Carnegie Mellon University
Electrical & Computer Engineering

MS Student Handbook – Silicon Valley

Department of Electrical & Computer Engineering

Academic Year 2024-2025

 This handbook is posted to the ECE Master's webpage prior to the start of each academic year and is updated as needed. This handbook is valid from August 26, 2024 to August 31, 2025.

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WELCOME TO ELECTRICAL AND COMPUTER ENGINEERING

Welcome to the Department of Electrical and Computer Engineering at Carnegie Mellon University. Since offering our first course in electrical engineering in 1908, our research and teaching has expanded to cover areas as broad as device sciences and nanotechnology, computer systems, data science, energy, control, communications, and circuits. The 2024 *US News and World Report* ranked our graduate programs in electrical engineering and computer engineering 7th and 5th in the nation, respectively, and we offer programs in Pittsburgh, Silicon Valley, Portugal, Thailand, and Africa.

Our distinguished faculty work closely with students to push the boundaries of technology and to shape the future of energy systems, bio-electronics, computing, data storage, and much more.

While this handbook is specific to your academic experience in the department, it is just one element of the Graduate Student Handbook Suite. There are several other resources within the suite that you should consult when needed:

- Your Program Handbook
- The College of Engineering's Handbook
- University-Wide Graduate Student Handbook (Office of Graduate & Postdoctoral Affairs)
- The Word Student Handbook

Information about The Word, the student handbook, the Office of Graduate and Postdoc Affairs, the Office of the Dean of Student Affairs and others are included in Appendix A of this handbook.

Please do not hesitate to contact us if you have any questions or comments.

Sincerely,

Larry Pileggi
Coraluppi Head and Tanoto Professor
Electrical and Computer Engineering

Core Values

The ECE Department has been a leader in both research and education for years; it is known for its innovative qualities, boldness of ideas, and unbridled enthusiasm. Our strategic plan is guided by our core values.

> **We value scientific truth, creativity, quality, innovation, and engineering solutions, all within a diverse and inclusive community guided by respect and joy of doing.**

Our core values form the foundation for what we do; we hold them to be intrinsically true. We believe in solving problems that have large societal impact. We also believe that to be successful, we must work within an environment of enthusiasm and openness, respect and integrity, and freedom to express and explore a variety of ideas.

Vision

Carnegie Mellon University will have a transformative impact on society through continual innovation in education, research, creativity, and entrepreneurship.

Mission and Objectives

The ECE Department mission is:

> **To inspire, educate, and produce electrical and computer engineers capable of tackling fundamental scientific problems and important societal challenges, and to do so with the highest commitment to quality, integrity, and respect for others.**

We aim to be the best at what we do, to apply all our skills and knowledge to execute our vision. We educate young people to become engineers sought after by industry and academia alike; we do so in an environment imbued by enthusiasm and love for what we do, with respect and willingness to listen to each other, with freedom to express our ideas and look at challenges from different points of view. We strive to be the ECE department of choice for those who are willing to step off the beaten path, for the visionaries and dreamers.

Students in the Master's of Science in Electrical and Computer Engineering program are provided with a thorough background in the fundamentals of electrical or computer engineering, as well as the opportunity for in-depth specialization in some particular aspect of these fields. Upon enrollment in the department, students are given the opportunity, with the help of an academic advisor and faculty mentor, to choose an educational program that is consistent with their background and is best suited to their own academic goals.

The Master of Science in Software Engineering (M.S.-SE) is a unique program offered exclusively at CMU’s Silicon Valley campus. It emphasizes a rigorous foundation in the core disciplines of software engineering. The program offers students a first-hand experience in software engineering by balancing theory and practice, engaging them in active learning, and encouraging collaboration on projects drawn from real world contexts.

Our students enter the program with a strong foundation in computer science. They leave the program with a deep knowledge of software engineering.

Philosophy

The Department of Electrical and Computer Engineering (ECE) at Carnegie Mellon University is dedicated to providing a world-class, transformative educational experience to the broadest possible student community. We foster an inclusive environment of learning, research, creativity, and collaboration, embracing and creating successful paths for students of all backgrounds and learning styles. Focused on both theoretical and applied studies, the ECE department incorporates ethics, fairness, and entrepreneurial thinking into all of its courses. We build innovative systems of every scale and scope that provide wide-reaching societal benefits, ensuring our work on campus has impact beyond the university's traditional borders.

