Computer Science & Engineering Handbook

Department of Computer Science & Engineering

FOR UNDERGRADUATES

1998-99
Letter from the Chair

Thank you for your interest in the University of Washington's Department of Computer Science & Engineering.

Of course, it's great to major in a field that's burgeoning, a field in which the world's most vibrant industry is right here in the Puget Sound region (where we boast more than 2,000 software and digital media firms). But the right reason to choose Computer Science or Computer Engineering as your major is that these fields are where the intellectual excitement is, where the breakthroughs are occurring, where the smartest young men and women are choosing to work. Computer Science and Computer Engineering are where the action is - from robots to personal communication systems to intelligent agents to computer animation to computational biology.

UW's Department of Computer Science & Engineering is ranked among the top ten in the nation, along with Stanford, MIT, Berkeley, Carnegie Mellon, Cornell, Princeton, Texas, Illinois, and Wisconsin. As an undergraduate in our department you'll have very special opportunities - the chance to reach, and even to help define, the forefront of the field. You'll find faculty, staff, and students who are among the finest at the University of Washington. You'll find state-of-the-art labs and curriculum. You'll find junior and senior classes that typically have 40 students, affording close faculty contact. You'll find co-ops and internships that complement your education; laboratory assistantships and teaching assistantships; "capstone" design courses where you'll work in a team to design and implement significant systems; and the chance to participate actively in research alongside graduate students and faculty.

We're committed to helping you get the great education that you deserve. We hope you choose to join us.

Sincerely,

Edward D. Lazowska
Professor and Chair
Computer Science and Computer Engineering Degree Information

The department offers two undergraduate degrees: a B.S. in Computer Engineering (CompE) and a B.S. in Computer Science (CS). These degree programs have much in common in that they necessarily share a common core of fundamental courses both in the prerequisites for admission as well as the 300-level courses in the Department. They both require a total of 180 credits. The differences lie in the requirements beyond the common core and in courses outside the department.

The computer engineering curriculum includes a background in engineering principles, engineering design, mathematics, and electrical engineering so as to provide a basis for understanding the underlying technologies of modern computing systems and the tradeoffs faced by the designers. There is also a particular emphasis on written and oral communication skills.

The computer science curriculum includes a wider range of humanities requirements in line with other programs in the College of Arts and Sciences. Students have a wide choice in shaping their program and can concentrate in topics such as business and economics, applied mathematics and statistics, biology and medicine, ethics and law, and many others.

Within the department, the two degree programs also share many upper-level courses. Given a common core, a computer science student can shape their program to look very much like computer engineering. The same is true for the computer engineering student. The different perspectives the two programs bring to the curriculum enrich the experience for both groups.

Computer scientists focus on software systems and understanding the limits of computation within the context of real and abstract computing devices. Computer engineers tend to focus more on the engineering of embedded systems (systems that involve both hardware and software).

Computer engineers design and implement computer hardware and software systems to solve a variety of problems in such diverse areas as communications, manufacturing, robotics, computer graphics, databases, and many others. A computer engineer might be involved in fundamental research, hardware design and fabrication, software creation, or systems integration.

Computer scientists are generally involved in applications that require the design of the representation of information: methods for its storage and retrieval; algorithms to display, edit, and transform the information; programming and mathematical languages to express the algorithms that operate on the information; and the hardware and software to execute these algorithms.
Frequently Asked Questions

What's the difference between majoring in Computer Science and Computer Engineering?
Computer Engineering and Computer Science are closely related. The department's junior-level courses are required of both CompE and CS majors, and many of the senior courses are taken by students in both disciplines. However, there are differences between the two degree programs. The key differences are as follows:

CompE students must satisfy the College of Engineering distribution requirements; CS students must satisfy the College of Arts and Sciences distribution requirements. The CompE major has more required courses and fewer electives. CompE students take substantially more courses in computer hardware and electrical engineering than CS. The CompE major is appropriate for students interested in building systems that include both custom hardware and software components, who have strong interests in EE, or who specifically want an Engineering degree.

The flexibility of the CS major allows students to double major with another Arts and Sciences program (for example, Mathematics or Economics). Please see the previous section (Degree Information) for additional details.

Can I major in both degree programs?
Due to the large overlap, a double major of Computer Engineering with Computer Science is not allowed. Admission for CompE and CS is handled separately. Both degree programs are competitive with more qualified applicants than spaces available.

What can I do with a degree in Computer Science and Engineering?
Both CS and CompE graduates have had excellent success in finding positions after graduation. Many positions are equally suitable for graduates with either degree.

We train our students for two career paths—graduate work in CS&E and entry into industry. Both programs are academically rigorous, and our graduates are highly competitive at the top graduate schools in the country. They are also at the forefront of the practical developments in computer technology and applications, as well as of theoretical investigations of computers, algorithms, and data. These qualities make our students highly valuable to local and national industry.

