



# **Computer Engineering**

**Computer Systems and  
Electrical Engineering  
Concentrations**

**MS Graduate Handbook  
2013 - 2014**



**MANUAL OF THE MS DEGREE IN  
COMPUTER ENGINEERING**

**ARIZONA STATE UNIVERSITY**

**2013 – 2014**

Computer Engineering (Computer Systems) graduate degrees please contact:

School of Computing, Informatics, and Decision Systems Engineering

Arizona State University

PO Box 878809

Tempe, AZ 85287-8809

PHONE: (480) 965-3199

E-mail address: [cidse.advising@asu.edu](mailto:cidse.advising@asu.edu)

<http://cidse.engineering.asu.edu/forstudent/graduate/computer-engineering/>

Computer Engineering (Electrical Engineering) graduate degrees please contact:

School of Electrical, Computer and Energy Engineering

Arizona State University

PO Box 875706

Tempe, AZ 85287-5706

PHONE: (480) 965-3424

E-mail address: [askee@asu.edu](mailto:askee@asu.edu)

<http://ecee.engineering.asu.edu/programs/graduate-electrical-engineering/>

Computer Engineering on the web:

<http://more.engineering.asu.edu/cen/>

Table of Contents

- I. Introduction to the Computer Engineering (CE) Program ..... 1
- II. Objective of the Handbook ..... 1
- III. Student Responsibility ..... 1
- IV. Faculty Responsibility ..... 1
- V. Admission and Eligibility to the MS Degree Programs ..... 2
  - Eligibility ..... 2
  - Application ..... 2
  - Application Deadlines ..... 2
  - GRE Scores. .... 2
  - English Proficiency ..... 2
  - Personal Statement. .... 2
  - Letters of Recommendation ..... 2
  - GPA Requirement ..... 3
  - Application Evaluation ..... 3
  - Recommended Academic Preparation. .... 3
  - Notice of Admission ..... 4
  - Pre-admission Credits and Transfer Credit..... 4
- VI. MS Degree Requirements..... 4
  - a. Degree Requirements. .... 4
  - Interactive Plan of Study (iPOS) Check Sheet ..... 7-8
  - b. Comprehensive Examination ..... 9
  - c. MS Thesis Option..... 9
  - d. Steps to Preparing for Your MS Defense ..... 9
- VII. General Information ..... 11
  - a. Research Standards for Publication of Thesis..... 11

b. Financial Assistance and/or Fellowships.....	11
c. Continuous Enrollment and Leave of Absence Policies .....	11
d. Maximum Time Limit .....	12
e. Registration Requirements for Research Assistants (RA) and Teaching Assistants (TA) ...	12
f. Satisfactory Progress, Academic Probation, Progress Probation, and Removal .....	12
1. Satisfactory Progress .....	12
2. Academic Probation.....	12
3. Progress Probation .....	13
4. Removal from the CE Program .....	13
g. Academic Integrity .....	13
h. CEN 584 Internship (Curricular Practical Training) .....	14
i. Optional Practical Training (OPT).....	16
j. CEN 590 Reading and Conference .....	16
k. Engineering Student Organizations.....	16
Computer Engineering Faculty .....	17
CE Areas of Study .....	20
Course Descriptions.....	23
Appendix I Prospective Student Study Guide.....	30
Appendix II MS Comprehensive Exam FAQ.....	33
Appendix III MS Comprehensive Exam Registration Form.....	35

## I. Introduction to the Computer Engineering Program

Computer Engineering is a multi-disciplinary program that builds on the fundamentals of Computer Science, Electrical Engineering, Industrial Engineering and Applied Mathematics. Graduates of this program will have the knowledge and skills necessary to advance the design, system integration, testing, evaluation and deployment of the state-of-the-art hardware and software for systems that include computing, communications and networking (wired and wireless), control functions, sensing, signal processing and actuation.

The MS degree program is intended for students that want to gain knowledge deeper than that provided at the BS level and sufficient for designing and implementing state-of-the-art systems in industrial research and development positions. The program is also appropriate for students contemplating future PhD study and desiring to gain experience in research. MS graduates may work under the direction of PhD scientists and engineers in high tech lab settings assisting in developing innovative products and systems that require strong foundational knowledge in the underlying sciences and the ability to synthesize and analyze engineering principles as they relate to the development of new computer engineering technology.

## II. Objective of the Handbook

The purpose of this handbook is to provide guidance and information related to admission, degree requirements, and general policies and procedures. Please note that in some cases you will find differences between the Graduate Policies and Procedures and the Computer Engineering Program requirements. In these cases, CE has established higher standards. Students must satisfy both sets of requirements. Please note that policies and procedures are occasionally amended to improve the program. Changes will be communicated to students through email, and posted bulletin boards.

## III. Student Responsibility

All students are expected to become familiar with university and program policies and procedures and abide by the terms set forth. Information is available both online and by hardcopy upon request. Most importantly you should visit the following websites:

- The Office of Graduate Education – <http://graduate.asu.edu> - visit the section on policies and procedures.
- The Schedule of Classes – [www.asu.edu/catalog](http://www.asu.edu/catalog)
- The Computer Engineering Program - <http://more.engineering.asu.edu/cen/>
- The International Student Office – <https://global.asu.edu/isso> , if applicable.
- The Ira A. Fulton Schools of Engineering – <http://engineering.asu.edu>

## IV. Faculty Responsibility

The members of the faculty of Computer Engineering have diverse backgrounds and knowledge. They are available to guide you in your plan of study and your educational and career goals. We encourage you to take the opportunity to make individual appointments with faculty members with whom you have common interests. Please

refer to the list of the faculty names, areas of expertise, and research interest at the end of this handbook.

#### V. **Admission and Eligibility to the MS Degree Programs**

The Computer Engineering MS degree requires a background in engineering, sciences or closely related fields. However, in some cases students with non-traditional educational backgrounds will be considered for admission. These students may be required to take foundational courses to better prepare for the graduate coursework. A student is encouraged to contact a graduate advisor in the respective concentration Advising Center to obtain advice on their educational pursuits.

**Eligibility** - Minimum of a bachelor's degree (*or equivalent*) or a graduate degree from a regionally accredited College or University of recognized standing in a related field such as: Computer Engineering, Computer Systems Engineering, Electrical Engineering, and Computer Science.

**Application** - All students are required to submit an application with the Office of Graduate Education and pay the required fee in order to have their application properly processed.

#### **Application Deadlines – December 31 for Fall and August 1 for Spring:**

To receive full consideration, we ask that you have all the required documents submitted by the deadline.

**GRE Scores** - Students (International and Domestic) are exempt from taking the GRE who have degrees from any ABET accredited program (from US or overseas institutions) and meet the minimum GPA requirements of the academic units. Students, who do not meet these requirements as outlined, will be required to take the GRE.

**English Proficiency** - The University requires all international applicants from a country whose native language is not English to provide the Test of English as a Foreign Language (TOEFL), the International English Language Testing System (IETLS), or the Pearson Test of English (PTE) scores. **Please note that your application will not be processed until the university receives official scores, which are valid two years from the start date of the degree program.** There are some exceptions for students who have been living in the United States and would like to have the English Proficiency waived. Consult the Graduate Catalog under “English Language Requirement” and the [Office of Graduate Education website](#) for details. Please address all English Proficiency questions to the Office of Graduate Education.

**Personal Statement** - Applicant must submit a personal statement that indicates professional goals and reasons for desiring to enroll in the MS program.

**Letters of Recommendation** – Computer Engineering requires three (3) letters of recommendation, at least one of which must come from former faculty. There is no standard form for letters of recommendation. Our current application process allows students to indicate the names and emails of their recommenders. In turn, the Office of Graduate Education sends an e-mail to the recommender alerting him or her to go online and submit a recommendation. We encourage letters from people who know you well, such as teachers, professional associates and supervisors. Ask people who can comment on your academic, emotional, intellectual and professional development.

**GPA Requirement** - To be considered for the MS program, we require a minimum of a 3.00 cumulative GPA (scale is 4.0) in the last 60 hours of a student's first bachelor's degree program.

**Application Evaluation** - Several factors are taken into consideration when evaluating a student's application: the student's cumulative GPA, major, institution, personal statement, letters of recommendation, standardized test scores, and performance in individual courses.

**Recommended Academic Preparation** – Computer Engineering graduate students should have knowledge in the following topics prior to applying for the program at Arizona State University: Computer Architecture & Organization, Algorithms & Data Structures, Digital Signal Processing, Digital VLSI, and Discrete Math.

