Computer Engineering

Computer Systems and Electrical Engineering Concentrations

Ph.D. Graduate Handbook

2013 - 2014

ARIZONA STATE UNIVERSITY

MANUAL OF THE PH.D. 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
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
http://ecee.engineering.asu.edu/programs/graduate-electrical-engineering/

Computer Engineering on the web:
http://more.engineering.asu.edu/cen/

Revised on 1/1/2014

Table of Contents

I. Introduction to the Computer Engineering Ph.D. Program 1

II. Objective of the handbook 1

III. Student responsibility 1

IV. Faculty responsibility 1

V. Admission and eligibility to the doctoral degree program 2

- Eligibility 2
- Application 2
- Application Deadlines 2
- GRE Scores 2
- English Proficiency 2
- Personal Statement 2
- Letters of Recommendation 3
- GPA Requirement 3
- Application Evaluation 3
- Recommended Academic Preparation 3
- Notice of Admission 3

VI. Doctoral degree requirements 4

- a. Core Courses 4
- b. Formulation of the Plan of Study 4
- Interactive Plan of Study (iPOS) Check Sheet 6-7
- c. Dissertation Supervisory Committee 8
- d. Comprehensive Examination 8
- e. The Dissertation Prospectus 9
- f. Steps to Preparing for Your Defense 10

VI. General Information 11

- a. Research Standards for Publication of Dissertation 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 13
1. Satisfactory Progress. 13
2. Academic Probation 13
3. Progress Probation 13
4. Removal from the CE Program 13
g. Academic Integrity 14
h. CEN 584 Internship (Curricular Practical Training) 14
i. Optional Practical Training (OPT) 16
j. CEN 790 Reading and Conference 16
k. Engineering Student Organizations 16
Computer Engineering Faculty 18
CE Areas of Study 20
Course Description 23
Appendix I Prospective Student Guide 29

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.

This Ph.D. program is intended for students with excellent skills in mathematics and physical science that are interested in gaining an in-depth knowledge of the foundational principles of engineering, as they pursue a career in academia, research or highly technical entrepreneurial innovation. The Ph.D. program provides a broader and more in-depth preparation than the M.S. program, in anticipation of a demonstrated ability to independently pursue more creative and substantive innovation with higher impact. Students are required to complete 84 credit hours—18 hours must be in one of two concentrations—and a dissertation. With approval of the student's supervisory committee, up to 30 credit hours from a previously awarded master's degree may be counted towards the degree requirements.

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 Catalog 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 e-mail, and posting on the paper and online 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 .
- The Graduate Catalog – www.asu.edu/catalog visit the section on policies and procedures.
- The Computer Engineering Program – http://cidse.engineering.asu.edu/forstudent/graduate/computer-engineering/
- The International Student Office – https://global.asu.edu/isso, if applicable.
- The Ira A. Fulton School 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 a list of the faculty names, areas of expertise, and research interest at the end of this handbook.

V. Admission and eligibility to the doctoral degree program

The Computer Engineering doctoral degree requires a background in computer engineering, computer systems engineering, electrical engineering, and computer science. However, in some cases, students with non-traditional educational backgrounds will be considered for admission. These students may be required to take fundamental courses to better prepare them for the program 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 Languages (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 - The application must include a personal statement. The statement should: 1) explain professional goals and reasons for desiring to enroll in the doctorate program; 2) describe any research experiences; 3) indicate personal research interests; **and 4) identify two or three ASU CE faculty with matching research interests.**

Letters of recommendation - CE 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. 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 – Minimum of a 3.00 cumulative GPA (scale is 4.0=A) in the last 60 hours of a student's first bachelor's degree program. A minimum GPA of 3.0 is required in the MS/MSE work for acceptance into the Ph.D. 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 provided 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 Course

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 - CE submits its recommendation of admission to the Office of Graduate Education and the final notice of admission decision is notified in writing by the Office of Graduate Education. You may check your application status on MyASU(my.asu.edu).