Can I take some of the prerequisite courses at a Washington State Community College?
Many students who apply to the department are transfer students or have taken some courses at a community college. For information about UW Courses Equivalencies at Washington State Community Colleges, please see the following website: http://www.washington.edu/students/ugs/transfer/course_equiv.html.

What are the deadlines for applying?
We admit students in the autumn and spring quarters. The deadline for the autumn quarter is JULY 1. The deadline for the spring quarter is FEBRUARY 1.

Please see the section on Admissions Procedures for additional information about applying.

How can I learn more?
We recommend you attend an information session about the programs. These sessions are held regularly, and the schedule is available at our website (http://www.cs.washington.edu/education/index.html) or by calling 206-543-1695. An advisor can also meet with you individually. Call to make an appointment.
Admission Prerequisites

Students applying to both the CS and CompE Programs must complete the following requirements prior to the deadline date:

- Be enrolled as a student at the UW or apply to enroll through the Office of Admissions, 320 Schmitz Hall (206-543-9686; askuwadm@u.washington.edu)
- Have a cumulative GPA (including all transfer units) of at least 3.0 (2.5 for CompE)
- Complete the following courses:
  Math 124, 125, 126
  Physics 121, 131
  CSE/ENGR 142

Additional Computer Science Prerequisites:
CSE/ENGR 143
Earn a minimum of 45 quarter credits applicable toward a bachelor's degree

Additional Computer Engineering Prerequisites:
Math 307
Physics 122, 123, 132 & 133
Chemistry 142
Five credits of English composition (selected from English 111, 121, 131, 197, 198, 199, or Comparative Literature 240)
Earn a minimum of 64 quarter credits applicable toward a bachelor's degree

Early Admission (Computer Engineering Only)
Students eligible for early admission must be currently enrolled at the UW, have completed 15 credits of Math 124, 125, 126 or higher, 10 credits of Physics 121, 122, 123 or Chem 142, CSE/ENGR 142, 5 credits of English composition, and have completed at least 15 credits at the UW.

This option is available for autumn quarter admission only.
Application Instructions

Application deadlines:
July 1 - Autumn quarter
February 1 - Spring quarter

To apply, the following documents must be submitted by the deadline:

1 COMPLETED APPLICATION
FORM IS AVAILABLE ON-LINE AT: http://www/cs.washington.edu/education/apply/

Transfer students must also be admitted to the University of Washington through the Office of Undergraduate Admissions, 320 Schmitz Hall. They should indicate their interest in Computer Engineering and/or Computer Science on their UW application and submit the application to the University Admissions Office early enough to meet both University and Department deadlines. The Admissions Office recommends you allow at least four weeks.

2 STATEMENT OF PURPOSE

This statement should be approximately 200 words, and should describe motivation, goals, and related work experience. Also, you may wish to discuss any unusual circumstances that may contribute to a better understanding of your record.

3 COPIES OF ALL UW AND NON-UW TRANSCRIPTS

These transcripts are in addition to those submitted to the University of Washington’s Admissions Office. Transcripts for the most recent quarter (Spring for Autumn admissions and Autumn for Spring admissions) must be included. We will accept unofficial UW transcripts available from the second floor of Schmitz Hall or the Undergraduate Advising Center in 9 Communications. If time does not allow obtaining a transcript that includes the most recent quarter, please submit the grade report for that quarter.

Students formerly majoring in Computer Engineering or Computer Science at the University of Washington and wishing to re-enroll should consult with an advisor.

It is the student’s responsibility to verify that the application has been received by the Department of Computer Science and Engineering before departmental deadlines.

Selection Process

Computer Science: Computer Science accepts approximately 80 students per year and is offered through the College of Arts and Sciences.

Computer Engineering: Computer Engineering accepts approximately 40 students per year and is an ABET-accredited program offered through the College of Engineering.

The Admissions Committee evaluates the qualifications of applicants exclusively on the basis of written material submitted by each applicant. Due to the large number of applications, it is not possible to conduct personal interviews in the selection process. Students are encouraged to consult with an undergraduate advisor prior to submitting their application.

Strong written and oral communication skills are essential to success in CompE and CS, both in the undergraduate programs and later in the workplace or graduate school. For this reason, the statement of purpose and evidence of written and oral communication skills will be evaluated by the Admissions Committee both on the basis of its content and also as a sample of the student’s writing ability.

Enrollment is limited due to space, faculty, and budgetary limitations. Applicants who, in the judgment of the Admissions Committee, are most likely to succeed in the program and contribute to the field will be admitted. Selection is made primarily on the basis of scholastic achievement and potential. Other selection criteria, such as work experience, is also considered.

Applicants will be notified of admission status by letter 4 to 6 weeks after departmental application deadlines.

In conformity with a standing policy of the University, the Department provides equal opportunity in education without regard to race, color, national origin, sex, age or handicap in accordance with Title VI of the Civil Rights Act of 1964, Title IX of the Education Amendments, Section 504 of the Rehabilitation Act of 1973, and the Age Discrimination Act of 1975.