If admitted to the Computer Engineering graduate program an exam will be administered on the first day of class to gauge knowledge in the topics. There will be one exam in CEN 501 covering Digital Signal Processing, Digital VLSI, and Discrete Math. A second exam will be given in CEN 502 covering Computer Architecture & Organization and Algorithms & Data Structures. The exam will count towards your overall grade in the course, percentile will be determined by the instructor, so it is highly advised that you have taken a related course and use the study guide (Appendix I) to refresh your knowledge prior to arriving at ASU. Based on the results of the exam it may be recommended that you take the corresponding course at ASU to better prepare you for the Computer Engineering graduate program.

#### **ASU Recommended Courses**

CSE 230 – Computer Organization and Assembly Language Programming

CSE 310 – Data Structures and Algorithms

EEE 203 – Signals and Systems I

EEE 335 – Analog and Digital Circuits

MATH 243 – Discrete Math Structures

**Notice of Admission** – Computer Engineering submits its recommendation of admission to the Office of Graduate Education and the final notice of admission decision are posted by the Office of Graduate Education on MyASU (my.asu.edu).

**Pre-admission Credits and Transfer Credit** – Please refer to the Office of Graduate Education policies and procedures.

**Transferring Between Programs** - Students that want to change from a Master’s to a Ph.D. in Computer Engineering must submit a new application with the Office of Graduate Education. If admitted, the Office of Graduate Education Pre-Admission policy states that student is allowed to use only twelve credits with grades of “B” or better from the original program to the new program. However, petitions to the Pre-Admission policy will be considered on a case-by-case basis.

## VI. MS Degree Requirements

A minimum of 30 credit hours of coursework beyond the bachelor’s degree and deficiency courses are required to complete the MS degrees. All Master's students are required to develop and submit an Interactive Plan of Study (iPOS) through online ASU Interactive prior to registering for courses for the upcoming semester. The POS should be developed with the aid of the student's faculty advisor. The CE Graduate Academic Advisor, acting on behalf of the Graduate Program Chair, will initially advise the student. Subsequently, each student should seek out a faculty member in his or her area of study to serve as advisor and committee chair.

### a. Degree Requirements

There are 6 credit hours required core courses for the MS in Computer Engineering program.

Required Core courses:

Course number & prefix	Course title	Credit hours
CEN 501	Computer Systems I: Circuits to Architectures	3
CEN 502	Computer Systems II: Fundamentals of Algorithms and Optimization Techniques	3

The combination of CEN501 and CEN502 serves to integrate the required knowledge of electrical engineering and computer science to ensure that all students have the necessary background to pursue advanced study in the areas of computer engineering.



CEN501 focuses on circuit and logic design, topics that span the electrical engineering to computer engineering interface. CEN502 begins with computer architecture and focuses on operating systems, compilers, and networking topics that cover the computer science to computer engineering interface. Together this pair of courses provides a common and necessary background for all students in the program to pursue graduate study in the six areas of the program. **As such, these courses must be taken during the first semester of availability.**

### **Mandatory Concentration Requirement**

The Computer Systems concentration requires the student take 18 total credit hours as follows:

- At least **12** credit hours of graduate level courses in CSE or CEN, and
- At least **6** credit hours of graduate level courses in EEE or CEN.

The Electrical Engineering concentration requires the student take 18 total credit hours as follows:

- At least **12** credit hours of graduate level courses in EEE or CEN, and
- At least **6** credit hours of graduate level courses in CSE or CEN.

### **Elective Courses**

Total credits hours for program electives:

Minimum of 18 credit hours (Thesis Option)

Minimum of 24 credit hours (Non-Thesis Option)

Non Thesis students will take 6 more credit hours towards their area electives.

These elective courses in the graduate Computer Engineering program are partitioned into six (6) areas of study, and listed in the table located at the end of this handbook. These courses will be referred to as Computer Engineering Area (CE-Area) courses.

The six (6) areas of study are:

- 1) VLSI and Architecture
- 2) Embedded Control Systems
- 3) Communication and Networks
- 4) Distributed, Dependable and Secure Systems
- 5) Multimedia and Signal Processing
- 6) Systems Optimization

### **Requirements:**

At least 6 credit hours of M\*(Master Level) or D\*(Doctorate Level) courses covering two (2) of the six (6) areas.

At least 6 credit hours from any of the CE-Area Courses (refer to table at the end of handbook)

At least 6 credit hours of graduate courses in Science, Engineering, or Mathematics (with the approval of the Computer Engineering Graduate Committee).

The combined set of 18 credit hours should be selected to ensure the student has adequate preparation to pursue research in the selected area of the thesis.

**400-Level Courses and Cross Listed Courses:**

- No more than 6 hours of 400-level coursework can be included on the graduate student program of study.
- No more than 12 hours of cross listed courses (4XX/5XX) can be included on the graduate student program of study.
- No more than a total of 12 hours of a combination of 400-level and cross listed courses (4XX/5XX) can be included on the graduate student program of study.
- If a 400 level course is cross listed with a 500 level course CE students will be required to enroll in the 500 level. Requests to register for a 400 level course not cross listed with a 500 level course should be emailed to your respective concentration Advising Center for permission.

NAME: \_\_\_\_\_



ASU ID: \_\_\_\_\_

## Master of Science in Computer Engineering (Computer Systems)

**6 Core Credits + 12 Area Credits + 6 Electives Credits+ 6 Elective or Thesis = 30 Credit Hours**

### 6 Credit Hours Core Courses

- CEN 501 Computer Systems I
- CEN 502 Computer Systems II

### 12 Credit Hours Area Courses

- At least **6 credit hours** of M\* (Master Level) or D\* (Doctorate Level) courses covering two (2) of the six (6) CE-Areas of Study

- M\* or D\* Course \_\_\_\_\_ Area \_\_\_\_\_
- M\* or D\* Course \_\_\_\_\_ Area \_\_\_\_\_

- At least **6 credit hours** from any of the CE-Areas of Study

- Course \_\_\_\_\_ Area \_\_\_\_\_
- Course \_\_\_\_\_ Area \_\_\_\_\_

### 6 Credit Hours Electives

- Course \_\_\_\_\_
- Course \_\_\_\_\_

### 6 Credit Hours Electives or Thesis

- Course \_\_\_\_\_
- Course \_\_\_\_\_
- or
- CEN 599 (3 credits Thesis)
- CEN 599 (3 credits Thesis)

### Overall Credits

- 30 or More Credits**
- 12 Credits CSE or CEN**
- 6 Credits EEE or CEN**
- Optional: CEN 584 Credit Hours (Thesis Maximum 2 & Non-Thesis Maximum 1)**
- No more than 6 credit hours 400 level courses**
- No more than 12 credits of cross listed courses (5XX/4XX)**
- No more than 12 credits combined cross listed courses and 400 level courses**

### CE Areas of Study

VLSI and Architecture – VLSI & A

Distributed, Dependable and Secure Systems – DDSS

Embedded Control Systems – ECS

Multimedia and Signal Processing - MSP

Communications and Networks – CN

Systems Optimization – SO

Please use this sheet as a guide when filling out the iPOS. After electronic submission of the iPOS please turn in this sheet to the CIDSE Advising Center, BYENG 208.

NAME: \_\_\_\_\_



ASU ID: \_\_\_\_\_

## Master of Science in Computer Engineering (Electrical Engineering)

**6 Core Credits + 12 Area Credits + 6 Electives Credits+ 6 Elective or Thesis = 30 Credit Hours**

### 6 Credit Hours Core Courses

- CEN 501 Computer Systems I
- CEN 502 Computer Systems II

### 12 Credit Hours Area Courses

- At least **6 credit hours** of M\* (Master Level) or D\* (Doctorate Level) courses covering two (2) of the six (6) CE-Areas of Study
  - M\* or D\* Course \_\_\_\_\_ Area \_\_\_\_\_
  - M\* or D\* Course \_\_\_\_\_ Area \_\_\_\_\_
- At least **6 credit hours** from any of the CE-Areas of Study
  - Course \_\_\_\_\_ Area \_\_\_\_\_
  - Course \_\_\_\_\_ Area \_\_\_\_\_

### 6 Credit Hours Electives

- Course \_\_\_\_\_
- Course \_\_\_\_\_

### 6 Credit Hours Electives or Thesis

- Course \_\_\_\_\_
- Course \_\_\_\_\_
- or
- CEN 599 (3 credits Thesis)
- CEN 599 (3 credits Thesis)

### Overall Credits

- 30 or More Credits**
- 12 Credits EEE or CEN**
- 6 Credits CSE or CEN**
- Optional: CEN 584 Credit Hours (Thesis Maximum 2 & Non-Thesis Maximum 1)**
- No more than 6 credit hours 400 level courses**
- No more than 12 credit hours of cross listed courses (5XX/4XX)**
- No more than 12 credit hours of combined cross listed courses and 400 level courses**

### CE Areas of Study

VLSI and Architecture – VLSI & A

Distributed, Dependable and Secure Systems – DDSS

Embedded Control Systems – ECS

Multimedia and Signal Processing - MSP

Communications and Networks – CN

Systems Optimization – SO

Please use this sheet as a guide when filling out the iPOS. After electronic submission of the iPOS please turn in this sheet to the EE Advising Center, Goldwater Center 209.