VI. Doctoral degree requirements

Degree requirements for the Ph.D. include a minimum of 84 semester hours beyond the bachelor's degree and deficiency courses. Students are allowed up to 30 credit hours from a previously awarded master's degree to count towards the degree requirements for the doctoral program, if approved by the student's supervisory committee.

The Ph.D is comprised of four major milestones which all students are required to pass successfully prior to graduation.

a. Completion of the core coursework
b. Filing an approved Plan of Study
c. Passing the Comprehensive Examination and approval of the dissertation prospectus to advance to candidacy
d. Successful oral defense of an approved written dissertation.

a. Core courses: All incoming students are required to complete the two core courses.

- CEN 501 – Computer Systems I: Circuits to Architectures
- CEN 502 – Computer Systems II: Fundamentals of Algorithms and Optimization Techniques

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 further advanced study in the six areas of the program. As such, these courses must be taken early in the student's course of graduate study.

b. Formulation of the Plan of Study: After successfully completing the core courses, students will be required to develop and submit a Plan of Study through MyASU. A minimum of 84 credit hours are required in the Plan of Study. A maximum of six credit hours of 400 level coursework may be used on an approved POS (400 level courses taken for a grade of Pass/Fail cannot be included on a POS). Courses with grades of "D" (1.00) and "E" (0.00) cannot be included on a POS.

The Plan of Study must have the following <u>required</u> minimum components:

1. Two core courses (6 credit hours) (see previous *Core courses* for details)
2. Elective Courses
   Must have a minimum of 42 credit hour elective courses.
   The elective course in the graduate Computer Engineering program are partitioned into six areas of study, and listed below. These courses will be referred to as Computer Engineering Area (CE-Area) courses.

The six areas of study are:

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

At least **24 credit hours of CE-Area courses** are needed to provide a breadth of knowledge in CE to support an extensive research and dissertation experience.

At least **18 credit hours of other graduate courses** (Graduate courses in Science, Engineering, or Mathematics with the approval of the Computer Engineering Graduate Committee). These courses are intended to provide a level of breadth and depth in basic science and analytical methods well beyond that required for the Masters level.

The above CE area courses must satisfy the following constraints:

- At most 6 credit hours of M*
- At least 12 credit hours of M* or D*

Remaining credit hours can be other graduate courses (Graduate courses in Science, Engineering, or Mathematics with the approval of the Computer Engineering Graduate Committee).

Research & Dissertation

- CEN 792 Research or graduate coursework (12-18 credit hours)
- CEN 799 Dissertation (12 credit hours)

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.

NAME: _____

Ira A. Fulton Schools of Engineering
ARIZONA STATE UNIVERSITY

ASU ID: _____

PH.D. in Computer Engineering (Computer Systems)

6 Core Credits + 42 Elective Credits + 0-6 Reading and Conf. + 12-18 Research + 12 Dissertation + 0-12 Electives = 84 Credit Hours

6 Credit Hours Core Courses

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

42 Credit Hours Elective Courses

☐ Select at least **24 credit hours** of courses from the CE-Area of Study to provide a breadth of knowledge in CE to support an extensive research and dissertation experience. Selection of CE-Area courses must satisfy the following constraints:

- ☐ Select at least **12 credit hours** of courses noted with **M*** or **D*** from the CE- Areas of Study.
- ☐ Select at most **6 credit hours** from courses noted with **M***in the CE-Areas of Study.
  - M*or D* Course _____ Area _____
  - M*or D* Course _____ Area _____
  - D* Course _____ Area _____
  - D* Course _____ Area _____
- ☐ Remaining credit hours can be other graduate courses in Science, Engineering, or Mathematics chosen in consultation with your graduate faculty advisor. (No M* Courses)
  - Course _____ Area _____
  - Course _____ Area _____
  - Course _____ Area _____
  - Course _____ Area _____

☐ Select at least **18 credit hours** of Science, Engineering, or Mathematics courses, in consultation with your graduate faculty advisor, that are intended to provide a level of breadth and depth in basic science and analytical methods well beyond that required for the Masters level.

