions by staff, visiting scholars and students on current research topic. Students delivering lectures may take the course for 2 units, students attending lecture and discussions may take the course for 1 unit. May not count towards minimum unit requirement for the degree. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 12 units.

Professional Course

CPLT 301 Teaching of Foreign Language at the College Level (4) Lecture, 3 hours; term paper, 3 hours. Prerequisite(s): graduate standing, or senior standing with consent of instructor. Covers first and second language acquisition; general models of L2 learning; learning different types of grammar; learning other components of language: acquisition of pronunciation, vocabulary, and discourse; multilingual societies and the goals of language teaching; and implications of second language acquisition research for the foreign language classroom. Graded Satisfactory (S) or No Credit (NC).

Computer Engineering

Subject abbreviation: CEN
The Marlan and Rosemary Bourns College of Engineering

Walid Najjar, Ph.D., Director
Sheldon Tan, Ph.D., Associate Director
Advising Office, A159 Bourns Hall
(951) 827-ENGR (3647);
student.engr.ucr.edu

Program Committee
Laxmi Bhuyan, Ph.D. (Computer Science and Engineering)
Philip Brisk, Ph.D. (Computer Science and Engineering)
Nael Abu-Ghazaleh, Ph.D. (Computer Science)
Roger Lake, Ph.D. (Electrical and Computer Engineering)
Walid Najjar, Ph.D. (Computer Science and Engineering)
Sheldon Tan, Ph.D. (Electrical and Computer Engineering)
Frank Vahid, Ph.D. (Computer Science and Engineering)
Albert Wang, Ph.D. (Electrical and Computer Engineering)
Qi Zhu, Ph.D. (Electrical and Computer Engineering)
Reza Abbaschian, Ph.D.
Dean, The Marlan and Rosemary Bourns College of Engineering, ex officio

Major

The Computer Engineering major stresses the study of core computer science and electrical engineering topics. It prepares students for careers in the design of complex systems involving computer hardware, computer software, electronics and electrical signals for communications, networking, desktop computing, and embedded computing.

The objective of the Computer Engineering program is to produce graduates who:

- have a mastery of the fundamental areas required for designing and using computers and engineered systems that contain computers
- have an ability to apply principles of engineering, mathematics, science, and statistics to the use, design, and interfacing of computers
- are able to apply modern design methodologies and state-of-the-art tools to design problems common to modern computer engineering practice
- have had extensive, relevant laboratory and hands-on experience to strengthen their understanding of scientific, logical, statistical, and engineering principles
- have a well-rounded and balanced education through required studies in elected areas of the humanities and social sciences

- are adept at both oral and written communication
- possess the high-quality undergraduate education necessary to progress to the M.S. and Ph.D. level or succeed in a career in industry
- understand the social, cultural, ethical, and environmental context of their work

The Computer Engineering B.S. degree program at UCR is accredited by the Engineering Accreditation Commission of ABET, **abet.org**. For more details, visit **cen.ucr.edu**.

The Intersegmental General Education Transfer Curriculum (IGETC) does not meet transfer requirements for Engineering.

All undergraduates in the College of Engineering must see an advisor at least annually. Visit **student.engr.ucr.edu** for details.

University Requirements

See Undergraduate Studies section.

College Requirements

See The Marlan and Rosemary Bourns College of Engineering, Colleges and Programs section.

The Computer Engineering major uses the following major requirements toward the satisfaction of some of the college's Natural Science and Mathematics breadth requirements.