Appeals Procedure

Students denied admission to the program may wish to consult with an undergraduate advisor for additional information and guidance. Students may request a review of the Admissions Committee decision by writing a letter to the Admissions Committee citing the reasons for the appeal. This letter must be submitted within two weeks after the notification of denial is mailed. The only legitimate basis for an appeal is that there was an error in the data considered by the Admissions Committee. Incomplete or inaccurate records submitted by the applicant will not be considered as a basis for an appeal.
Computer Engineering and Computer Science Curriculum

All Computer Engineering and Computer Science students must take the following courses (32 credits):
CSE 142, 143, 321, 322, 325, 341, 370, 378

<table>
<thead>
<tr>
<th>Computer Engineering Credit Requirements</th>
<th>Computer Science Credit Requirements</th>
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<tbody>
<tr>
<td><strong>Additional CompE requirements:</strong></td>
<td><strong>Additional CS requirements:</strong></td>
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<tr>
<td>36 credits</td>
<td>18 credits (must include 2 projects)</td>
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<tr>
<td>ENGR 215, CSE 451, 467, 471, and 477</td>
<td>Most core at least 4 classes from the following</td>
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<tr>
<td>EE 233, 391 and 392</td>
<td>CSE 401, 403, 421, 431, 444, 451, 457, 471, 473</td>
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<tr>
<td><em>Elective (14 credits):</em></td>
<td><em>Electives (7 credits):</em></td>
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<tr>
<td>See CSE electives list on page 14</td>
<td>See CSE electives list on page 14</td>
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<tr>
<td><em>Math (12 credits):</em></td>
<td><em>Math (15 credits):</em></td>
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<tr>
<td>MATH 124, 125, 126, 307, 308, STAT 290</td>
<td>MATH 124, 125, 126, and 3 courses selected from the following: MATH 307, 308, 309; any of the Math or Statistics courses in the CSE elective component; or Stat/Environ 331</td>
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<tr>
<td><em>Science (10 credits):</em></td>
<td><em>Science (16 credits):</em></td>
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<td>PHYS 121, 122, 123, 131, 132, 133; CHEM 142</td>
<td>PHYS 121, 122, 123, 131, 132, 133</td>
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<tr>
<td><em>General Education (4 credits):</em></td>
<td><em>General Education (4 credits):</em></td>
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<tr>
<td><em>YIPE and IPE (3 credits):</em></td>
<td><em>YIPE, CIS, the Natural World (2 credits):</em></td>
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<tr>
<td>As prescribed by the College of Engineering.</td>
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<tr>
<td><em>Written and Oral Communication (10 credits):</em></td>
<td><em>Written and Oral Communication (10 credits):</em></td>
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<tr>
<td>English Composition, ENGR 231, 333.</td>
<td>English Composition, Foreign Language, GSR, W courses and/or additional composition.</td>
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</table>

Registration, Mathematics, and Science Electives (4 credits)
Any graded ENGR course. Any graded course at the 300-level and above in an engineering or science department. (*Biology 201, 202, CHEM 150, 151, 260, 161, EE 235, ENGR 498R, 499R*).

*Applies to mathematics, science, chemistry, biology, and general science classes.

Free Electives (5 credits)
Free Electives (approximately 26-30 credits).

Additional CompE Requirements:
In order to be awarded a CompE degree, a student must accumulate 50 credits of Math and Basic Sciences, 50 credits of Engineering Science, and 26 credits of Engineering Design. In addition to completing all the required courses listed, each engineering course has been evaluated for its Engineering Science and Engineering Design content. The list of current credit assignments can be obtained from an undergraduate advisor.

Courses graded S/NS may not be applied to any distribution or major requirement. Courses graded CR/NC may be applied where appropriate.
# CSE Senior Electives