- Course _____
- Course _____
- Course _____
- Course _____
- Course _____
- Course _____

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

Ira A. Fulton Schools of Engineering
ARIZONA STATE UNIVERSITY

PH.D. in Computer Engineering (Computer Systems)

6 Core Credits + 42 Elective Credits + 0-6 Reading and Conf. + 12-18 Research + 12 Dissertation + 0-12 Electives = 84 Credit Hours

Reading and Conference

☐ At most **6** credit hours of CEN 790: Reading and Conference

- CEN 790: Credit Hours _____

Research

☐ At least **12** and at most **18** credit hours of CEN 792: Research

- CEN 792: Credit Hours _____

Dissertation

☐ **12** credit hours of CEN 799: Dissertation

☐ A successful oral dissertation defense

Electives - If needed to meet 84 Credits

- Course _____
- Course _____
- Course _____
- Course _____

Overall Credits

☐ **At least 84 Credits**
☐ **12 Credits CSE**
☐ **6 Credits EEE**
☐ **CEN 584 Credit Hours (Maximum 2) _____**
☐ **No more than 6 credits 400 level courses**
☐ **No more than 12 credits cross listed courses (5XX/4XX)**
☐ **No more than 12 credits of combined cross listed courses and 400 level courses**

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 Advising Center, BYENG 208.

NAME: _____

Ira A. Fulton Schools of Engineering
ARIZONA STATE UNIVERSITY

ASU ID: _____

PH.D. in Computer Engineering (Electrical Engineering)

6 Core Credits + 42 Elective Credits + 0-6 Reading and Conf. + 12-18 Research + 12 Dissertation + 0-12 Electives = 84 Credit Hours

6 Credit Hours Core Courses

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

42 Credit Hours Elective Courses

☐ Select at least **24 credit hours** of courses from the CE-Area of Study to provide a breadth of knowledge in CE to support an extensive research and dissertation experience. Selection of CE-Area courses must satisfy the following constraints:

- ☐ Select at least **12 credit hours** of courses noted with **M*** or **D*** from the CE- Areas of Study.
- ☐ Select at most **6 credit hours** from courses noted with **M***in the CE-Areas of Study.
  - M*or D* Course _____ Area _____
  - M*or D* Course _____ Area _____
  - D* Course _____ Area _____
  - D* Course _____ Area _____
- ☐ Remaining credit hours can be other graduate courses in Science, Engineering, or Mathematics chosen in consultation with your graduate faculty advisor. (No M* Courses)
  - Course _____ Area _____
  - Course _____ Area _____
  - Course _____ Area _____
  - Course _____ Area _____

☐ Select at least **18 credit hours** of Science, Engineering, or Mathematics courses, in consultation with your graduate faculty advisor, that are intended to provide a level of breadth and depth in basic science and analytical methods well beyond that required for the Masters level.

- Course _____
- Course _____
- Course _____
- Course _____
- Course _____
- Course _____

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

Ira A. Fulton Schools of Engineering
ARIZONA STATE UNIVERSITY

PH.D. in Computer Engineering (Electrical Engineering)

6 Core Credits + 42 Elective Credits + 0-6 Reading and Conf. + 12-18 Research + 12 Dissertation + 0-12 Electives = 84 Credit Hours

Reading and Conference

☐ At most **6** credit hours of CEN 790: Reading and Conference

- CEN 790: Credit Hours _____

Research

☐ At least **12** and at most **18** credit hours of CEN 792: Research

- CEN 792: Credit Hours _____

Dissertation

☐ **12** credit hours of CEN 799: Dissertation

☐ A successful oral dissertation defense

Electives - If needed to meet 84 Credits

- Course _____
- Course _____
- Course _____
- Course _____

Overall Credits

☐ **At least 84 Credits**
☐ **12 Credits EEE or CEN**
☐ **6 Credits CSE or CEN**
☐ **CEN 584 Credit Hours (Maximum 2) _____**
☐ **No more than 6 credits 400 level courses**
☐ **No more than 12 credits cross listed courses (5XX/4XX)**
☐ **No more than 12 credits of combined cross listed courses and 400 level courses**