1. MATH 008B or MATH 009A
2. PHYS 040A, PHYS 040B, PHYS 040C

Major Requirements

1. Lower-division requirements (72 units):
   a) ENGR 001G
   b) CS 010 or CS 10V, CS 012 or CS 012V, or CS 013, CS 014, CS 061
   c) CS 011/MATH 011
   d) EE 001A, EE 01LA, EE 001B, EE 020
   e) MATH 008B or MATH 009A, MATH 009B, MATH 009C, MATH 010A, MATH 046
   f) PHYS 040A, PHYS 040B, PHYS 040C
   g) One course of 4 or more units in an engineering discipline outside the field of computer science to be selected in consultation with a faculty advisor. Either a lower-division or an upper-division course may be used to satisfy this requirement.
2. Upper-division requirements (73 units minimum)
   a) CS 100, CS 141, CS 153, CS 161, CS 161L
   b) CS 120A/EE 120A, CS 120B/EE 120B; one course from CS 122A or EE 128
   c) CS 111
   d) CS 168
   e) ENGR 180W
   f) EE 100A
   g) EE 114 or STAT 155
   h) Five courses (at least 20 units) as technical electives from the following set of Computer Science and Engineering, and Electrical Engineering upper-division courses

      CS 122A, CS 122B, CS 130, CS 133, CS 150, CS 152, CS 160, CS 162, CS 164, CS 165, CS 166, CS 169, CS 170, CS 171, CS 172, CS 177, CS 179 (E-Z), CS 180, CS 181, CS 183, CS 193

      EE 100B, EE 105, EE 110A, EE 110B, EE 115, EE 128, EE 132, EE 133, EE 134, EE 135, EE 140, EE 141, EE 144, EE 146, EE 150, EE 151, EE 152, EE 175A, EE 175B, EE 175C

      The technical electives selected from h) must include either CS 179 (E-Z) or EE 175A and EE 175B and EE 175C. The selection of the remaining technical electives must be planned, in consultation with a faculty advisor, to include at least one coherent sequence of two classes from either Computer Science and Engineering or Electrical Engineering. The technical electives must be distinct from those used to satisfy the upper-division requirements specified in items a) and b) above.

Students may petition for exceptions to the above degree requirements. Exceptions to Computer Science course requirements must be approved by the Computer Science and Engineering undergraduate advisor or chair, and exceptions to Electrical Engineering course requirements must be approved by the Electrical Engineering undergraduate advisor or chair. Exceptions to other requirements require the approval of the undergraduate advisors or chairs of both departments.

Visit the Student Affairs Office in the College of Engineering or **student.engr.ucr.edu** for a sample program.

Graduate Program

The Computer Engineering program offers the B.S. + M.S. program and the M.S. degree in Computer Engineering. Specific requirements for each degree are described below.

Master's Degree

M.S. in Computer Engineering The college offers an M.S. program in Computer Engineering.

Admission All applicants to this program must have completed a bachelor's degree or its approved equivalent from an accredited institution and to have attained undergraduate record that satisfies the standards established by the Graduate Division and University Graduate Council. Applicants should have at least an undergraduate major in Computer Engineering, Computer Science, Electrical Engineering or a closely related field. Applicants who fail to meet this criterion may sometimes be admitted with course deficiencies. However, no more than three deficiencies will be allowed.

A student who is deficient in a competency area may be asked to complete the corresponding UCR course with a letter grade of at least B+, or to pass a challenge examination based on that course's final exam with a grade of at least B+. All such remedial work should be completed with the first year of graduate study, and in all cases the deficiency(s) must be corrected BEFORE a student can enroll in any graduate course from the same specialty area.

All applicants must submit scores from the Graduate Record Exam, General Test (GRE). The GRE subject test in Computer Science or Electrical Engineering is recommended but not required. Applicants whose first language is not English are required to submit acceptable scores from the TEST of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS) unless they have a degree from an institution where English is the exclusive language of instruction. Additionally each applicant must submit three letters of recommendation, at least two of which must be academic references. All other application requirements are specified in the graduate application.

Prerequisite Material Competence in the areas defined by the following UCR courses is essential to graduate study in computer engineering:

EE 100A, EE 100B, CS 153, CS 161, CS 161L, CS 120A/EE 120A, CS 120B/EE 120B

A student who is deficient in any of these competency areas may be asked to complete the corresponding UCR course with a letter grade of at least B+, or to pass a challenge examination based on that course's final exam with a grade of at least B+. All such remedial work should be completed within the first year of graduate study, and in all cases the deficiency must be corrected BEFORE a student can enroll in any graduate course from the same specialty area. The admission prerequisite courses listed above may not be taken for graduate credit.