**b. Comprehensive Examination (Non-Thesis Option):** For Non-Thesis CE Graduate students, a written comprehensive examination can be taken after 6 courses have been completed including the Core courses. You must achieve a 60% or higher score on the Comprehensive Exam to graduate. **The Comprehensive Examination cannot be waived.** The Comprehensive Examination is held once in Fall on the third Friday in October from 2:00pm-5:00pm and once in Spring on the third Friday in March from 2:00pm-5:00pm. Any changes to these dates and times will be communicated to the students at the time of registration for the exam. Students who plan to take the exam should get a written “no conflict” permission from his/her class instructors before registering for the exam. A student must have a cumulative graduate grade-point-average (CUM GPA) 3.0 or higher, graduate grade-point-average (500 level courses GPA) 3.0 or higher, and 3.0 over all iPOS courses, to take the Comprehensive Examination. The exam will be a closed book three hour exam. If you pass the exam you may not view the results. Only those who fail the comprehensive examination will be allowed to review the results during the two-week period following the posting of results. This will be done along with the student’s academic advisor in the Advising Center. No review will be allowed after two weeks.

A student who fails the comprehensive examination must petition for re-examination and receive approval from the supervisory committee, CE Program Chair, and the Vice Provost for Graduate Education before the date of the examination. A student is allowed to retake the examination one time only in the test period immediately following the period in which the examination was failed. If the student’s petition for re-examination is not approved or the student fails the re-examination, the department will recommend to the Office of Graduate Education to remove the student from the MS program.

**c. MS Thesis Option:** MS students writing a thesis require a research advisory committee comprised of at least three faculty members including the committee chair. The two additional members are chosen jointly by the committee chair and the student to facilitate the student's research. At least one additional member should be from the CE faculty. Please refer to the back of the handbook for a list of area faculty and their research.

For MS students, the thesis and a successful oral defense constitute their final examination. A majority pass vote by the student's committee is required.

**d. Steps to Preparing for Your MS Defense:**

Detailed instructions can be found at the following websites.

CE Concentration: <http://cidse.engineering.asu.edu/defenseinformation/>

EE Concentration: <http://graduate.asu.edu/progress/completing/defenses>

Prior to defense:

- Obtain a consensus of approval from the committee chair and the committee members to proceed with the oral defense.
- Schedule a date and time with your committee for the oral defense on MyASU.
- Important: Ensure that a minimum of 50% of the official committee be physically present at the defense. The Chair must be physically present at the defense. If at least 50% of the committee cannot be physically present, the defense must be rescheduled.
- Visit the Office of Graduate Education website to familiarize yourself with the dates and deadlines on format approval.

10 working days prior to the defense: These steps are required to be complete prior to 10 working days from the date of oral defense.

- Reserve a room for your defense.
  - CE students please visit the front desk on the 5<sup>th</sup> floor of the Brickyard.
  - EE students please visit go the EE advising center or call the main number at 480-965-3424 as ask to speak to your graduate advisor.
- Submit an electronic version of your abstract with title, full names of your committee members, defense date/time/place, and your name as you want it to appear on the defense announcement to your respective concentration advising center.
- Submit an electronic copy of your completed thesis to the Graduate Program Chair.
- Schedule your defense through your MyASU (my.asu.edu) Defense tab.

On the day of the defense:

- Set-up all your equipment at least one half-hour prior to your presentation to make sure they work properly.

After the defense:

- Your committee will have comments and a discussion with you. At the end, the committee makes a recommendation: Pass, Pass with minor revisions, Pass with major revisions, or Fail.
- Revisions are normal and must be completed within one year. This includes remaining registered and uploading the finished document on MyASU Format Tools.
- If you have revisions you must submit a copy of the Thesis Defense Report Form (Pass/Fail form) to the Office of Graduate Education within 10 working days of the defense. Your graduate advisor can assist you by emailing the form to the Office of Graduate Education.
- You must be registered for at least one credit hour graduate level coursework each semester until the final submission of your thesis.

- After you have passed the defense and/or completed all required revisions hand-deliver your original Thesis Defense Report form (Pass/Fail Form) to your respective concentration advising center. The advisor will email the form to the Office of Graduate Education.
- Upload your thesis online through ProQuest.

## VII. General Information

### a. Research Standards for Publication of Thesis

Graduate research is the study of an issue that is of sufficient breadth and depth to be publishable in CE-related journal. The effort should reflect a minimum of 750 hours of thoughtful work for a thesis (M.S.). The research should follow the 'scientific method' and thus be both objective and reproducible. The thesis should demonstrate independent, original, and creative inquiry. There should be predefined hypotheses or developmental goals and objectives that are measurable and can be tested. The document should demonstrate proficiency with written English and should conform to the Office of Graduate Education format guidelines. For more information on format guidelines, please visit the Office of Graduate Education web site <http://graduate.asu.edu>

### b. Financial Assistance and/or Fellowships

Students interested in funding should contact faculty members to inquire about their funded projects for potential hourly or assistantship positions. We also encourage our students to explore assistantships available outside CIDSE as well as explore the [Office of Graduate Education](#) website.

### c. Continuous Enrollment and Leave of Absence Policies

Once admitted to a graduate degree program, master and doctoral students must be registered for a minimum of one credit hour of graduate level coursework (not audit) during all phases of their graduate education. This includes periods when they are engaged in research, working on or defending theses, taking comprehensive exams, or in any other way using university facilities or faculty time including the term in which they graduate. This credit must appear on the iPOS or must be an appropriate graduate-level course (e.g. 595 Continuing Registration). Courses with grades of "W" and "X" are not considered valid registration for continuous enrollment purposes.

Students planning to discontinue enrollment for a semester or more must request approval for a leave of absence. Students may petition the Office of Graduate Education for a leave of absence for a maximum of two semesters during their entire program. A petition for a leave of absence, endorsed by the members of the student's supervisory committee and the head of the academic unit, must be approved by the Office of Graduate Education. This request must be filed and approved before the anticipated absence.

An approved leave of absence will enable students to re-enter their program without re-applying to the university. Students who do not enroll for a fall or spring semester without an approved leave of absence by the Office of Graduate Education are considered withdrawn from the university under the assumption that they have decided to discontinue their program. A student removed for this reason may reapply for admission to resume their degree program; the application will be considered along with all other new applications to the degree program.

A student on leave is not required to pay fees, but in turn is not permitted to place any demands on university faculty or use any university resources.

**d. Maximum Time Limit**

All work toward a MS degree must be completed within six consecutive years. The six years begins with the semester and year of admission to the program. Graduate courses taken prior to admission that are included on the iPOS must have been completed within three years of the semester and year of admission to the program.

**e. Registration Requirements for Research Assistants (RA) and Teaching Assistants (TA)**

Students awarded an assistantship within the Ira A. Fulton Schools of Engineering are required to be registered for 12 credit hours (no more, no less). Audit credit hours do not count towards the 12 credit hours.

Students who obtain an assistantship outside the Ira A. Fulton Schools of Engineering are required to follow the policy of the unit that hires them.

TAs and RAs are treated as residents for tuition purposes. To be eligible for tuition remission, TAs and RAs must be employed a minimum of 10 hours per week (25 percent Full Time Equivalency {FTE}). TAs/RAs working 10-19 hours per week (25-49 percent FTE) receive a 50 percent remission of tuition for the semester or summer session of their employment. TAs/RAs working 20 hours per week (50 percent FTE) do not pay tuition during the semester or summer session of their employment. In addition, the university pays the individual's health insurance premium for those TAs and RAs working 20 hours per week (50 percent FTE).

**f. Satisfactory Progress, Academic Probation, Progress probation, and Removal from the CE Program:** Each semester, the Computer Engineering Program reviews students' files for satisfactory progress towards completion of the degree. All students are placed on one of the four categories:

1. Satisfactory progress
2. Academic Probation
3. Progress Probation
4. Removal from the Computer Engineering Program.



**1. Satisfactory Progress** means that the student does not have any academic and progress probationary issues. In addition to the probationary rules, satisfactory progress includes communication each semester with the student's Committee Chair regarding his or her progress.

**2. Academic Probation** pertains to grades that might affect Program and University policies including graduation. The following are notices/letters you will receive if one of these pertains to your academics:

- GPA below 3.0 in approved POS courses.
- Overall post baccalaureate (cumulative) GPA below 3.0.
- Overall graduate (500 level or above) GPA below 3.0.

**3. Progress Probation** pertains to issues dealing with making progress towards a degree. The following are notices/letters you will receive if one of these pertains to your academics:

- Failure to pass the Comprehensive Examination.