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.

c. Dissertation Supervisory Committee: The role of the supervisory committee is to provide guidance and direction for the student's educational and research plan. As such, the committee must have the necessary expertise to guide and evaluate research in the proposed dissertation area. A minimum of four committee members is required, including the committee chair or two co-chairs. The committee chair must be a Computer Engineering faculty member. Typical committees are made up of two committee members from the CEN faculty in the student's major area; one member from the CEN faculty outside of the area of the major; and one member from outside CEN Program. The supervisory committee must be approved by the CEN Program Chair and by the Office of Graduate Education prior to taking the Comprehensive Examination.

d. Comprehensive Examination: The comprehensive examination and the dissertation prospectus are separate processes, both of which culminate with the oral comprehensive examination. Your committee chair will advise you of the expectations of the exam.

The student first makes arrangements with the advisory committee chair to schedule a five-week time period for the examination. Care must be taken to ensure that the entire examination will fall into one of the two regular semesters. The exam consists of two parts: a) a written exam; b) an oral defense on both the Comprehensive Exam and the Dissertation Prospectus. While separate, the two oral portions of the exam may be held at the same time. **The student is required to bring a Report of Doctoral Comprehensive Examination and Approval of the Ph.D. Dissertation Prospectus forms available on the CIDSE website http://cidse.engineering.asu.edu/academic-advising/graduate-advising/gradforms/ to the oral examination, and after completion of the examination, the Chairperson or student should submit the form to the Graduate Academic Advisor.**

The five-week period will be spent as follows:

1. The student will submit a research proposal to the advisory committee. Guidelines for proposals are presented in Dissertation Prospectus below.
2. The members of the committee will submit written question(s) to the chair of the committee one week after submission of the research proposal. These questions should relate to the research area suggested by the student or to the coursework taken by the student.
3. The student will have 17 consecutive calendar days to develop written responses to the questions. The candidate should submit one complete, bound set of answers to all questions to each committee member.
4. The general knowledge oral portion of the examination will be held within two weeks of submission of the written responses. This examination normally lasts about two hours and will be primarily related to the research area, the student's written responses, and the dissertation prospectus. Appropriate related fundamental concepts may also be covered.
5. The final Pass/Fail is determined based on the combined responses to written and oral examination questions. A majority vote by the committee and a pass vote by

the committee chair are required to pass.

6. Passing the examination makes the student a candidate for the Ph.D. degree. The Office of Graduate Education will inform the student and CE Office when candidacy is granted.

Should a student fail the examination, the advisory committee will decide if and when a retake of the examination is possible. A reexamination may be administered as early as three months and no later than one year from the date of the original examination. Only one retake is allowed.

e. The **Dissertation Prospectus** is a research proposal that precedes the dissertation. It is a document that introduces the doctoral student's proposed original contribution to the field of computer engineering that will be created through the doctoral research and writing of the dissertation. The prospectus should raise an important issue in the field and discuss the issue's contribution to the discipline. The doctoral student should work with their advisor or co-advisors to prepare the prospectus. Upon completion, the student will deliver a hard copy of the prospectus to his/her supervisory committee. The committee will gather to discuss the prospectus. Following that, an oral delivery and review of the Dissertation Prospectus should be scheduled. This oral prospectus defense is considered part of the Comprehensive Exam and may be held in conjunction with the general knowledge defense.

While the format of the proposal is up to the committee chair, the written proposal typically contains:

1. A title page with author's name, committee members' names, institution, and date.
2. A table of contents.
3. An introduction explaining the nature of the research.
4. A clear statement of the research problem.
5. A thorough review of all relevant literature.
6. An argument that the problem is of sufficient relevance and importance to study.
7. A description of the proposed methodology and argument for its acceptability.
8. A statement of the expected contributions of the research.
9. A plan/schedule for completion of the research.
10. A complete bibliography following an accepted style.