INTRODUCTION

Graduate Degrees and Programs Offered

Master of Science in Electrical and Computer Engineering – Standard Program

- Pittsburgh
- Silicon Valley
- Thailand
- Africa

Master of Science in Electrical and Computer Engineering – Applied Study [*]

- Pittsburgh
- Silicon Valley

Master of Science in Electrical and Computer Engineering – Advanced Study

- Pittsburgh

Master of Science in Electrical and Computer Engineering – Applied Advanced Study *

- Pittsburgh

Master of Science in Software Engineering – Standard Program

- Silicon Valley

Master of Science in Software Engineering – Applied Study*

- Silicon Valley

Master of Science in Artificial Intelligence Engineering – Electrical and Computer Engineering

- Pittsburgh

Doctor of Philosophy in Electrical and Computer Engineering

- Pittsburgh
- Portugal
- Thailand
- Washington, D.C.

Please note: The instruction for all degrees and programs will occur in English.

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[*] Available to students matriculating Fall 2020 to Spring 2023

Graduate Student Catalog/Handbook

This catalog/handbook is intended to set guidelines and expectations for new and current Master's students in the Department of Electrical and Computer Engineering at Carnegie Mellon University Silicon Valley. This catalog/handbook is not exhaustive and is subject to revision at any time by the ECE department. It covers Master's students in Silicon Valley.

It is the responsibility of each student to read and understand the contents of this catalog/handbook.

This catalog/handbook, along with any revisions, will be posted and announced annually to the ECE website. Students with disabilities may request this catalog/handbook in other formats by contacting the Advising and Academic Services Center.

DEPARTMENTAL INFORMATION

Personnel

Throughout a student's time in the MS program, they will encounter a variety of faculty and staff who will help them on their way to completing their degree. Students may view a list of faculty and a list of staff affiliated with ECE online. Below is a list of faculty and staff whom students are likely to encounter during their time in the MS program.

- Dean of the College of Engineering: Professor William Sanders
- Associate Dean of Graduate and Faculty Affairs: Professor Lisa Porter
- Department Head: Professor Larry Pileggi
- Director, Office of the Department Head: Kimmy Nguyen
- Interim Director, CMU-Africa: Professor Conrad Tucker
- Associate Department Head for Research: Professor Shawn Blanton
- Associate Department Head for Academic Affairs: Professor James A. Bain
- Associate Department Head for Students: Professor Tamal Mukherjee
- Director of Finance and Sponsored Research: Charlotte Ambrass
- Director of Admissions and Academic Affairs: Tara Moe
- Director of Advising and Academic Services: Megan Oliver
- Ph.D./M.S. Senior Academic Program Advisor in Silicon Valley: Brittany Bristoll

A general list of contacts can also be found on the ECE website.

Department Resources

Course Instructors

ECE courses are taught by world-renown educators and researchers.

Hakan Erdogmus, Teaching Professor
Ph.D., Telecommunications, Université du Québec
Cecile Peraire, Associate Teaching Professor
Ph.D., Computer Science, Swiss Federal Institute of Technology
John Shen, Professor
Ph.D., Electrical Engineering, University of Southern California
Leonardo da Silva Souza, Assistant Teaching Professor
Ph.D., Computer Science, Pontifícia Universidade Católica do Rio de Janeiro
Rafal Wlodarski, Assistant Teaching Professor
Ph.D., Lodz University of Technology

Academic Advising

Each student will have an *academic advisor* and a *faculty advisor,* listed in students' SIO portal, who work together as a team to best support their advisees.

The academic advisor is the main point of contact and a skilled staff member who serves as students' primary support in navigating their academic program. Academic advisors handle

crucial compliance-related advising tasks, including tracking degree progress, certifying graduation, and completing enrollment and university-related paperwork. The academic advisor in Silicon Valley is Brittany Bristoll.

The faculty advisors are full-time, PhD-trained faculty members who can help students with things like technical questions, course selection, career guidance, finding research projects, working with instructors, and more. The faculty advisors are Professor Hakan Erdogmus, Professor Cécile Péraire, Professor Leonardo da Silva Sousa, and Professor Rafal Wlodarski.