## COMPUTER ENGINEERING & COMPUTER SCIENCE

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>ENGR/Engr. 400, 405</td>
<td>Methods in Applied Mathematics I, II, III (4, 4, 4)</td>
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<tr>
<td>485</td>
<td>GUI Workshop (3, 9)</td>
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<tr>
<td>464</td>
<td>Analytical Design/Analysis (3)</td>
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<tr>
<td>IE/IEEngr. 465</td>
<td>User Interface Design (3)</td>
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<tr>
<td>480, 481</td>
<td>System (6, 4)</td>
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<tr>
<td>Ling/Phil 479</td>
<td>Formal Semantics and Natural Language (3)</td>
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<tr>
<td>Math 402, 403, 406</td>
<td>Introduction to Modern Algebra (3, 3, 3)</td>
</tr>
<tr>
<td>407</td>
<td>Linear Optimization (3)</td>
</tr>
<tr>
<td>408</td>
<td>Nonlinear Optimization (3)</td>
</tr>
<tr>
<td>409</td>
<td>Discrete Optimization (3)</td>
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<tr>
<td>410, 412, 413</td>
<td>Number Theory (3, 3)</td>
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<tr>
<td>420, 425, 426</td>
<td>Advanced Calculus (3, 3)</td>
</tr>
<tr>
<td>436</td>
<td>Introduction to Systems (3)</td>
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<tr>
<td>438, 439</td>
<td>Introduction to Partial Differential (3)</td>
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<tr>
<td>440, 441</td>
<td>Advanced Geometry (3)</td>
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<tr>
<td>460, 461, 462</td>
<td>Combinatorial Theory  (3)</td>
</tr>
<tr>
<td>464, 466, 468</td>
<td>Numerical Analysis I, II, III (4, 4, 4)</td>
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<tr>
<td>Music 401, 402, 403</td>
<td>Computer Music Seminar (3)</td>
</tr>
<tr>
<td>Stat 461, 462</td>
<td>Introduction to Probability &amp; Statistics (3)</td>
</tr>
<tr>
<td>492</td>
<td>Data Analysis (4)</td>
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<tr>
<td>Stat/Engr. 590, 595</td>
<td>Probability I, II (3, 3)</td>
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<tr>
<td>401, 402</td>
<td>Introduction to Stochastic Process (3)</td>
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<tr>
<td>EE 401</td>
<td>Of Science and Technical Writing (3)</td>
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<tr>
<td>EE 407</td>
<td>Computer Documentation (3)</td>
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</table>

## COMPUTER SCIENCE ONLY

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tr>
<td>Stat 498</td>
<td>Up to 6 credits of CSE 498 (Senior Project) are allowed, except for honors students, who must take 9 credits of CSE 498R.</td>
</tr>
</tbody>
</table>

Courses not on this list can apply toward the senior elective component, subject to approval by the Undergraduate Faculty Advisor.

## Additional Opportunities

### Co-op Program

The Co-op Office in 353 Loew Hall coordinates co-op jobs and minority student internships. These programs give students the opportunity to investigate the practice of the profession and define their own career goals by spending one or more quarters in a job in the computer industry while enrolled in the degree program. A co-op job is an opportunity to put academic knowledge to use in a way that helps students see the relationships between various parts of the curriculum and add to that knowledge in important ways. Students gain a wide variety of skills and abilities related to working in a team setting — a setting that is very difficult to emulate in a university. Many Computer Science & Engineering students have found co-ops to be a valuable part of their studies, and majors are strongly encouraged to take advantage of the opportunities that co-ops present for professional and personal development.

Students going on co-op should notify an undergraduate advisor and plan a tentative schedule for their returning quarter. The quarters they spend off campus are exceptions to the department's Satisfactory Progress Policy.

Due to a College of Engineering rule, credits earned through co-op do not apply to any CompE degree requirements.

Up to 4 credits of ENGR 321 (Engineering Cooperative Education) can be used as free elective credits toward the 180 total credits required for the CS degree.

### Center for Career Services

The University's Center for Career Services, located in 301 Loew Hall, offers extensive services for students searching for career and job opportunities. Many local, national, and international companies send recruiters to campus each year to interview students in CompE, CS and other disciplines.

### Research Opportunities

The department's research activities include most of the principal areas of Computer Science and Computer Engineering.

### Scholarships

Scholarship opportunities are provided throughout the academic year. Scholarships are generally contributed by industry or federal agencies with awards based on academic performance, financial need, research contributions and student leadership. Awards can include monies, tuition and/or internships. Please refer to the department's web site for a listing and explanation of the scholarship opportunities.

### Teaching Assistantships

Many departmental courses, from the introductory programming courses through the senior-level VLSI and graphics courses, use undergraduates as laboratory assistants and teaching assistants.
Policies and Procedures

Honors Programs
Both degree programs offer an honors program. Students who qualify for the Honors Program should request the appropriate form from an Undergraduate Advisor. Students must apply to graduate with honors at least one quarter in advance of graduation. Honors will be noted on the diploma.

Computer Science requirements for entry:
1. An overall GPA of at least 3.3.
2. A GPA of at least 3.6 for all courses in the Computer Science core and elective components.
3. Affiliation with the College of Arts and Sciences.

To graduate with honors, a student must:
1. Maintain the above cumulative grade-point averages.
2. Take nine credits of CSE 498H, and complete a Senior Thesis, which must satisfy the following requirements:
   a. It should be a well-written document, clearly presented.
   b. It should be work done independently by the student under the supervision of a faculty member. The work should be original and demonstrate creative thinking, as judged by the faculty supervisor and the Undergraduate Faculty Advisor.
   c. Final approval of the thesis must be obtained from the faculty supervisor and the Undergraduate Faculty Advisor.

Computer Engineering requirements for entry:
1. An overall GPA of at least 3.5.
2. A GPA of at least 3.5 for all courses in the Computer Engineering core and elective components.
3. Affiliation with the College of Engineering.