The final version of the proposal is a binding agreement between the student and the Committee and will be enforced by the CE Program. Satisfactory completion of the research as outlined in the proposal will result in an approved dissertation. Following approval of the written dissertation, the student must schedule and pass a final oral defense.

Dissertation Defense and 10-Day Rule: Defense of a dissertation comprises submission of an approved dissertation followed by its successful oral defense. Students are required to submit a paper based on the dissertation research to an CE-related refereed journal before the final examination. They are strongly encouraged to present a conference paper(s) on their work during the course of the research. These publications are normally jointly written with the advisor and other appropriate faculty. Successful oral defense of

the dissertation fulfills the CEN 799 requirement.

f. Steps to Preparing for Your Defense

Prior to defense:

1. Obtain a consensus of approval from the committee chair and the members to proceed with the oral defense.
2. Schedule a date and time with your committee for the oral defense.
3. 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.
4. Visit the Office of Graduate Education website and MyASU Programs and Degree under the defense tab to become familiar with the dates and deadlines on format approval and oral defense.
5. REVIEW ALL GRADUATION DEADLINES! http://graduate.asu.edu/graddeadlines.html

10 days prior to the defense:

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

1. Reserve a room for your defense.
    a. CS please see the CIDSE front desk (Brickyard 5th floor).
    b. EE please visit your Graduate Academic Advisor
2. 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.
3. Submit an electronic copy of your completed dissertation to the CE Program Chair.
4. Schedule your defense through your MyASU (my.asu.edu) defense tab.

On the day of the defense:

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

After the defense:

1. Your committee will discuss the results of the exam with you and may have additional comments for you. At the end, the committee will make a recommendation: Pass, Pass with minor revisions, Pass with major revisions, or Fail.
2. Revisions are normal and must be completed within one year. This includes remaining registered and uploading the finished document on MyASU Format Tools.
3. If you have revisions you must submit a copy of the Doctoral 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.

4. You must be registered for at least one credit hour graduate level coursework each semester until the final submission of your dissertation.
5. After you have passed the defense and/or completed all revision hand-deliver the original Doctoral Defense Report (Pass/Fail Form) to your respective concentration advising center. The graduate advisor will email the form to the Office of Graduate Education.
6. Upload your dissertation online through ProQuest.

VI. General Information

a. Research standards for publication of dissertation

Graduate research is the study of an issue that is of sufficient breadth and depth to be publishable in a CE-related journal. The effort should reflect a minimum of 1,500 hours of thoughtful work for a dissertation (Ph.D.). The research should follow the 'scientific method' and thus be both objective and reproducible. The dissertation 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.

b. Financial assistance and/or fellowships

The Computer Engineering Program's goal is to provide support to all incoming Ph.D. students. According to the student's academic performance and past academic research, funding offers will be extended to individual students with the highest academic achievements. We encourage students to highlight their past academic achievements in their personal statement and in their resume.

c. Continuous Enrollment and Leave of Absence Policies

Once admitted to a graduate degree program, doctoral students must be registered for a minimum of one graduate credit hour (not audit or undergrad) during all phases of their graduate education. This includes periods when they are engaged in research, working on or defending theses or dissertations, 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 Plan of Study or must be an appropriate graduate-level course (e.g. 695, or 795, 580, 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. Student 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

Doctoral students must complete all program requirements within a ten-year period. The ten-year period starts with the semester and year of admission to the doctoral program. Graduate courses taken prior to admission that are included on the Plan of Study must have been completed within three years of the semester and year of admission to the program (previously awarded master's degrees used on the Plan of Study are exempt).

In addition, the student must defend the dissertation within five years after passing the Comprehensive Examinations. Therefore, the maximum time limit is the shortest of the following:

1. Time period since initial enrollment (10 year time limit).
2. Time after passing the comprehensive exams (5 year time limit).

Any exceptions must be approved by the supervisory committee and the Office of Graduate Education and ordinarily involves repeating the comprehensive examinations. The Office of Graduate Education may withdraw students who are unable to complete all degree requirements and graduate within the allowed maximum time limits.

e. Registration requirements for research assistants (RA) and teaching assistants (TA)

Students awarded an assistantship within the Ira A. Fulton School of Engineering are required to be registered for 12 credit hours. Audit credit hours do not count towards the 12 credit hours.