Course Requirements Students must be in residence for one year and complete a minimum of 36 quarters units of graduate and upper division undergraduate courses in or related to the major subject area. Students who have completed similar courses elsewhere may petition for waiver of a required course or for substitution of an alternative course. For students interested in interdisciplinary research, individual study programs can be approved.

1. **Core Requirement (12 units)**. Three courses from the list of core courses below, with no grade lower than B-.

   CS 201 or CS 202, CS 203, CS 220, EE 213, EE 221

2. **Technical Electives (12 units)**. Three courses from the list of technical elective courses below.

   CS 204, CS 213, CS 218, CS 223, CS 239, CS 240, CS 246, CS 255, CS 257, EE 202, EE 203, EE 210, EE 211, EE 215, EE 222, EE 226, EE 229, EE 235, EE 241, EE 243.

3. **Professional Development Requirement, Colloquium (3 units)**. Satisfactory completion of three quarters of CS 287 (Colloquium in Computer Science) or EE 259 (Colloquium in Electrical Engineering) in three distinct quarters.

4. **Capstone Experience** All students must complete a capstone experience that synthesizes and integrates the knowledge and skills obtained throughout the master's program, by either passing a comprehensive exam, writing a thesis, or completing a project. The Comprehensive Examination plan is the default option. If a student choses the alternative project or thesis plan, it is their responsibility to find a faculty member willing to supervise the master's project or thesis, to form the faculty examining committee, and to schedule the oral examination.

   a. **Comprehensive Examination (Plan I).** A minimum of 36 units are required, of which 24 must be selected from the Core Requirement and Technical Electives courses above. The remaining 12 units must be in approved graduate-level courses related to the major subject area, and/ or approved Computer Engineering undergraduate technical electives. Units obtained in graduate research for the thesis or dissertation, directed research, or directed studies (CS 290, CS 297, CS 299, EE 290, EE 297, EE 299) may not be used to satisfy any course requirements under this plan. Students must pass a comprehensive examination administered by the Computer Engineering Program.

   b. **Project (Plan II).** A minimum of 36 units are required, of which 24 must be selected from the Core Requirement and Technical Electives courses above. The remaining 12 units must be in approved graduate-level courses related to the major subject area, and/ or approved Computer Engineering undergraduate technical electives, and may include up to 4 units of directed research (CS 297, EE 297) and/ or directed studies (CS 290, EE 290). Units obtained in graduate research for the thesis or dissertation (CS 299, EE 299) may not be used to satisfy any course requirements under this plan. Students must complete a research project under the guidance of a faculty member. The project will be approved by a committee of at least two faculty members and requires a presentation and written report.

   c. **Thesis (Plan III).** A minimum of 36 units are required, of which 24 must be selected from the Core Requirement and Technical Electives courses above. The remaining 12 units must be in approved graduate-level courses related to the major subject area, approved Computer Engineering undergraduate technical electives, or graduate research for the thesis or dissertation (CS 299, EE 299). Units obtained in directed research or directed studies (CS 290, CS 297, EE 290, EE 297) may not be used to satisfy any course requirements under this plan. Students must submit a master's thesis in accordance with the general requirements of the university. The thesis is original research work, and it should demonstrate the student's ability to study a research area, identify an open problem and make a research contribution. The thesis requires a presentation and must be approved by a committee of at least three faculty members.

Combined B.S. + M.S. Five-Year Program. The college offers a combined five year B.S. + M.S. program, designed to allow successful UCR Computer Engineering B.S. graduates to complete the Master of Science degree in Computer Engineering in one year, by allowing up to 12 credits of coursework taken as a UCR undergraduate to be counted towards the elective requirements of the M.S. (The courses that can be double counted are those that are eligible to be counted as technical electives in the B.S. requirements.)