To graduate with honors, a student must:
1. Take a minimum of 9 credits from Honors Seminars. The College offers a minimum of one Honors Seminar per quarter. A list of the year’s seminars is available at the beginning of Autumn Quarter in the Office of Academic Affairs, 356 Loew Hall. These seminars should be selected from the following:
   ENGR 498H Special Topics in Engineering (1-3, max 6)
   ENGR 499H Special Projects in Engineering (1-3, max 6)

Satisfactory Progress
Due to limited resources and the need to maintain program quality, we are not able to accept all students who apply to study Computer Science & Engineering. The Satisfactory Progress Policy has been developed to use the available resources effectively and to best serve our students.

Our program is designed to be pursued on a full-time basis. Students admitted to the Computer Science and Engineering undergraduate degree program should plan to engage in full-time study. In addition, certain levels of academic performance are required to continue in the program. The criteria and procedures below will be used in administering the Satisfactory Progress Policy of the Department. These criteria and procedures are in addition to those of the University of Washington.

1. Completed students must complete 12 or more credit hours applicable toward their degree program each academic quarter in residence except summer quarter. CS students must complete two or more courses applicable to their degree program each academic quarter in residence except for summer quarter. Students for both programs who have not completed their English as a Second Language (ESL) requirements must enroll in and satisfactorily complete at least one ESL class each quarter, starting with their first quarter in the program and continue to take ESL courses each quarter until ESL requirements are completed.

2. In exceptional circumstances students may petition to take fewer than the minimum requirements stated in item 1 above. Petitions must be filed no later than 10 days prior to the start of the applicable quarter and must contain a plan for completing all degree requirements. Students who are given permission to take fewer than 12 credits must complete the program approved in their petition. The department reserves the right to limit the number of students who are allowed to take fewer than the required course or credit limit.

3. The minimum acceptable grade for any required or elective course is 2.0 for both degree programs. A course may be taken a total of two times to satisfy this requirement.

4. A student’s overall grade point average must not fall below 2.0. If a course is taken more than once, all grades will be used in computing the grade point averages.

5. Graduation applications must be filed in accordance with University rules and regulations so that graduation takes place once all the requirements are satisfied.

6. Students who withdraw from the University without prior written approval of the Department, or are dropped for non-payment of fees, will forfeit their place in the program. Students must reapply for admission and, if re-admitted, must fulfill the requirements in effect at the time of re-admission.
Review of Progress

Each student’s progress is reviewed at the conclusion of each quarter to insure compliance with the criteria set forth above. In the event that a student fails to meet the criteria for satisfactory progress, a probation letter which indicates the reason(s) for the probationary status will be sent during the following quarter to the last address on record requesting that the student contact an undergraduate advisor.

Probation and Dismissal

Students who fail to comply with the criteria set forth above will have their performance reviewed for possible probationary action. In the absence of compelling extenuating circumstances, such a student will be placed on probation for failing to make satisfactory progress. The probationary quarter will be the quarter in residence that immediately follows the one in which the noncompliance occurred.

Students who fail to meet the criteria for satisfactory progress for two consecutive quarters in residence will be dismissed from the program. In addition, students who accumulate three probationary quarters will also be dismissed from the program. Such action will be communicated in writing to students at their last address on record and any current registrations or pre-registrations in Departmental courses will be canceled.

Academic Misconduct

Academic misconduct is any form of deception by which the student claims as his or her own work that which actually belongs to another, or otherwise gains unfair advantage over other students. This includes such actions as cheating on class assignments or examinations and plagiarism as well as more severe offenses, such as theft or alteration of other persons’ academic materials for purposes of acquiring academic credit or enhancing grades.

All incidents of alleged academic misconduct will be reported to the Office of Academic Affairs. Unless the incident has been resolved to the satisfaction of the student and instructor involved, the Dean’s Office will conduct a hearing. While the deposition of each case will be determined on the basis of its particular circumstances, the following general guidelines may be stated:

1. Any proven instance of cheating or plagiarism will at minimum result in disciplinary probation for the student(s) involved. Such probation will carry with it the possibility of dismissal if there is an additional proven act of academic misconduct on the part of the student(s).

2. If it is proven that a student has stolen or altered academic materials belonging to another student or an instructor for the purposes of achieving academic credit or enhancing a grade, the department will normally initiate proceedings to have the student dismissed from the University for at least one year and be permanently dropped as a CSE major.

In all considerations of academic misconduct, the department will carefully follow the letter and the spirit of the University’s Student Conduct Code. This code has been separately printed in pamphlet form and is available to any interested student at the College of Engineering’s Office of Academic Affairs, Room 371, Loew Hall and the Undergraduate Advising Center in 9 Communications. The Student Conduct Code is made a part of this document by reference.

Another form of misconduct is the misuse of computing facilities, for example, obtaining improper access to another student’s account. Before students obtain accounts on departmental computers they sign an agreement stating that they will not misuse their accounts. Violations of this agreement may result in the loss of computer accounts and/or being dropped from the major.

Each student who accepts admission into the Computer Science & Engineering degree programs agrees to be bound by the provisions of this section.

Graduation

It is the responsibility of the Computer Science & Engineering students to ensure that they meet all of the degree requirements. Assistance in the program planning is available from an undergraduate advisor. Application for graduation should be made with the advisor at least two quarters prior to the quarter students wish to graduate.

