Computer Engineering

Computer Systems and Electrical Engineering Concentrations

Ph.D. Graduate Handbook

~~2017 – 2018~~

2016 – 2017 Addendum

The catalog years were the only addendum made in this handbook.

ARIZONA STATE UNIVERSITY

MANUAL OF THE PH.D. DEGREE IN COMPUTER ENGINEERING

ARIZONA STATE UNIVERSITY

~~**2017 – 2018**~~
2016 – 2017 Addendum

http://cen.engineering.asu.edu/

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

Computer Engineering (Electrical Engineering) graduate degrees please contact:

School of Electrical, Computer and Energy Engineering
Arizona State University
PO Box 875706
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I. Introduction to the Computer Engineering Program

Computer Engineering (CEN) is a multi-disciplinary program that builds on the fundamentals of Computer Science, Electrical Engineering, Applied Mathematics, and Physical Sciences. 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 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.

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, CEN 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 online. Most importantly you should visit the following websites:

- The Office of Graduate College – http://graduate.asu.edu - visit the section on policies and procedures.
- The Schedule of Classes – www.asu.edu/catalog
- The Computer Engineering Program – http://cen.engineering.asu.edu/
- The International Student and Scholars Center – https://students.asu.edu/international , 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 on the Computer Engineering website http://cen.engineering.asu.edu/.

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 – A 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 College and pay the required fee in order to have their application properly processed.

Application deadlines – December 31 for Fall and August 15 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 an 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 College 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 CEN faculty with matching research interests.**

Letters of recommendation - CEN 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 – A 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, Discrete Math, and Random Signal Analysis.

ASU Recommended Course

CSE 230 – Computer Organization and Assembly Language Programming

CSE 310 – Data Structures and Algorithms

EEE 203 – Signals and Systems I

EEE 350 – Random Signal Analysis

MAT 243 – Discrete Math Structures

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

Pre-admission Credits and Transfer Credit – Please refer to the Office of Graduate College's policies and procedures.

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 and the Program Chair.

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, area, and elective 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.

Credit Requirements Summary

- 30 credit hours satisfying the requirements described in the CEN MS Handbook, or approved to be transferred from a successfully completed master's degree.
- 6 credit hours of core courses
- 18 credit hours of Computer Engineering Area Courses and Reading and Conference (CEN 790) with at least 12 credit hours of Computer Engineering Area Courses (12 to 18 credit hours) and at most 6 credit hours CEN 790 (0 to 6 credit hours).
    - CEN-CS Concentration: 12 credits CSE or CEN courses and 6 credits EEE or CEN courses
    - CEN-EE Concentration: 12 credits EEE or CEN courses and 6 credits CSE or CEN courses
    - 12 of the 18 credit hours should be M* (Master Level) or D* (Doctorate Level) courses with at most 6 credits hours being M*
- 12 credit hours of Research (CEN 792)
- 12 credit hours of Dissertation (CEN 799)
- 6 credit hours of elective graduate courses (~~can be internship,~~* reading and conference, or approved Science, Engineering, or Mathematics graduate courses)

*See correction: CPT policy page 13

The area 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 (CEN-Area) courses.

The six (6) areas of study are:
1) VLSI and Architecture (VLSI)
2) Embedded Control Systems (ECS)
3) Communication and Networks (CN)
4) Distributed, Dependable and Secure Systems (DDSS)
5) Multimedia and Signal Processing (MSP)
6) Systems Optimization (SO)

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

Core Courses:

- CSE 551 – Foundations of Algorithms (3)
- EEE 554 – Random Signal Theory (3)

All students are required to take the core courses, CSE 551 Foundations of Algorithms and EEE 554 Random Signal Theory in their first two semesters. Students in the Computer Systems Concentration (CEN-CS) are required to take CSE 551 in their first semester. Students in the Electrical Engineering Concentration (CEN-EE) are required to take EEE 554 in their first semester. These courses have a pre-requisite of CSE 310 for CSE 551 and EEE 350 for EEE 554. If students are deficient in CSE 310 or EEE 350, they may choose to take these concurrently with the core courses or they can petition to take these in their first semester before taking the core courses.

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. Must satisfy the 30-credit CEN MS degree requirements (refer to Computer Engineering MS Handbook for a detailed description of these requirements), or can use towards Ph.D. degree, upon approval, up to 30 credits from a successfully completed Master's degree.
3. Must have a minimum of 12 credit hours CEN-Area courses satisfying the following constraints:

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

Mandatory Concentration Requirement

The <u>Computer Systems</u> concentration requires the student take 18 total credit hours as follows:

- At least **12** credit hours of graduate level CEN-Area courses in CSE or CEN or Reading and Conference (max 6 credit hour CEN 790), and
- At least **6** credit hours of graduate level CEN-Area 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 CEN-Area courses in EEE or CEN or Reading and Conference (max 6 hour CEN 790), and
- At least **6** credit hours of graduate level courses in CSE or CEN.