Students who obtain an assistantship outside the Ira A. Fulton School of Engineering are required to be enrolled a minimum of 6 credit hours. Audit credit does not count towards the 6 credit hours. Enrollment in continuing registration (CEN 795) does not count towards the 6 hour requirement.

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 health insurance premium for those TAs and RAs working 20 hours per week (50 percent FTE).

f. Satisfactory Progress, Academic Probation, Progress probation, and Withdrawal 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) Withdrawal from the CE Program.

1. **Satisfactory progress** means that a student does not have any academic and progress probationary issues. In addition to the probationary rules, satisfactory progress includes each semester communication with the student's Committee Chair regarding his/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 Ph.D. Comprehensive Examination.

4. A student is recommended for **withdrawal 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 withdrawal. The student will have 5 calendar days from the date of the letter to appeal the decision. The CE 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's Academic Affairs to withdraw 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's Academic and Student Affairs will recommend to the Office of Graduate Education to withdraw the student from the CE Program. Please refer the Office of Graduate Education catalog on policies and procedures or contact your respective concentration graduate advisor.

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.

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 can be removed at a later date if the student does not complete an internship. CEN 584 CPT Internship course cannot be added to a final 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. Ph.D. 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. The 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.

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, graduate GPA, and iPOS GPA of 3.0 is required. Any student who has a sanctioned academic integrity violation is 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").

Renege: (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.naceweb.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 ISSO 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 ISSO 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.. 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 790 Reading and Conference (Independent Study)

Independent study is available for Ph.D. students. The student must get written approval from the supervising faculty outlining the coverage of the content. The Independent Study form must be approved by the Program Chair and will be placed in the student's file.

k. Engineering Student Organizations

There are dozens of engineering student organizations and teams ranging from honors and professional associations to groups creating underwater robots, concrete canoes

and launching rockets. 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

Surname	Given Name	Rank	Degree	Expertise	Website
Ahn	Gail-Joon	Assoc. Prof	Ph.D.	Network security	
Askin	Ronald	Prof.	Ph.D.	Applied optimization	http://engineering.asu.edu/people/901090
Candan	Kasim (Selcuk)	Prof	Ph.D.	Database systems	http://engineering.asu.edu/people/20861
Cao	Yu (Kevin)	Asst. Prof	Ph.D.	Nanoscale modeling	http://engineering.asu.edu/people/749044
Chakrabarti	Chaitali	Prof	Ph.D.	VLSI architecture	http://engineering.asu.edu/people/22557
Chatha	Karam	Assoc. Prof	Ph.D.	Embedded Systems	http://engineering.asu.edu/people/388446
Baral	Chitta	Prof	Ph.D.	Autonomous agents	
Clark	Larry	Assoc. Prof	Ph.D.	Low power electronics	http://engineering.asu.edu/people/751415
Colbourn	Charles	Prof	Ph.D.	Network reliability	http://engineering.asu.edu/people/384970
Dasgupta	Partha	Assoc. Prof	Ph.D.	Security & Op. systems	http://engineering.asu.edu/people/75201
Vasileska	Dragica	Prof	Ph.D.	Semiconductor Devices	http://engineering.asu.edu/people/106590
Fainekos	Georgios	Asst. Prof	Ph.D.	Cyber physical systems	http://graduate.asu.edu/graduate_faculty/person/Georgios|Fainekos
Fowler	John	Prof.	Ph.D.	Scheduling theory	http://www.fulton.asu.edu/~ie/people/faculty/onepagebios/fowler_j.php
Gel	Esma	Assoc. Prof	Ph.D.	Stochastic modeling	http://engineering.asu.edu/people/257696
Gupta	Sandeep	Prof	Ph.D.	Cyber physical systems	http://engineering.asu.edu/people/313263
Huang	Dijiang	Asst. Prof	Ph.D.	Network security	http://engineering.asu.edu/people/835028
Hui	Joseph	Prof	Ph.D.	Wireless networks	http://engineering.asu.edu/people/230953
Kambhampati	Subbarao	Prof	Ph.D.	Automated planning	http://engineering.asu.edu/people/95646
Karam	Lina	Prof	Ph.D.	Signal/Image processing	http://engineering.asu.edu/people/53561
Kim	Seugnchan	Prof	Ph.D.	Signal Processing	
Tsakalis	Konstantinos	Prof	Ph.D.	System optimization	http://engineering.asu.edu/people/105332
Lee	Yahn-Hang	Prof	Ph.D.	Real-Time systems	http://engineering.asu.edu/people/284224