In order to be awarded the CompE degree, each candidate for the degree must fulfill the appropriate Accreditation Board for Engineering and Technology requirements, as well as the specific degree requirements set forth in this Handbook.

Applicability

The requirements contained in this Handbook apply to all students admitted in or after Autumn 1997 and until such time as a new Handbook or amendment is issued. Students admitted while this Handbook is current will not be subject to additional requirements that might be issued in the future, except those found necessary to comply with accreditation requirements.

Changes to policy and administrative procedures can be applied to students admitted prior to the effective date of this Handbook as long as such changes do not modify the degree requirements. In the context of this Handbook, “degree requirements” specifically means the total number of credits and the distribution of those credits required to earn a CS or CompE degree.
The coursework offered in the Computer Science & Engineering curriculum can be divided into four categories: hardware, systems, applications, and theory.

Hardware courses are concerned with digital logic and its specification, design, simulation, implementation, and testing. They include a significant laboratory component, culminating in a digital system design course that involves designing, simulating, constructing, and debugging a substantial project of the student’s choosing. In addition to the hardware courses offered by the Computer Science and Engineering Department, the curriculum includes a substantial number of Electrical Engineering courses.

Courses in the systems area are concerned with the logical structure “architecture” of computer systems and with the design and implementation of computer system software, such as operating systems and compilers. Many courses in this area include independent study projects.

Courses in the applications area deal with computers as tools to solve problems. Examples of topics in this area are artificial intelligence, computer graphics, and databases.

Theory courses are concerned with abstract notions of computing that are for the most part independent of any specific computing technology. Topics include designing efficient algorithms and analyzing the basic computational requirements of any algorithm for solving a particular class of problems.

**Computer Science and Engineering Courses for Pre-Majors**

| CSE/ENGR 142 COMPUTER PROGRAMMING FOR ENGINEERS AND SCIENTISTS I (4) |
| Basic programming in the small abilities and concepts. Highlights include procedural and functional abstraction with simple built-in data type manipulation. Basic abilities of writing, executing and debugging programs. Not available for credit to students who have completed CSE 210 or ENGR 141. |

| CSE 143 COMPUTER PROGRAMMING FOR ENGINEERS AND SCIENTISTS II (5) |
| Continuation of CSE/ENGR 142. Concepts of modularity and encapsulation, focusing on modules and abstract data types. Covers some basic data structures. Not available for credit to students who have completed CSE 211. Prerequisite: ENGR/CSE 142. |
CSE 321 DISCRETE STRUCTURES (4)
Fundamentals of set theory, graph theory, enumeration, and algebraic structures, with applications in computing. Prerequisite: Math 126 and CSE 142.

CSE 322 INTRODUCTION TO FORMAL MODELS IN COMPUTER SCIENCE (3)
Finite automata and regular expressions; context-free grammars and pushdown automata; nondeterminism; Turing machines and the halting problem. Emphasis on understanding models and their applications and on rigorous use of basic techniques of analysis. Induction proofs, simulation, diagonalization and reduction arguments. Prerequisite: CSE 321.

CSE 326 DATA STRUCTURES (4)

CSE 341 PROGRAMMING LANGUAGES (4)
Designed to make the student reasonably fluent in several radically different languages, such as LISP, Prolog, and Smalltalk. Prerequisite: CSE 143. No credit if CSE 413 has been taken.

CSE 370 INTRODUCTION TO DIGITAL DESIGN (4)
Introductory course in digital logic and its specification and simulation. Boolean algebra, combinational circuits including arithmetic circuits and regular structures, sequential circuits including finite-state machines, use of programmable logic devices. Simulation and high-level specification techniques are emphasized.

CSE 378 MACHINE ORGANIZATION AND ASSEMBLY LANGUAGE (4)
Differences and similarities in machine organization; central processors; fundamentals of machine language and addressing; assembly language programming, including macros; operating system interfaces. Prerequisite: CSE 143. No credit if CSE 410 has been taken.

CSE 401 INTRODUCTION TO COMPILER CONSTRUCTION (3)
Fundamentals of compilers and interpreters; symbol tables, lexical analysis, syntax analysis, semantic analysis, code generation, and optimization for general purpose programming languages. Prerequisites: CSE 322, CSE 326, CSE 341, and CSE 378. No credit if CSE 413 has been taken.

CSE 403 SOFTWARE ENGINEERING (4)
This course presents the fundamentals of software engineering using a group project as the basic vehicle. Topics covered include the software crisis, managing complexity, requirements specification, architectural and detailed design, testing and analysis, software process, and tools and environments. Prerequisites: CSE 321, CSE 341, and CSE 378. Either CSE 401 or CSE 451 is recommended.

CSE 421 INTRODUCTION TO ALGORITHMS (3)
Techniques for design of efficient algorithms. Methods for showing lower bounds on computational complexity. Particular algorithms for sorting, searching, set-manipulation, arithmetic, graph problems, pattern-matching, etc. Prerequisites: CSE 322 and CSE 326.