Internship and thesis credits do not count toward the required concentration requirement.

Research & Dissertation

- CEN 792 Research or graduate coursework (at least 12 and at most 18 credit hours)
- CEN 799 Dissertation (12 credit hours)

Remaining credit hours can be other graduate courses (e.g., graduate courses in Science, Engineering, or Mathematics with the approval of the Computer Engineering Graduate Committee, Reading and Conference, or CEN-Area courses).

Reading and Conference

- At most 6 credit hours of CEN 790 Reading and Conference

400-Level Courses and Cross Listed Courses

- 400-Level Courses and Cross Listed Courses are only permitted as part of the first 30 credits towards the 84-credit PhD degree.
- 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, CEN students will be required to enroll in the 500 level.

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 or at least one of the co-chairs must be a Computer Engineering Graduate Faculty member with the right to chair. At least two members must be CEN Graduate Faculty members. The supervisory committee must be approved by the CEN Program Chair and by the Office of Graduate College prior to taking the Comprehensive Examination.

d. Comprehensive Examination: The comprehensive exam is two parts:

- Written exam and
- Oral exam

Your committee chair will advise you of the expectations of the exam. The syllabus for the written exam will be decided by your committee.

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 student is required to bring a Report of Doctoral Comprehensive Examination available on the Computer Engineering website to the oral examination, and after completion of the written examination, the Chairperson should submit the form to the Graduate Academic Advisor Office.**

The five-week period will be spent as follows:

1. The student consults the committee members to determine the start day of the written portion of the exam. This has to happen at least two weeks before the start date.
2. The members of the committee will submit written question(s) to the chair of the committee before the start date. These questions should relate to the syllabus decided by the committee.
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 oral portion of the examination will be held within two weeks of submission of the written responses. This examination normally lasts about two hours
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 College will inform the student and CEN 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 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. .

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.

Once the prospectus has been approved by the chair or co-chairs of the supervisory committee, the student should schedule the doctoral prospectus defense. The committee members should be given at least two weeks to review the prospectus.

The oral portion consists of a presentation which is open to public and a closed session with the committee members.

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

f. Doctoral Dissertation 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 a CEN-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.

Steps to Preparing for Your Defense

<u>Prior to defense:</u>

1. Student should have submitted a paper based on dissertation research to a CEN-related refereed journal. Also, a student is encouraged to present work at a conference during the course of research.
2. Obtain a consensus of approval from the committee chair and the members to proceed with the oral defense.
3. Schedule a date and time with your committee for the oral defense.
4. 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.
5. Visit the Office of Graduate College website and MyASU Programs and Degree under the defense tab to become familiar with the dates and deadlines on format approval and oral defense.
6. 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. Contact your respective concentration advising center for help with room reservation.
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. 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 College within 10 working days of the defense. A copy of the pass/fail form should be submitted to the advising office as well. 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 revisions 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 College.
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 CEN-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 College 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" and Incomplete (changes to permanent incomplete grade after one year) 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 College 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 CEN Program Chair, must be approved by the Office of Graduate College. 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 College 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 his/her 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 College and ordinarily involves repeating the comprehensive examinations. The Office of Graduate College 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 at least 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 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 CEN 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 CEN 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.
    - Failure to pass the PhD Prospectus

4. A student is recommended for **withdrawal from the CEN Program** if she or he fails to meet the probationary standards placed upon her/him 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 CEN 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 and Student Affairs to withdraw the student from the CEN 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 the Associate Dean and the CEN 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 College to withdraw the student from the CEN Program. Please refer the Office of Graduate College website for 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 an academic experience usually obtained at off-campus work settings, allowing the student to apply knowledge and skills gained in various classes. It is intended as a unique, hands-on learning experience to provide students with a number of valuable skills that they can use upon graduation from their graduate degree programs. Accordingly, it is not available to full-time or part-time workers regularly employed by the company where the internship is proposed.

The CPT is available to both domestic and international students. However, international students must work with the International Students and Scholars Center (ISSC) and submit additional documentation to obtain work authorization. Furthermore, international students must include the CPT courses CEN 584 (1 credit hour) as an integral part of their Program of Study, reflected by their approved iPOS. The CPT courses (up to three 1-credit CEN 594) should be included within the first 84 credits on the student's iPOS but these do not count towards the 84-credit degree requirement.

It is highly recommended that the CPT course(s) be listed at the initial submission of the student's iPOS during the first semester of study. (Note that each student is required to file an iPOS by the end of his/her first semester of study). Later additions of CPT courses must be requested and approved prior to the proposed start date of the internship course.. Exceptions may be made if the internship is relevant to thesis (or dissertation) research.