A student may apply at the start of their senior year by submitting an application to the Computer Engineering M.S. program, provided that at the end of junior year, the student was a UCR Computer Engineering B.S. student with cumulative GPA at least 3.4 and had completed the following courses with no grade less than a B- and average grade at least 3.2: CS 100, CS 120A, CS 120B, CS 161, CS 161L. The application to the M.S. program must include at least two recommendation letters from UCR Academic Senate faculty members (at least one, and preferably both, CSE faculty). Submission of GRE scores with the application is recommended but not required. Matriculation into the combined program occurs in the Fall term following senior year, provided: (a) the M.S. application is accepted, (b) throughout senior year, the student is a Computer Engineering B.S. major with cumulative GPA 3.4 or higher, (c) by the end of senior year, the student completes the Computer Engineering B.S. degree requirements.

Incoming students who are applying to the Computer Engineering B.S. program may simultaneously apply for preliminary admission into the combined program provided their high school GPA is at least 3.6, their SAT-I combined score is at least 1950, they satisfy the Entry Level Writing requirement before matriculation, and they have sufficient math preparation to enroll in calculus upon arrival. Preliminary admission status is maintained as long as the student is a Computer Engineering or Computer Science B.S. student in good standing with a cumulative GPA of at least 3.4. Preliminarily admitted students still need to apply for full admission in their senior year as described above.

Five-year programs leading to M.S. degrees in other programs (including Computer Science) are also available. They are described separately in the catalog sections for those programs.

Computer Science and Engineering

Subject abbreviation: CS
The Marlan and Rosemary Bourns College of Engineering

Marek Chrobak, Ph.D., Chair
Department Office,
351 Winston Chung Hall
(951) 827-5639; **cs.ucr.edu**

Distinguished Professor
Laxmi N. Bhuyan, Ph.D.

Professors
Marek Chrobak, Ph.D.
Nael Abu-Ghazaleh, Ph.D.
Rajiv Gupta, Ph.D.
Tao Jiang, Ph.D. *President's Chair*
Eamonn Keogh, Ph.D.
Srikanth Krishnamurthy, Ph.D.
Stefano Lonardi, Ph.D.
Mart L. Molle, Ph.D.
Walid Najjar, Ph.D.
Michael Pazzani, Ph.D.
Kadangode K. Ramakrishnan, Ph.D.
Chinya Ravishankar, Ph.D.
Vassilis Tsotras, Ph.D.
Frank N. Vahid, Ph.D.
Neal Young, Ph.D.

Professors Emeriti
Yang-Chang Hong, Ph.D.
Thomas H. Payne, Ph.D.
Teodor C. Przymusinski, Ph.D.

Associate Professors
Evangelos Christidis, Ph.D.
Iulian Neamtiu, Ph.D.
Christian Shelton, Ph.D.
Victor Zordan, Ph.D.

Assistant Professors
Philip Brisk, Ph.D.
Zizhong Chen, Ph.D.
Zhiyun Qian, Ph.D.
Tamar Shinar, Ph.D.

**

Adjunct Professors
Gianfranco Ciardo, Ph.D.
Michalis Faloustsos, Ph.D.

Cooperating Faculty
Bir Bhanu, Ph.D. (Electrical and Computer Engineering)
Ilya Dumer, Ph.D. (Electrical and Computer Engineering)
Thomas Girke, Ph.D. (Botany and Plant Sciences)
Roger Lake, Ph.D. (Electrical and Computer Engineering)
Michel L. Lapidus, Ph.D. (Mathematics)
Erik Rolland, Ph.D. (Accounting and Information Systems)
Amit Roy-Chowdhury, Ph.D. (Electrical and Computer Engineering)
Thomas Stahovich, Ph.D. (Mechanical Engineering)
Sheldon Tan, Ph.D. (Electrical and Computer Engineering)
Qi Zhu, Ph.D. (Electrical and Computer Engineering)

Major

The Department of Computer Science and Engineering offers three majors at the undergraduate level. UCR's offerings of all three majors are unique compared to many schools in the emphasis on theoretical foundations and practical applications.

The **Computer Science** major stresses the study of core and advanced computer science topics. It prepares students for a large variety of careers in computing, including software