CSE 431 INTRODUCTION TO THEORY OF COMPUTATION (3)
Models of computation, computable and non-computable functions, space and time complexity, tractable and intractable functions. Prerequisite: CSE 322.

CSE 444 INTRODUCTION TO DATABASE SYSTEMS (3)
Fundamental concepts, system organization and implementation of database systems will be covered. Topics include the relational, hierarchical and network data models, file organizations and data structures, query languages, query optimization, database design, concurrency control, security, and issues involving distributed database systems. Prerequisite: CSE 326.

CSE 453 INTRODUCTION TO OPERATING SYSTEMS (4)
Principles of operating systems. Process management, memory management, auxiliary storage management, resource allocation. Prerequisites: CSE 326 and CSE 378. No credit if CSE 410 or EE 474 has been taken.

CSE 457 COMPUTER GRAPHICS (3)
Techniques of computer image synthesis, including both hardware and software. Line drawing and color raster graphics; geometric transformations, hidden surface and smooth shading algorithms. Prerequisite: CSE 326.

CSE 458 COMPUTER ANIMATION (5)
Introduction to basic principles of computer-generated animation. Focus on the modeling and lighting of animated charactera. Students from Art, CSE, and Music team up on projects to be built on commercially-available modeling and lighting packages. Prerequisites: CSE 417 or ART 380 or MUSC 403 and permission of instructor.

CSE 461 INTRODUCTION TO COMPUTER-COMMUNICATION NETWORKS (1)
Computer network architectures, protocol layers, Transmission media, encoding systems, error detection, multiplexing, switching. Data link, multiple access channel protocols. Methods for network routing, congestion control, flow control, End-to-end transport services, protocols, Network security, privacy. Applications including electronic mail, virtual terminals, distributed operating systems. Prerequisite: Senior standing. Joint with EE 461.

CSE 467 ADVANCED DIGITAL DESIGN (3)
Advanced techniques in the design of digital systems. Hardware description languages, combinational and sequential logic synthesis and optimization methods, partitioning, mapping to regular structures. Emphasis on reconfigurable logic as an implementation medium. Memory system design. Digital communication including serial/parallel and synchronous/asynchronous methods. Prerequisites: CSE 326 and CSE 370.
CSE 450 VERY LARGE SCALE INTEGRATION (3)
Introduction to CMOS technology and circuit design: implementation of combinational and sequential logic; VLSI design methodologies; CAD tools for layout, simulation and validation. Students design a VLSI chip using CAD tools. Prerequisites: CSE 467 or permission of instructor.

CSE 471 COMPUTER DESIGN AND ORGANIZATION (3)
CPU instruction addressing models, CPU structure and functions, computer arithmetic and logic unit, register transfer level design, hardware and microprogram control, memory hierarchy design and organization, I/O and system components interconnection. Laboratory project involves design and simulation of an instruction set processor. Prerequisites: CSE 370 and CSE 378.

CSE/LING 472 INTRODUCTION TO COMPUTATIONAL LINGUISTICS (3)
Introduction to computer applications of linguistic theory, including syntactic processing, semantic, and pragmatic interpretation and natural language generation. Prerequisite: Ling 471, or permission of instructor.

CSE 473 INTRODUCTION TO ARTIFICIAL INTELLIGENCE (3)
Principal ideas and developments in artificial intelligence: theorem proving, problem-solving methods; representation of knowledge, natural language analysis and synthesis, programming languages for artificial intelligence. Prerequisites: CSE 326, CSE 342 recommended. No credit if CSE 415 has been taken.

CSE 477 DIGITAL SYSTEM DESIGN (4)
Students use the laboratory to design, simulate, construct, and debug a substantial project that includes hardware, software, and communication components. Lectures focus on use of embedded processors in digital system design and interfacing techniques. Writing and debugging of real-time reactive software emphasized. Prerequisites: CSE 378 and CSE 467.

CSE 490 SPECIAL TOPICS IN COMPUTER SCIENCE & ENGINEERING (1-6)
Lectures and discussions on topics of current interest in computer science and engineering not covered by other CSE undergraduate courses.

CSE 498, 498M SENIOR PROJECT (1-6) HONORS (9)
Consists of a report (and perhaps demonstration) describing a development, survey, or small research project completed by the student in an area of specialization. Objectives are: (1) applying and integrating the classroom material from several courses, (2) introducing the professional literature, (3) gaining experience in writing a technical document, and (4) enhancing employability through the evidence of independent work. The project may cover an area in computer science and engineering or an application to another field. The work normally extends over more than one quarter. Prerequisites: Senior standing and permission of instructor.

CSE 499 READING AND RESEARCH (1-24)
Available in special situations for advanced Computer Engineering majors to do reading and research in the field. Subject to approval of the undergraduate advisor and a Computer Science and Engineering faculty member. Unable as a free elective, but not in place of a core course or Computer Engineering elective. Prerequisites: Senior standing and permission of instructor. Credit/no credit.