The Graduate Program Chair will determine the need for a CPT internship in such cases in consultation with the Graduate Academic Advisor. Note that approval of an iPOS

with the CEN 584 course confirms that the internship is an integral part of the degree requirements as planned by the student.

In order to be eligible for internship, a student must be in **good academic standing and not have an academic integrity violation** in a course for two full semesters (summer semesters not included) from the initial reporting of the incident. For example, a sanctioned academic integrity violation initially reported on April 15, 2016 will make the student ineligible for this approval until the end of Spring 2017 semester.

International students need to be aware of immigration policies and regulations, which may jeopardize their academic status. Hence, it is strongly recommended for international students to consult with the International Students and Scholars Center (ISSC).

All students (domestic and international) may take part in an Out-Of-State internship in the Summer semester. The eligibility requirements for CPT internships remain the same as mentioned.

During the regular Fall and Spring semesters international graduate students in F-1 status must register for a minimum of nine (9) credit hours to maintain full-time status and be enrolled in a minimum six (6) credit hours of in-person, on-campus coursework at an ASU campus. A maximum of three (3) credit hours of online courses is permitted. The CEN 580 Practicum course will not count as satisfying the student's "physical presence" at ASU. Students will not be able to take part in internships outside the Phoenix metropolitan area. In some cases students may be approved to do an internship in Tucson or other nearby locations to Phoenix, as long as the student is able to prove they can physically attend their courses on campus.

Required documents and forms for the internship proposal must be submitted to the respective concentration advising center at least two weeks prior to the beginning of the semester in which the internship is planned. Students will not be able to request late-add registration of the CEN 584 Internship credit to their class schedule after the drop/add deadline of each semester.

An approved proposal is required before commencing the internship. The request will include a statement from the employer that indicates they understand that the work is to satisfy a degree requirement. A sample letter and other required forms are available from the respective concentration advising center and are posted on the Computer Engineering website. Students must receive approval from their faculty advisor and from the Graduate Program Chair before registering for CEN 584. **In order to register for CEN 584, a student must have a CUM GPA of 3.00 or higher.** A final Plan of Study must be filed with the Office of Graduate College showing the Internship course before registering for CEN 584. All application materials for an Internship must be completed by the last day of regular registration for any semester. The student must take classes appearing on the Plan of Study the semester following the internship.

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.

A five-page final report is required before a grade and credit is given. The final report must be submitted to the reporting supervisor for comments and then to the faculty advisor for grade assignment.

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 his/her 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 courses are 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 Organizations.

l. Instructional Concerns and Course-Related Complaints

Being part of a large university creates opportunities to learn from a diverse instructor population with different teaching styles and modalities for delivering course content. Courses are offered by a diverse set of faculty including those who are research intensive, those whose primary responsibility is teaching, and part-time faculty who are working in the field. Based on enrollment or modality of offering, faculty may also be supported by

graduate student teaching assistants and graders. This diverse higher education delivery platform may differ significantly from the high school experience, and while it provides opportunity to expand the student's ability to learn and develop problem solving skills, concerns and conflicts with requirements and instructors may occasionally arise. CEN students with instructional concerns should review and adhere to the following guidelines for attempting to resolve their issues. First and foremost keep in mind that the faculty and advising staff are experienced, dedicated educators that are here to help you achieve your educational goals but at the same time they have a responsibility to ensure standards are maintained and student outcomes are achieved prior to graduation. The university culture recognizes the value of diversity in multiple dimensions as well as the presumption of expertise and academic freedom of the faculty.

Communicate with your Instructor

If you have a difference of opinion with your instructor or teaching assistant (TA), or have concerns about technical or administrative aspects of the course, visit the instructor or TA during office hours or contact them via email (if you cannot visit them during the office hours). Express your concerns clearly and respectfully and ask for help. Be sure to provide succinct information about what you are having trouble understanding in the course or your concern. Instructors and TAs are here to help. Please remember that you are responsible for pre-requisite knowledge/skills required for a course and regularly studying the material taught in the course. The teaching staff may not be able to help you with your problem if you lack in the pre-requisite knowledge/skills or have not been keeping up with the course material. As a guideline, you should be spending three hours studying every week for -each hour of course credit. Thus you should schedule 8-10 hours of time each week to devote to each 3-credit course. In addition, make sure to resolve the issues as soon as they occur and maintain all documentation. For example, if the assignment instructions are not clear, get the clarification on the day the assignment is assigned and do not wait until the deadline of the assignment.

If, after communicating with your instructor or TA, you are still having problems in the course, connect with your academic advisor to understand your options moving forward.