**4.** A student is recommended for **removal from the CE Program** if she or he fails to meet the probationary standards placed upon in the semester mentioned in the probationary letter. The student will receive a letter from the Computer Engineering Program explaining the reasons for the removal. The student will have 5 calendar days from the date of the letter to appeal the decision. The Computer Engineering Graduate Programs Committee (GPC) will review the case and will make the necessary recommendation. The Graduate Program Chair, on behalf of the GPC, will provide a written explanation of the outcome. If the outcome is favorable, the student will have to meet all the outlined requirements at the end of the specified period. The student will be required to sign an agreement acknowledging the recommendations and the consequences if the agreements are not met. If the GPC recommends that the appeal is not granted in favor of the student, the Graduate Program Chair, on behalf of the GPC, will recommend to the Dean of Academic Affairs to remove the student from the CE Program. The student will then have the opportunity to appeal to the Ira A. Fulton Schools Standards Committee which reviews the student's case and makes the final ruling to Associate Dean and the CE Program. If the appeal is not granted in favor of the student, the Dean of Academic and Student Affairs will recommend to the Office of Graduate Education to remove the student from the CE MS Program. Please refer the Office of Graduate Education catalog on policies and procedures or contact the graduate advisor in your respective concentration advising center.

#### **g. Academic Integrity**

The highest standards of academic integrity are expected of all graduate students, both in the academic coursework and in their related research activities. The failure of any graduate student to meet these standards may result in serious consequences including

suspension or expulsion from the university and/or other sanctions as specified in the academic integrity policies of individual colleges as well as the university.

Violations of academic integrity include, but are not limited to: cheating, fabrication, tampering, plagiarism, or aiding and/or facilitating such activities. At the graduate level, it is expected that students are familiar with these issues and each student must take personal responsibility in their work. In addition, graduate students are expected to follow university guidelines related to the Student Code of Conduct. University policies related to academic integrity and code of conduct are available in the Office of Student Life, or at [www.asu.edu/studentaffairs/studentlife/judicial](http://www.asu.edu/studentaffairs/studentlife/judicial).

#### **h. CEN 584 Internship (Curricular Practical Training)**

Curricular Practical Training (CPT) is a type of off-campus employment authorization for F-1 international students who must complete an internship course in order to graduate from their current degree program.

Internships may be necessary if the student needs practical engineering experience to complete qualifications for an advanced degree, needs industrial experience to gain the ability to perform required degree research, or needs the use of unique industrial facilities not available on campus to complete research study. Students must complete two semesters at ASU before becoming eligible for CPT Internship.

The Graduate Program Chair determines this need in consultation with the Graduate Academic Advisor. An approved Interactive Plan of Study (iPOS) is required with the CEN 584 CPT Internship course included. The CEN 584 CPT Internship course should be added to the initial iPOS submission. The course will not be able to be removed at a later date (See [CPT Policy](#)). CEN 584 CPT Internship course cannot be added to an approved iPOS once all coursework has been completed and approved by the Office of Graduate Education. Exceptions may be made if the internship is relevant to thesis research. CEN 584 credit hours do not apply to the 30 credit hours required for the MS degree.

CEN 584 CPT Internship course registration is for one credit hour per term. Non-Thesis students will be allowed to participate in a maximum of one term (Spring, Summer, or Fall) internship. The iPOS should list only one credit hour of CEN 584 listed during the term of the planned internship. MS Thesis students are allowed a maximum two terms (Spring, Summer, and/or Fall) to participate in an internship. This can be two terms with one company or two different companies. MS Thesis iPOS should list a maximum of two credit hours of CEN 584; one credit hour of CEN 584 listed during the term of each planned internship. Students are allowed to work a maximum of 20 hours in fall and spring terms and 40 hours in the summer.

CEN 584 Internship is only available to full-time, on-campus students. Full-time is defined as having completed nine credit hours or more for two semesters preceding the internship. A cumulative GPA of 3.0 is required. Any student who has a sanctioned academic integrity violation are NOT eligible for counting the internship experience in their iPOS for a full year after the violation.

An international student having 12 months or more of full-time internship will become ineligible for Optional Practical Training (OPT).

During any regular semester (fall or spring), a student on an internship must be registered full-time. CEN 584 CPT Internship course credit counts toward this requirement. For a summer internship the student needs to register for only one credit hour of CEN 584 CPT Internship.

After the internship period ends, a minimum five page report is required before a grade and credit is given. Please see the [Internship and CPT Guide](#) for complete instructions on the details that should be included in the report. The final report should be submitted to the Industry supervisor for comments and approval, then to the student's respective concentration Advising Center for approval and a grade assignment of "Y". It is recommended the student submit the report in the final week of the internship. The student must submit the report by the end of the following term at the latest (i.e. end of Fall term for Summer internship) or the grade will be a failing grade ("E").

***Reneg: (verb) to fail to carry out a promise or commitment***

Never accept a job with the intention of turning it down if "something better" comes along. Not only is it inconsiderate and unprofessional, it also reflects badly on Arizona State University and might negatively impact another ASU student's opportunities with that employer. Also, employers communicate with each other and you don't want to get a bad reputation.

After you have given your decision careful consideration and accepted an offer, stop looking. Inform other employers who have extended offers that you have accepted another position. Don't accept further interview invitations or search further. Please refer to NACE's [Playing Fair...Your Rights and Responsibilities as a Job Seeker](http://www.nacweb.org/playing_fair/) [http://www.nacweb.org/playing\\_fair/](http://www.nacweb.org/playing_fair/) to become familiar with Principles for Professional Practice.

Students who renege on a job offer will be evaluated on a case-by-case basis. Reneging is grounds for exclusion from CPT and requests for switching employers will not be considered or processed.

### **CPT Internship Application Procedures for CS Concentration:**

1. Read through the ISSC CPT website: <https://global.asu.edu/isso/cpt>
2. Read through the [Curricular Practical Training \(CPT\) Instructions](#) webpage and specifically the **Internship and CPT Guide** for CEN students.
3. Follow the directions on the [Curricular Practical Training \(CPT\) Instructions](#) webpage to have the required Academic Advisor/Department Letter generated and to be granted department consent to register for the CEN 584 CPT Internship course. This can take up to two weeks to generate so please plan accordingly.
4. Follow the remaining CPT Application Procedures found on the [ISSC](#) website.

### **CPT Internship Application Procedures for EE Concentration:**

1. Read through the ISSO CPT website: <https://global.asu.edu/isso/cpt>
2. Read through the [Internship Checklist](#) and see the required internship forms at <http://ecee.engineering.asu.edu/forms-and-faqs/>
3. Follow the directions on the [Internship Checklist](#) to have the required Academic Advisor/Department Letter generated and to be granted department consent to register for the CEN 584 CPT Internship course. This can take up to two weeks to generate so please plan accordingly. Submit all documents to your graduate advisor.

#### **i. Optional Practical Training (OPT)**

Please visit the [International Students Services](#) website for details regarding OPT and Pre-OPT. Students must be in good academic standing and have an approved iPOS. Non-thesis students must pass the comprehensive examinations prior to Pre-OPT. A student does (Pre-) OPT at their own risk since if the student doesn't graduate in the semester indicated on the iPOS, no letter will be issued by advising to support a later graduation date unless the delay is for reasons beyond the control of the student.

#### **j. CEN 590 Reading and Conference**

CEN 590 Reading and Conference is available for students considering pursuing thesis. A maximum of 3 credit hours is allowed on the iPOS. The student must get written approval from the supervising faculty outlining the coverage of the content.

#### **k. Engineering Student Organizations**

Student organizations are excellent opportunities to learn about career possibilities as many of the student groups operate in conjunction with industry professional societies ... get involved today!

Please visit <http://studentorgs.engineering.asu.edu/> for a list of Engineering Student Organization.