Li	Baixin	Asst. Prof	Ph.D.	Multimedia processing	http://engineering.asu.edu/people/747601
Li	Jing	Prof	Ph.D.	Statistical modeling	http://engineering.asu.edu/people/356293
Michandani	Pitu	Prof	Ph.D.	Real-time control	https://webapp4.asu.edu/directory/person/1439066
Palais	Joseph	Prof	Ph.D.	Optical communications	http://engineering.asu.edu/people/47394
Panchanathan	Sethuraman	Prof	Ph.D.	Ubiquitous computing	http://engineering.asu.edu/people/88253
Phillips	Stephen	Prof	Ph.D.	Micro electrical systems	http://engineering.asu.edu/people/547474
Reisslein	Martin	Assoc.Prof	Ph.D.	Fiber/wireless networks	http://engineering.asu.edu/people/287028
Richa	Andrea	Assoc. Prof	Ph.D.	Network optimization	http://engineering.asu.edu/people/198256
Runger	George	Prof	Ph.D.	Data mining	http://engineering.asu.edu/people/87655
Sen	Arunabha	Prof	Ph.D.	Network optimization	http://engineering.asu.edu/people/40210
Shrivastava	Aviral	Asst. Prof	Ph.D.	Multicore architecture	http://engineering.asu.edu/people/969623
Si	Jennie	Prof	Ph.D.	Nonlinear dynamic systems	http://engineering.asu.edu/people/48345
Spanias	Andreas	Prof	Ph.D.	Digital signal processing	http://engineering.asu.edu/people/93829
Sundaram	Hari	Assoc. Prof	Ph.D.	Multimedia &databases	http://engineering.asu.edu/people/522896
Syrotiuk	Violet	Assoc. Prof	Ph.D.	Mobile ad hoc networks	http://engineering.asu.edu/people/518662
Tsai	Wei-Tek	Prof	Ph.D.	Software engineering	http://engineering.asu.edu/people/258423
Vrudhula	Sarma	Prof	Ph.D.	VLSI circuit design	http://engineering.asu.edu/people/761142
Wonka	Peter	Asst. Prof	Ph.D.	Computer graphics	http://engineering.asu.edu/people/755237
Xue	Guoliang	Prof	Ph.D.	QoS routing & security	http://engineering.asu.edu/people/378651
Yau	Stephen	Prof	Ph.D.	Network security	http://engineering.asu.edu/people/94570
Zhang	Yanchao	Assoc. Prof	Ph.D.	Cyber security	
Zhang	Junshan	Prof	Ph.D.	Wireless networks	http://engineering.asu.edu/people/284251
Zhang	Muhong	Asst. Prof	Ph.D.	Robust optimization	http://engineering.asu.edu/people/1099666

Computer Engineering Areas of Study

1. VLSI – VLSI and Architecture
2. ECS – Embedded Control Systems
3. CN – Communications and Networks
4. DDSS – Distributed, Dependable Secure Systems
5. MSP – Multimedia and Signal Processing
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		

Course & Prefix	Course Title (Credit Hours)	VLSI	ECS	CN	DDSS	MSP	SO
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	

Course & Prefix	Course Title (Credit Hours)	VLSI	ECS	CN	DDSS	MSP	SO
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

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.

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 may 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 Al
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 Conding 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. 6th 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 teees (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)