Connect with your Graduate Program Chair

If you are unable to resolve the concern after initial contact with the instructor or the TA, and you have met with your academic advisor, you should then connect with the Computer Engineering Program Chair (or the department offering the course). The Program Chair will confer with the instructor and/or TA to better understand the concern and try to resolve the problem. Please note that before meeting with the Graduate Program Chair you should have made a reasonable effort to meet with the course instructor (not just the TA) and get the issue resolved. When contacting the Program Chair provide all the relevant details such as the course syllabus, assignment handout, email exchange with the instructor etc. so that the Graduate Program Chair can promptly act on your concerns. Please be brief and precise in the description of your concerns. In some cases, the Program Chair would like to meet you. When coming for the meeting please bring along all the relevant documents.

If the instructional concern is not resolved with the Program Chair or the department offering the course, contact the Associate Dean of Academic and Student Affairs' office for the college offering the course for assistance.

Remain Focused

When faced with instructional concerns, it is important to remain focused on the rest of the course while addressing specific areas that are under review. Be sure to stay connected with your academic advisor if there are any changes in your situation.

NOTE:

- Misrepresentation of facts or disrespectful behavior when confronting your instructor or teaching assistant is considered an academic integrity violation.
- Maintain all documentations.
- Act proactively and promptly.

In Summary, Guidelines for Avoiding Problems

- Be sure you have the necessary prerequisite knowledge before starting a course;
- Attend class and on-line exercises regularly;
- Devote time each week to studying to avoid getting behind;
- Contact the TA (if assigned) or instructor during office hours at first sign of trouble and come prepared to ask precise questions and to explain your difficulty
- Accept the fact that you grow intellectually and professionally by being challenged and learning to deal with diverse expectations and environments.

Process for Resolving Conflicts in Grading, Course Expectations, etc.

- Contact the TA (if available) or instructor to explain your concern and seek resolution;
- If the TA/instructor has attempted to assist you but you are still having academic difficulty that is causing personal stress or hindering your academic success, see your Academic Advisor;
- If the TA/instructor is not responsive or does not provide a legitimate response/accommodation, then contact your Graduate Program Chair.
- If you still feel there is a legal, ethical or procedural violation that is victimizing you, contact the Office of the Associate Dean of Engineering for Academic Affairs.
- Circumventing this process will be considered a violation of professional ethics and protocol.

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	Multimedia Information Systems (3)					X	
CSE 412	Database Management (3)				X		
CSE 420	Computer Architecture I (M*) (3)	X					
CSE 438	Embedded Systems Programming (M*) (3)		X				
CSE 434	Computer Networks (M*) (3)			X			
CSE 440	Compiler Construction I (M*) (3)				X		
CSE 445	Distributed Software Development (3)				X		
CSE 468	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		

Course & Prefix	Course Title (Credit Hours)	VLSI	ECS	CN	DDSS	MSP	SO
CSE 534	Advanced Computer Networks (D*) (3)			X			
CSE 535	Mobile Computing (3)			X			
CSE 536	Advanced Operating Systems (D*) (3)				X		
CSE 539	Applied Cryptography (3)				X		
CSE 543	Information Assurance and Security (3)				X		
CSE 545	Software Security (3)				X		
CSE 548	Advanced Computer Network Security (3)			X			
CSE 550	Combinatorial algorithms and intractability () (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 572	Data Mining (3)				X		
CSE 574	Planning and Learning Methods in AI (3)		X				
CSE 575	Statistical Machine Learning (3)		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			

Course & Prefix	Course Title (Credit Hours)	VLSI	ECS	CN	DDSS	MSP	SO
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*) (4)					X	
EEE 509	DSP Algorithms and Software (3)					X	
EEE 511	Artificial Neural Computation (3)		X				
EEE 525	VLSI Design (D*) (4)	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 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				

Course & Prefix	Course Title (Credit Hours)	VLSI	ECS	CN	DDSS	MSP	SO
EEE 606	Adaptive Signal Processing (3)					X	
EEE 607	Speech Coding for Multimedia Communications (3)					X	
EEE 625	Advanced VLSI Design (4)	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

For course descriptions please see the course catalog: https://webapp4.asu.edu/catalog/

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: Discrete Math, Digital Signal Processing, Computer Architecture & Organization, Algorithms & Data Structures, and Random Signal Analysis.

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.

Random Signal Analysis (ASU Course: EEE 350)

Textbook: Yates and Goodman, *Probability and Stochastic Processes*, second edition, Wiley, 2005.

1. Axiomatic probability
2. Random variables, distribution functions, and density functions
3. Special distributions: Gaussian, exponential, etc.
4. Expectation and variance
5. Multiple random variables
6. Central limit theorem and law of large numbers
7. Maximum-likelihood estimation and confidence intervals
8. Random processes
9. Statistical analysis using sample statistics, histograms, and linear regression

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)