**Computer Engineering Faculty**  
[http://graduate.asu.edu/graduate\\_faculty\\_main](http://graduate.asu.edu/graduate_faculty_main)

Surname	Given Name	Rank	Degree	Expertise	Website
Ahn	Gail-Joon	Prof	Ph.D.	Network security	<a href="https://webapp4.asu.edu/directory/person/1258895">https://webapp4.asu.edu/directory/person/1258895</a>
Askin	Ronald	Director	Ph.D.	Applied optimization	<a href="https://webapp4.asu.edu/directory/person/901090">https://webapp4.asu.edu/directory/person/901090</a>
Candan	Kasim (Selcuk)	Prof	Ph.D.	Database systems	<a href="https://webapp4.asu.edu/directory/person/20861">https://webapp4.asu.edu/directory/person/20861</a>
Cao	Yu (Kevin)	Assoc. Prof	Ph.D.	Nanoscale modeling	<a href="https://webapp4.asu.edu/directory/person/749044">https://webapp4.asu.edu/directory/person/749044</a>
Chakrabarti	Chaitali	Prof	Ph.D.	VLSI architecture	<a href="https://webapp4.asu.edu/directory/person/22557">https://webapp4.asu.edu/directory/person/22557</a>
Chatha	Karam	Assoc. Prof	Ph.D.	Embedded Systems	<a href="https://webapp4.asu.edu/directory/person/388446">https://webapp4.asu.edu/directory/person/388446</a>
Baral	Chitta	Prof	Ph.D.	Autonomous agents	<a href="https://webapp4.asu.edu/directory/person/231973">https://webapp4.asu.edu/directory/person/231973</a>
Clark	Lawrence	Prof	Ph.D.	Low power electronics Microarchitecture	<a href="https://webapp4.asu.edu/directory/person/751415">https://webapp4.asu.edu/directory/person/751415</a>
Colbourn	Charles	Prof	Ph.D.	Network reliability	<a href="https://webapp4.asu.edu/directory/person/384970">https://webapp4.asu.edu/directory/person/384970</a>
Dasgupta	Partha	Assoc. Prof	Ph.D.	Security & Op. systems	<a href="https://webapp4.asu.edu/directory/person/75201">https://webapp4.asu.edu/directory/person/75201</a>
Fainekos	Georgios	Asst. Prof	Ph.D.	Cyber physical systems	<a href="https://webapp4.asu.edu/directory/person/1426990">https://webapp4.asu.edu/directory/person/1426990</a>
Fowler	John	Prof.	Ph.D.	Scheduling theory	<a href="https://webapp4.asu.edu/directory/person/36406">https://webapp4.asu.edu/directory/person/36406</a>
Gel	Esmā	Assoc. Prof IE Prog. Chair	Ph.D.	Stochastic modeling	<a href="https://webapp4.asu.edu/directory/person/257696">https://webapp4.asu.edu/directory/person/257696</a>
Gupta	Sandeep	Prof Comp. Eng. Prog, Chair	Ph.D.	Cyber physical systems	<a href="https://webapp4.asu.edu/directory/person/313263">https://webapp4.asu.edu/directory/person/313263</a>
Huang	Dijiang	Asst. Prof	Ph.D.	Network security	<a href="https://webapp4.asu.edu/directory/person/835028">https://webapp4.asu.edu/directory/person/835028</a>
Hui	Yu (Joseph)	Prof	Ph.D.	Wireless networks	<a href="https://webapp4.asu.edu/directory/person/230953">https://webapp4.asu.edu/directory/person/230953</a>
Kambhampati	Subbarao	Prof	Ph.D.	Automated planning	<a href="https://webapp4.asu.edu/directory/person/95646">https://webapp4.asu.edu/directory/person/95646</a>
Karam	Lina	Prof	Ph.D.	Signal/Image processing	<a href="https://webapp4.asu.edu/directory/person/53561">https://webapp4.asu.edu/directory/person/53561</a>
Lee	Yann-Hang	Prof/CSE Prog. Chair	Ph.D.	Real-Time systems	<a href="https://webapp4.asu.edu/directory/person/284224">https://webapp4.asu.edu/directory/person/284224</a>

Li	Baixin	Asst. Prof	Ph.D.	Multimedia processing	<a href="https://webapp4.asu.edu/directory/person/747601">https://webapp4.asu.edu/directory/person/747601</a>
Li	Jing	Asst. Prof	Ph.D.	Statistical modeling	<a href="https://webapp4.asu.edu/directory/person/356293">https://webapp4.asu.edu/directory/person/356293</a>
Michandani	Pitu	Prof	Ph.D.	Real-time control	<a href="https://webapp4.asu.edu/directory/person/1439066">https://webapp4.asu.edu/directory/person/1439066</a>
Palais	Joseph	Emeritus Prof	Ph.D.	Optical communications	<a href="https://webapp4.asu.edu/directory/person/47394">https://webapp4.asu.edu/directory/person/47394</a>
Panchanathan	Sethuraman	Prof	Ph.D.	Ubiquitous computing	<a href="https://webapp4.asu.edu/directory/person/88253">https://webapp4.asu.edu/directory/person/88253</a>
Phillips	Stephen	Prof	Ph.D.	Micro electrical systems	<a href="https://webapp4.asu.edu/directory/person/547474">https://webapp4.asu.edu/directory/person/547474</a>
Reisslein	Martin	Prof	Ph.D.	Fiber/wireless networks	<a href="https://webapp4.asu.edu/directory/person/287028">https://webapp4.asu.edu/directory/person/287028</a>
Richa	Andrea	Assoc. Prof	Ph.D.	Network optimization	<a href="https://webapp4.asu.edu/directory/person/198256">https://webapp4.asu.edu/directory/person/198256</a>
Runger	George	Prof	Ph.D.	Data mining	<a href="https://webapp4.asu.edu/directory/person/87655">https://webapp4.asu.edu/directory/person/87655</a>
Sen	Arunabha	Prof	Ph.D.	Network optimization	<a href="https://webapp4.asu.edu/directory/person/40210">https://webapp4.asu.edu/directory/person/40210</a>
Shrivastava	Aviral	Asst. Prof	Ph.D.	Multicore architecture	<a href="https://webapp4.asu.edu/directory/person/969623">https://webapp4.asu.edu/directory/person/969623</a>
Si	Jennie	Prof	Ph.D.	Nonlinear dynamic systems	<a href="https://webapp4.asu.edu/directory/person/48345">https://webapp4.asu.edu/directory/person/48345</a>
Spanias	Andreas	Prof	Ph.D.	Digital signal processing	<a href="https://webapp4.asu.edu/directory/person/93829">https://webapp4.asu.edu/directory/person/93829</a>
Sundaram	Hari	Assoc. Prof	Ph.D.	Multimedia &databases	<a href="https://webapp4.asu.edu/directory/person/522896">https://webapp4.asu.edu/directory/person/522896</a>
Syrotiuk	Violet	Assoc. Prof	Ph.D.	Mobile ad hoc networks	<a href="https://webapp4.asu.edu/directory/person/518662">https://webapp4.asu.edu/directory/person/518662</a>
Tao	Nongjian	Prof	Ph.D.	Molecular Electronics Nanoelectronics	<a href="https://webapp4.asu.edu/directory/person/324368">https://webapp4.asu.edu/directory/person/324368</a>
Tsakalis	Konstantinos	Prof	Ph.D.	System optimization	<a href="https://webapp4.asu.edu/directory/person/105332">https://webapp4.asu.edu/directory/person/105332</a>
Tsai	Wei-Tek	Prof	Ph.D.	Software engineering	<a href="https://webapp4.asu.edu/directory/person/258423">https://webapp4.asu.edu/directory/person/258423</a>
Vasileska	Dragica	Prof	Ph.D.	Semiconductor Devices	<a href="https://webapp4.asu.edu/directory/person/106590">https://webapp4.asu.edu/directory/person/106590</a>
Vrudhula	Sarma	Prof	Ph.D.	VLSI circuit design	<a href="https://webapp4.asu.edu/directory/person/761142">https://webapp4.asu.edu/directory/person/761142</a>
Wonka	Peter	Asst. Prof	Ph.D.	Computer graphics	<a href="https://webapp4.asu.edu/directory/person/755237">https://webapp4.asu.edu/directory/person/755237</a>
Xue	Guoliang	Prof	Ph.D.	QoS routing & security	<a href="https://webapp4.asu.edu/directory/person/378651">https://webapp4.asu.edu/directory/person/378651</a>
Yau	Stephen	Prof	Ph.D.	Network security	<a href="https://webapp4.asu.edu/di">https://webapp4.asu.edu/di</a>

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Yu	Shimeng	Asst. Prof	Ph.D.	Device and Architecture Beyond CMOS	<a href="http://www.public.asu.edu/~shimengy/">http://www.public.asu.edu/~shimengy/</a>
Zhang	Yanchao	Assoc. Prof	Ph.D.	Cyber security	<a href="https://webapp4.asu.edu/directory/person/1620062">https://webapp4.asu.edu/directory/person/1620062</a>
Zhang	Junshan	Prof	Ph.D.	Wireless networks	<a href="https://webapp4.asu.edu/directory/person/284251">https://webapp4.asu.edu/directory/person/284251</a>
Zhang	Muhong	Asst. Prof	Ph.D.	Robust optimization	<a href="https://webapp4.asu.edu/directory/person/1099666">https://webapp4.asu.edu/directory/person/1099666</a>