Computer Science and Engineering Courses for Non-Majors
Note: CSE 373, 410, 413, and 415 are intended for non-majors only. Prospective Computer Science or Computer Engineering majors should not take these courses. Instead, they should wait until they are admitted to the major and take the major courses listed in the previous section.

CSE 135 COMPUTATIONAL TECHNIQUES (4)
Principles of computer and techniques for using the computer as a tool in science and engineering. Basic programming techniques (conditional, iteration, procedural, and data abstraction). Introduction to simulation, visualization, and symbolic mathematics. Solving engineering and science problems using computer tools rather than conventional programming languages. Prerequisites: Math 124. Note: this course is not a requirement for either the Computer Science or the Computer Engineering degree.

CSE 373 DATA STRUCTURES AND ALGORITHMS (3)
Fundamental algorithms and data structures for their implementation. Techniques for solving problems by programming. Linked lists, stacks, queues, directed graphs, trees: representations and traversals. Searching (hashing, binary search trees, multitype trees). Garbage collection, memory management, internal and external sorting. Prerequisites: CSE 243. No credit if CSE 326, CSE 374, or EE 374 has been taken.

CSE 410 COMPUTER SYSTEMS (3)
Structure and components of hardware and software systems. Machine organization, including central processor and input-output architectures; assembly language programming; operating systems, including process, storage, and file management. Prerequisite: CSE 373. No credit if CSE 378 or CSE 451 has been taken.

CSE 413 PROGRAMMING LANGUAGES AND THEIR IMPLEMENTATION (3)
Concepts and implementation strategies for Algol-class languages, including Pascal, Modula, Algol 60, Ada. Compilers for Algol-class languages. Languages with late binding times, including LISP, APL, Smalltalk. Prerequisite CSE 373. No credit if CSE 341 or CSE 401 has been taken.

CSE 415 INTRODUCTION TO ARTIFICIAL INTELLIGENCE (5)
Principles and programming techniques of artificial intelligence: LISP, symbol manipulation knowledge representation, logical and probabilistic reasoning, learning, language understanding, vision, expert systems, and social issues. Prerequisites: CSE 373, or CSE 143 and permission of instructor. No credit if CSE 473 has been taken.
Parallel algorithms, computational geometry, combinatorial optimization.

Local and wide area distributed systems, operating systems, computer architecture.

Jean-Loup Baer, Professor, Adjunct Professor of EE (1969) Ph.D., 1968, UCLA.
Parallel processing, system architecture.

Computational complexity, parallel computation, circuit-based complexity, cryptography.

Operating systems, distributed systems, architecture.

Programming languages and environments, human-computer interaction, computers and society.

Gaetano Borriello, Professor, Adjunct Associate Professor of EE (1988) Ph.D., 1988, UC Berkeley. Embedded systems, computer-aided design synthesis of hardware/ software systems, user interfaces.

Object-oriented language design and implementation.

Computer graphics, active machine vision.

Computational linguistics, computer science education.

Integrated circuit design, biologically inspired learned chips, and neural networks.

VLSI architectures, computer aided design.

Parallel architecture and parallel program behavior, compiler-directed parallelization, trace-driven methodology.

Artificial intelligence: machine learning, integrated architectures, planning.

Automated planning, temporal reasoning, and decision making under uncertainty. Logic as a tool for artificial intelligence.

On-line algorithms, probabilistic algorithms and probabilistic analysis.

Combinatorial algorithms, computational complexity, parallel algorithms, computational biology.
Theory of computation, computational complexity, design and analysis of algorithms, computer
communication theory, computers to aid the handicapped.

Computer systems: modeling and analysis, design and implementation, distributed and
parallel systems.

Software engineering, software and system safety, software reliability and fault tolerance.

Database systems, artificial intelligence, query optimization, data integration,
knowledge representation.

Computer architecture, operating systems, distributed and parallel systems, object-oriented systems.

Software engineering, software evolution, software environments, software systems, parallel systems and
environments.

Computational complexity, parallel computation.

Computer graphics, user interfaces, computational geometry.

Linda Shapiro, Professor, Professor of EE (1986). Ph.D., 1974, Iowa.
Computer vision, artificial intelligence, robotics, pattern recognition, intelligent information systems.

Operating systems, software specifications, real-time systems.

Parallel computation, VLSI.

Steven L. Tanimoto, Professor, Adjunct Professor of EE (1977). Ph.D., 1975, Princeton.
Image analysis, computer graphics, artificial intelligence.

Computational complexity.

Dan Weld, Associate Professor (1988). Ph.D., 1988, MIT.
Artificial intelligence, qualitative and causal reasoning, automated design and diagnosis.

Paul Young, Professor (1983). Ph.D., 1963, MIT.
Computational complexity, computability, and connections with mathematical logic.

Computer systems, performance modeling and evaluation, performance and scheduling issues in parallel
and distributed systems.