### Computer Engineering Areas of Study

- |                                       |  |
|---------------------------------------|--|
| 1. VLSI – VLSI and Architecture       | 4. DDSS – Distributed, Dependable Secure Systems |
| 2. ECS – Embedded Control Systems     | 5. MSP – Multimedia and Signal Processing        |
| 3. CN – Communications and Networks   | 6. SO – Systems Optimization                     |
| M*- Content of course is Master level | D* - Content of course is Doctorate level        |

Course & Prefix	Course Title (Credit Hours)	VLSI	ECS	CN	DDSS	MSP	SO
APM 506	Computational methods (3)						X
APM 523	Optimization (Continuous) (D*) (3)						X
CSE 408/598	Multimedia Information Systems (3)					X	
CSE 412/598	Database Management (3)				X		
CSE 420/598	Computer Architecture I (M*) (3)	X					
CSE 430	Operating Systems (M*) (3)				X		
CSE 434/598	Computer Networks, or (M*) (3)			X			
CSE 440/598	Compiler Construction I (M*) (3)				X		
CSE 445/598	Distributed Software Development (3)				X		
CSE 450/598	Design and Analysis of Algorithms (M*) (3)						X
CSE 468/598	Computer Network Security (3)			X			
CSE 509	Digital Video Processing (D*) (3)					X	
CSE 512	Distributed Database Systems (3)				X		
CSE 515	Multimedia Web Databases (3)					X	
CSE 520	Computer Architecture II (D*) (3)	X					
CSE 522	Real Time Embedded Systems (D*) (3)				X		
CSE 531	Distributed & Multiprocessor Operating Systems (D*) (3)				X		
CSE 534	Advanced Computer Networks (D*) (3)			X			
CSE 535	Mobile Computing (3)			X			
CSE 539	Applied Cryptography (3)				X		



CSE 543	Information Assurance and Security (3)				X		
<b>Course &amp; Prefix</b>	<b>Course Title (Credit Hours)</b>	<b>VLSI</b>	<b>ECS</b>	<b>CN</b>	<b>DDSS</b>	<b>MSP</b>	<b>SO</b>
CSE 545	Software Security (3)				X		
CSE 550	Combinatorial algorithms and intractability (M*) (3)						X
CSE 552	Randomized and Approximation Algorithms (3)						X
CSE 555	Theory of Computation (3)						X
CSE 565	Software Verification, Validation, and Testing (3)				X		
CSE 574	Planning and Learning Methods in AI (3)		X				
CSE 591	Digital Logic Synthesis and Verification Algorithms. (3)	X					
CSE 591	Formal Methods for System Verification (3)	X					
CSE 591	Introduction to Hybrid Systems (D*) (3)		X				
CSE 591	Lower Power Architectures (3)	X					
CSE 591	Machine Learning		X				
CSE 591	VLSI Cad 1 (3)	X					
CSE 598	System-level Hardware/Software Co-design	X					
EEE 404/591	Real-Time Digital Signal Processing (M*) (4)					X	
EEE 407/591	Digital Signal Processing (M*) (4)					X	
EEE 425/591	Digital Circuits and Systems (M*) (4)	X					
EEE 455/591	Communication Systems (M*) (3)			X			
EEE 459/591	Communication Networks (M*) (3)			X			
EEE 480/591	Feedback Systems (M*) (4)		X				
EEE 481/591	Computer Controlled Systems (M*) (3)		X				
EEE 505	Time-Frequency Signal Processing (3)					X	
EEE 507	Multidimensional Signal Processing (3)					X	
EEE 508	Digital Image and Video Processing and Compression (D*) (3)					X	

EEE 509	DSP Algorithms and Software (3)					X	
<b>Course &amp; Prefix</b>	<b>Course Title (Credit Hours)</b>	<b>VLSI</b>	<b>ECS</b>	<b>CN</b>	<b>DDSS</b>	<b>MSP</b>	<b>SO</b>
EEE 511	Artificial Neural Computation (3)		X				
EEE 525	VLSI Design (D*) (3)	X					
EEE 526	VLSI Architectures (3)	X					
EEE 551	Information Theory (D*) (3)			X			
EEE 552	Digital Communications (3)			X			
EEE 553	Coding and Cryptography (3)			X			
EEE 554	Random Signal Theory (D*) (3)					X	
EEE 555	Modeling and Performance Analysis (3)					X	
EEE 557	Broadband Networks (3)			X			
EEE 558	Wireless Communications (3)			X			
EEE 582	Linear System Theory (3)		X				
EEE 585	Digital Control Systems (D*) (3)		X				
EEE 586	Nonlinear Control Systems (3)		X				
EEE 587	Optimal Control (3)		X				
EEE 588	Design of Multivariable Control Systems (3)		X				
EEE 606	Adaptive Signal Processing (3)					X	
EEE 607	Speech Coding for Multimedia Communications (3)			X			
EEE 625	Advanced VLSI Design (3)	X					
EEE 686	Adaptive Control (3)		X				
IEE 533	Scheduling (3)						X
IEE 572	Design of Engineering Experiments (3)						X
IEE 574	Applied Deterministic Operations Res. Methods (3)						X
IEE 575	Applied Stochastic Operations Res. Methods (3)						X
IEE 620	Optimization I (Discrete) (D*) (3)						X

IEE 670	Mathematical Statistics (3)							X
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## Course Descriptions

### **APM 506 Computational Methods**

Covers interpolation, solution of nonlinear equations and systems, numerical differentiation, numerical integration, numerical solution of ordinary and partial differential equations. Students should be an APM graduate student.

### **APM 523 Optimization**

Linear programming, unconstrained nonlinear minimization, line search algorithms, conjugate gradients, quasi-Newton methods, constrained nonlinear optimization, gradient projection, and penalty methods. Completion of courses in Applied Linear Algebra and Computational Methods is strongly recommended prior to enrollment in this course.

### **CEN 591 Memory System: Device, Circuit and Architecture**

The functionality and performance of today's computing systems are increasingly dependent on the characteristics of the memory sub-system. This course covers the memory sub-system from the low-level device building blocks to the high-level architecture array design. The concept of memory hierarchy is used as an outline through the whole course. The first part of the course discusses the mainstream semiconductor memory device technologies that enable various levels in the memory hierarchy, including SRAM, DRAM, and FLASH technologies. Issues such as basic operation principles, device design considerations, and device scaling trend and peripheral circuitry will be addressed. In addition, emerging memory candidates that may have the potential to change the memory hierarchy are also introduced, e.g. STT-MRAM, PCRAM, and RRAM. The second part of the course discusses the memory architecture across different levels in the memory hierarchy, including the cache design, main memory design, and solid-state drive (SSD) design.

### **CSE 480 Multimedia Information Systems**

Design, use, and applications of multimedia systems. Introduces acquisition, compression, storage, retrieval, and presentation of data from different media such as images, text, voice, and alphanumeric.

### **CSE 412 Database Management**

Introduces DBMS concepts. Data models and languages. Relational database theory. Database security/integrity and concurrency.

### **CSE 420 Computer Architecture I**

Computer architecture. Performance versus cost tradeoffs. Instruction set design. Basic processor implementation and pipelining.

### **CSE 430 Operating Systems**

Operating system structure and services, processor scheduling, concurrent processes, synchronization techniques, memory management, virtual memory, input/output, storage management, and file systems.

**CSE 434 Computer Networks**

Distributed computing paradigms and technologies, distributed system architectures and design patterns, frameworks for development of distributed software components.

**CSE 440 Compiler Construction I**

Introduces programming language implementation. Implementation strategies such as compilation, interpretation, and translation. Major compilation phases such as lexical analysis, semantic analysis, optimization, and code generation.

**CSE 445 Distributed Software Development**

Distributed system architectures and design, service-oriented computing, and frameworks for development of distributed application and software components.

**CSE 450 Design and Analysis of Algorithms**

Design and analysis of computer algorithms using analytical and empirical methods; complexity measures, design methodologies, and survey of important algorithms.

**CSE 509 Digital Video Processing**

Concepts of digital video compression, video analysis, video indexing, browsing and retrieval, video transmission over networks, video processors, MPEG 1, 2, 4, and 7 standards.

**CSE 512 Distributed Database Systems**

Distributed database design, query processing, and transaction processing. Distributed database architectures and interoperability. Emerging technology.

**CSE 515 Multimedia and Web Databases**

Data models for multimedia and Web data; query processing and optimization for inexact retrieval; advanced indexing, clustering, and search techniques.

**CSE 520 Computer Architecture II**

Computer architecture description languages, computer arithmetic, memory-hierarchy design, parallel, vector, multiprocessors, and input/output.

**CSE 534 Advanced Computer Networks**

Advanced network protocols and infrastructure, applications of high-performance networks to distributed systems, high-performance computing and multimedia domains, special features of networks.

**CSE 535 Mobile Computing**

Mobile networking, mobile information access, adaptive applications, energy-aware systems, location-aware computing, mobile security and privacy.

**CSE 539 Applied Cryptography**

Uses cryptography for secure protocols over networked systems, including signatures, certificates, timestamps, electrons, digital cash, and other multiparty coordination.

**CSE 543 Information Assurance and Security**

Comprehensive understanding of information assurance and security problems with the solutions as well as hands-on experiences about applying these solutions.

**CSE 545 Software Security**

Theories and tools for software security, including secure design, threat analysis and modeling, security testing and coding.

**CSE 550 Combinatorial Algorithms and Intractability**

Combinatorial algorithms, nondeterministic algorithms, classes P and NP, NP-hard and NP-complete problems, and intractability, Design techniques for fast combinatorial algorithms.

**CSE 552 Randomized and Approximation Algorithms**

Introduces two important areas of algorithm design for graduate students. A randomized algorithm is allowed to rely on the outcome of a random experiment in deciding on its next step. In many applications, randomized algorithms are simpler than any deterministic algorithms known, but in several cases, they are in fact more powerful or more efficient than any deterministic algorithms. Covers basic paradigms for randomized algorithm design and analysis, as well as for derandomization.

**CSE 555 Theory of Computation**

Rigorous treatment of regular languages, context-free languages, Turing machines and decidability, reducibility, and other advanced topics in computability theory.

**CSE 565 Software Verification, Validation, and Testing**

Test planning, requirements-based and code-based testing techniques, tools, reliability models and statistical testing.

**CSE 574 Planning and Learning Methods in AI**

Reasoning about time and action, plan synthesis and execution, improving planning performance, applications to manufacturing intelligent agents.

**CSE 591 Seminar**

A small class emphasizing discussion, presentations by students, and written research papers.

**CSE 598 Special Topics**

Topical courses not offered in regular course rotation – e.g., new courses not in the catalog, courses by visiting faculty, courses on timely topics, highly specialized courses responding to unique student demand.

**EEE 404 Real-Time Digital Signal Processing**

Digital signal processors, translating signals and systems concepts into real-time multimedia and communications applications, real-time algorithms.

**EEE 407- Digital Signal Processing**

Time and frequency domain analysis, difference equations, z-transform, FIR and IIR digital filter design, discrete Fourier transform, FFT, and random sequences.

**EEE 425 Digital Systems and Circuits**

Digital logic gate analysis and design. Propagation delay times, fan out, power dissipation, noise margins. Design of MOS and bipolar logic families, including NMOS, CMOS, standard and advanced TTL, ECL, and BiCMOS. Inverter, combinational and sequential logic circuit design, MOS memories, VLSI circuits. Computer simulations using PSPICE.

**EEE 455 Communication Systems**

Signal analysis techniques applied to the operation of electrical communication systems. Introduction to and overview of modern digital and analog communications.

**EEE 459 communication Networks**

Fundamentals of communication networks. Study of Seven-Layer OSI model. Focus on functionality and performance of protocols used in communication networks.

**EEE 480 Feedback Systems**

Analysis and design of linear feedback systems. Frequency response and root locus techniques, series compensation, and state variable feedback.

**EEE 481 Computer-Controlled Systems**

Implements computer-based, embedded, control systems using MATLAB xPC Target toolbox. Small-scale, representative projects demonstrate theoretical issues and provide hands-on expertise.

**EEE 505 Time-Frequency Signal Processing**

Joint time-frequency analysis of time-varying signals and systems; linear and quadratic time-frequency representations; applications in current areas of signal processing.

**EEE 507 Multidimensional Signal Processing**

Processing and representation of multidimensional signals. Design of systems for processing multidimensional data. Introduces image and array processing issues.

**EEE 508 Digital Image and Video Processing and Compression**

Fundamentals of digital image perception, representation, processing, and compression. Emphasizes image coding techniques. Signals include still pictures and motion video.

**EEE 509 DSP Algorithms and Software**

Linear systems review, digital filter design, software aspects, DFT, FFT, random signals, programming aspects, applications projects, MATLAB and Java simulations.

**EEE 511 Artificial Neural Computation Systems**

Networks for computation, learning function representations from data, learning algorithms and analysis, function approximation and information representation by networks, applications in control systems and signal analysis.

**EEE 525 VLSI Design**

Analysis and design of Very Large Scale Integrated (VLSI) circuits. Physics of small devices, fabrication, regular structures, and system timing.

**EEE 526 VLSI Architectures**

High throughput and low-power VLSI architectures for signal processing. Array processor systems; data path design and optimization; memory design; high-level synthesis; low-power design at system level, algorithm level, and architecture level.

**EEE 551 Information Theory**

Entropy and mutual information, source and channel coding theorems, applications for communication and signal processing.

**EEE 552 Digital Communications**

Complex signal theory, digital modulation, optimal coherent and incoherent receivers, channel codes, coded modulation, Viterbi algorithm.

**EEE 553 Coding and Cryptography**

Introduces algebra, block and convolutional codes, decoding algorithms, turbo codes, coded modulation, private and public key cryptography.

**EEE 554 Random Signal Theory**

Applies statistical techniques to the representation and analysis of electrical signals and to communications systems analysis.

**EEE 555 Modeling and Performance Analysis**

Modeling and performance analysis of stochastic systems and processes such as network traffic queueing systems and communication channels.

**EEE 557 Broadband Networks**

Physics of wireless and optical communications. Broadband multiplexing and switching methods. Blocking and queuing analysis. Network optimization, routing, and economics.

**EEE 558 Wireless Communications**

Cellular systems, path loss, multipath fading channels, modulation and signaling for wireless, diversity, equalization coding, spread spectrum, TDMA/FDMA/CDMA.

**EEE 582 Linear System Theory**

Controllability, observability, and realization theory for multivariable continuous time systems. Stabilization and asymptotic state estimation. Disturbance decoupling, noninteracting control.

**EEE 585 Digital control Systems**

Analysis and design of digital and sampled data control systems, including sampling theory, z-transforms, the state transition method, stability, design, and synthesis.

**EEE 586 Nonlinear Control Systems**

Stability theory, including phase-plane, describing function, Liapunov's method, and frequency domain criteria for continuous and discrete, nonlinear, and time-varying systems.

**EEE 587 Optimal Control**

Optimal control of systems. Calculus of variations, dynamic programming, linear quadratic regulator, numerical methods, and Pontryagin's principle.

**EEE 588 Design of Multivariable Control Systems**

Practical tools for designing robust MIMO controllers. State feedback and estimation, model-based compensators, MIMO design methodologies, CAD, real-world applications.

**EEE 591 Seminar**

A small class emphasizing discussion, presentations by students, and written research papers.

**EEE 606 Adaptive Signal Processing**

Principles and applications of adaptive signal processing, adaptive linear combiner, Wiener least-squares solution, gradient search, performance surfaces, LMS/RLS algorithms, block time/frequency domain LMS.

**EEE 607 Speech Coding for Multimedia Communications**

Speech and audio coding algorithms for applications in wireless communications and multimedia computing.

**EEE 625 Advanced VLSI Design**

Practical industrial techniques, circuits, and architectures appropriate to high-performance and low-power digital VLSI designs such as microprocessors.



**EEE 686 Adaptive Control**

Main topics covered: adaptive identification, convergence, parametric models, performance and robustness properties of adaptive controllers, persistence of excitation, and stability.

**IEE 572 Design Engineering Experiments**

Analysis of variance and experimental design. Topics include strategy of experimentation, factorials, blocking and confounding, fractional factorials, response surfaces, nested and split-plot designs. Prerequisite: IEE 380.

**IEE 620 Optimization I**

First course of the Ph.D. level deterministic course series. This course covers foundations of optimization and linear programming. Prerequisites: MAT 272, 242, and IEE 376.

**IEE 670 Mathematical Statistics**

This course is an introduction to the field of mathematical statistics at a level intended for first-year Ph.D. students in Industrial Engineering. It builds a solid background in the principles, concepts and techniques of mathematical statistics. The class prepares students for advanced study and research in statistics, and is useful for understanding statistical data analysis techniques and developing statistical thinking. Prerequisites: IEE 380

**Appendix I**  
 Computer Engineering Graduate Program  
 Prospective Student Information and Study Guide

Computer Engineering graduate students should have knowledge in the following topics prior to applying for the program at Arizona State University: Digital VLSI, Discrete Math, Digital Signal Processing, Computer Architecture & Organization, and Algorithms & Data Structures.

If admitted to the Computer Engineering graduate program an exam will be administered on the first day of class to gauge knowledge in the topics. This exam will count towards your overall grade in the Core course, percentile will be determined by the instructor, so it is highly advised that you have taken a related course and use this study guide to refresh your knowledge prior to arriving at ASU. Based on the results of the exam it may be recommended that you take the corresponding course at ASU to better prepare you for the Computer Engineering graduate program.

For each of the topics there is a suggested book and list of topics along with suggested Chapters from the book in some cases. Note that a student is free to study from any other relevant book on the subject.

**Digital VLSI (ASU Course: EEE 335)**

Textbook: Digital Integrated Circuits: A Design Perspective by Rabaey, Chandrakasan and Nikolic. Prentice Hall. 2nd edition.

1. Diode -- static and dynamic behavior. (Chapter 3)
2. MOSFET transistor -- static and dynamic behavior. (Chapter 3)
3. CMOS inverter characteristics including switching threshold, propagation delay, power consumption. (Chapter 5)
4. Designing complex CMOS gates, Boolean logic.

EEE 335 Course Textbook: Microelectronic Circuits by Sedra/Smith. 6<sup>th</sup> Edition

**Discrete Mathematics (ASU Course: MAT 243)**

Textbook: Discrete Mathematics and Its Applications, Kenneth H. Rosen; Publisher: McGraw-Hill; 7th Ed.

1. Foundations: Logic and Proofs: understand mathematical reasoning and ability to construct mathematical proofs; mathematical induction. (Chapter 1 & 5)
2. Combinatorial Analysis: ability to solve counting problems. (Chapter 6 & 8)

3. Elementary Number Theory: (Chapter 4)
4. Discrete Probability: fundamentals of probability theory, conditional probability, random variables. (Chapter 7)
5. Graph Theory: basics of graph theory including properties of trees. (Chapter 10-11)
6. Boolean Algebra: basics of Boolean algebra, Boolean functions and their representation, minimization of Boolean circuits. (Chapter 12).

### **Digital Signal Processing (ASU Course: EEE 203)**

Textbook: Signals and Systems by Oppenheim, Willsky and Nawab. Prentice Hall 2nd edition.

1. Signals: continuous-time and discrete-time; unit step; unit impulse; sinusoids; transformations of the time variable. (Chapter 1)
2. Systems: LTI systems -- linearity, time-invariance, causality, stability; impulse response; convolution (graphical as well as analytical); block diagrams, input-output equations. (Chapter 1, 2)
3. Fourier Transform (FT): calculation of forward and inverse transform of simple signals; use FT properties to determine the FT of a transformed signal; frequency response. (Chapter 4)
4. Discrete-time Fourier Transform (DTFT): calculation of forward and inverse transform of simple signals; use DTFT properties to determine the DTFT of a transformed signal; frequency response. (Chapter 5)
5. Sampling: converting a continuous-time signal to a discrete-time signal; sampling theorem. (Chapter 7)
6. z-Transform: calculation of forward and inverse transform of simple signals; region of convergence; properties. (Chapter 10)

### **Computer Architecture & Organization (ASU Course: CSE 230)**

Textbook: "Computer Organization and Design" The hardware software Interface, by David A. Patterson, and John L. Hennessey, 4th edition.

1. Assembly Language Programming: Understand assembly language, and write assembly language programs for simple problems.
2. Procedure Calling Convention: Know about register conventions, including caller saved, callee saved, argument and return value registers. Student should be able to write procedures and recursive functions in assembly language.

3. Data Representation: Understand the data representation (unsigned, 2's complement, and floating point) inside the processor, and perform arithmetic operations on them. An understanding of hardware structures to perform these operations will be a plus.
4. Pipelined Processor Design: Understand the working of a single-cycle, and pipelined processor. Pipeline hazards, and basic techniques on how to avoid them.
5. Memory Hierarchy: Understand the rationale behind the memory organization, and know how caches operate.
6. I/O: Have a basic understanding of storage and I/O.
7. Advanced Computer Architecture: Be aware of the trends in computer organization and design, including superscalar, multi-threading, and multi-core architectures.

### **Algorithms and Data Structures (ASU Course: CSE 310)**

Textbook: Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, 3rd Ed.

1. Basics of algorithm design and analysis (Chapter 1 to 3).
2. Divide and Conquer (Chapter 4)
3. Elementary Data Structure, hash tables (Chapter 10,11)
4. Sorting: Heapsort (Chapter 6), Quicksort (Chapter 7), Radix Sort and Bucket Sort (Chapter 8)
5. Searching: Binary Search Trees. (Chapter 12), red-black trees (Chapter 13.1-4)
6. Dynamic Programming (Chapter 15)
7. Greedy Algorithms. (Chapter 16)
8. Minimum Spanning Tree (Chapter 23)
9. Shortest-Path Problems (Chapter 24-25)
10. Elementary Graph Theory (Chapter 22)
11. String Matching (Chapter 32)
12. NP-completeness (Chapter 34)

**Appendix II**  
Computer Engineering  
M.S. Comprehensive Exam  
Frequently Asked Questions (FAQ)

For Non-Thesis Computer Engineering (CS) (EE) Graduate students, a written comprehensive examination can be taken after 6 courses have been completed including the Core courses. You must achieve a 60% or higher score on the Comprehensive Exam to graduate. **The Comprehensive Examination cannot be waived.** The Comprehensive Examination is held once each Fall and Spring semester. A student must have a cumulative graduate grade-point-average (CUM GPA) 3.0 or higher in all graduate courses, and 3.0 over all iPOS courses, to take the Comprehensive Examination.

**1. What is the exam format?**

- a. The exam will be three hours. It will be closed book, closed notes. A scientific calculator is allowed, however cell phones and laptops are not allowed. **Please do not bring them with you as there is no place to store them.**
- b. The exam will consist of two sections: **Core and Breadth.**

**Core Section:** Answer three out of four questions. There will be 2 questions from each core course:

CEN 501/591 - Computer Systems I: Circuits to Architectures

CEN 502/591 - Computer Systems II: Fundamentals of Algorithms and Optimization Techniques

**Breadth Section:** Answer three questions from a list of breadth course questions. You will specify four courses on your signup sheet as your breadth courses. Breadth course selections must be from courses taught by Computer Engineering faculty. There will be at least one question from every breadth course you or the other students specified on the exam. You will be free to answer any three questions from the list of questions in the breadth section. However, you will be required to indicate the questions that you want to be graded. In absence of any clear indication of the questions you want graded, the first three answers will be graded.

**2. What is the passing score?**

- a. You must achieve a 60% on the entire exam.

**3. When can I take the exam?**

- a. The exam can be taken the semester immediately following the completion of the two core courses CEN 501/591 - Computer Systems I: Circuits to Architectures and CEN 502/591 - Computer Systems II: Fundamentals of

Algorithms and Optimization Techniques and four other courses. You must have completed at least these 6 courses before you take the exam. You must have a cumulative graduate grade-point-average (CUM GPA) 3.0 or higher, graduate grade-point-average (500 level courses GPA) 3.0 or higher, and 3.0 over all iPOS courses, to take the Comprehensive Examination.

**4. Can I take the exam a second time? When?**

- a. A student who fails the comprehensive examination can petition to retake the examination, one time only, in the semester immediately following the semester in which the examination was failed. In order to retake the exam, you must file a Graduate College Petition and get it approved prior to taking the exam.

**5. Can I review my exam after it has been graded?**

- a. If you pass the exam you may not view the results. Only those who fail the comprehensive examination will be allowed to review the results during the two-week period following the posting of results. This will be done along with the student's academic advisor in the Advising Center. No review will be allowed after two weeks.

**6. Can I take the exam before filing my Plan of Study (iPOS)?**

- a. No, you must have an approved Plan of Study (iPOS) with the Graduate College.

**7. Can I take the exam when I am currently enrolled in my sixth course?**

- a. No, because you have to complete both core courses and the four breadth courses.

## Appendix III

## COMPUTER ENGINEERING (CEN)

## MS COMPREHENSIVE EXAM



Student ID Number:	Date:
Name (Last, First):	
E-mail:	
Expected Graduation Date:	
First or Second Attempt:	
Check CE Concentration: Computer Sys:	Electrical Eng:
Exam Semester and Year:	

Eligibility for the comprehensive Exam:	YES	NO
Current Cumulative GPA is => 3.0	___	___
iPOS GPA =>3.00	___	___
Graduate Courses GPA =>3.00	___	___
Approved iPOS from the Office of Graduate Education	___	___

**Core Courses Taken**

Course Number	Course Title	Instructor	Sem Taken	Grade
CEN 501/591	Computer Systems I: Circuits to Architectures			
CEN 502/591	Computer Systems II: Fundamentals of Algorithms and Optimization Techniques			

**Breadth Courses Taken**

Course Number	Course Title	Instructor	Sem Taken	Grade

**EXAM RESULTS**Exam Score 

PASS	<input type="text"/>
FAIL	<input type="text"/>

The exam will be three hours. It will be closed book, closed notes. A scientific calculator is allowed, however cell phones and laptops are not allowed. Please do not bring them with you as there is no place to store them.