The head of the ECE Advising Group is Professor Tamal Mukherjee, Associate Department Head for Students, who also serves as a faculty advisor. Megan Oliver, Director of Advising & Academic Services, reports to Professor Mukherjee.

Concerns and conflict with your academic advisor can be shared with the Director of Advising & Academic Services. Concerns and conflict with your faculty advisor can be shared with the Associate Department head for Students. Beyond this, students are encouraged to communicate with Professor James Bain, Associate Department Head for Academic Affairs, or Coraluppi Head and Tanoto Professor Larry Pileggi, the Department Head. Beyond the department all graduate students can communicate their concerns to Professor Lisa Porter, Associate Dean of Graduate and Faculty Affairs.

Faculty Credentials

For all faculty please visit the ECE faculty directory here:

https://www.ece.cmu.edu/directory/faculty.html.

Faculty based in Silicon Valley and teaching in Silicon Valley:

Cecile Peraire, Associate Teaching Professor
Ph.D., Computer Science, Swiss Federal Institute of Technology

John Shen, Professor
Ph.D., Electrical Engineering, University of Southern California

Leonardo da Silva Souza, Assistant Teaching Professor
Ph.D., Computer Science, Pontifícia Universidade Católica do Rio de Janeiro

Rafal Wlodarski, Assistant Teaching Professor
Ph.D., Lodz University of Technology

Faculty based in Pittsburgh and broadcasting courses to Silicon Valley:

Lujo Bauer, Associate Professor
Ph.D., Computer Science, Princeton University

Hakan Erdogmus, Teaching Professor
Ph.D., Telecommunications, Université du Québec

Franz Franchetti, Professor
Ph.D., Computational Mathematics, Vienna University of Technology

Virgil Gligor, Professor
Ph.D., Electrical Engineering and Computer Science, University of California at Berkeley

Limin Jia, Associate Research Professor
Ph.D., Computer Science, Princeton University

Bill Nace, Teaching Professor
Ph.D., Electrical and Computer Engineering, Carnegie Mellon University

Aswin Sankarayaranan, Associate Professor
Ph.D., Electrical and Computer Engineering, University of Maryland

Vyas Sekar, Associate Professor
Ph.D., Computer Science, Carnegie Mellon University

Osman Yagan, Associate Research Professor
Ph.D., Electrical and Computer Engineering, University of Maryland

Graduate Studies Committee (GSC)

The Graduate Studies Committee is a committee consisting of ECE faculty and ex-officio administrators from the Student and Academic Affairs Office. The Graduate Studies Committee meets throughout the academic year to address student petitions, discuss program policies, and to approve and assign doctoral qualifying exams.

The GSC Chair for the 2024-2025 academic year is Professor Rohit Negi. Students should ask their academic advisor when this semester's GSC meetings take place.

Bulletin Boards

Students in Silicon Valley can find bulletin boards located in Buildings 23. Bulletin boards will be cleared on a regular basis.

Shipping & Receiving

Students on the Silicon Valley campus should work with their instructor if supplies are needed.

Computer Clusters

There are no computer clusters available in Silicon Valley. There are several remote access computer clusters located in the ITS Cyert Hall machine room via the Pittsburgh campus.

Printers

Printers https://www.cmu.edu/idplus/services/printing.html are provided for student academic use.

Printers: Printers are for use in the hallway in B23 outside of 109/110. Instructions for adding printers and policies are posted next to each printer.

Keys

The Silicon Valley Facilities department will provide each Master student with relevant keys to B23 meeting rooms. To avoid any financial implications to you, keys must be returned prior to your final departure from CMU. To report a lost key or to request a replacement, please email facilities@sv.cmu.edu.

Graduate Student Lounges

There are several spaces for students in Silicon Valley to use. The main student lounges (open spaces) can be found in B23, downstairs Room 129, and CMIL. To see the full list of rooms and spaces, please see here: https://sv.cmu.edu/information-center/campus-resources/rooms-and-spaces.html.

Department Office/Building Security, Repairs and Services

Any damages, repairs, or security concerns should be reported to Stacy Marshall, Facilities and Events Manager, by emailing facilities@sv.cmu.edu. In an emergency, please contact NASA Police at 650-604-5555.

General Silicon Valley Facilities Description

The Silicon Valley campus is located in the historic Shenandoah Plaza on the NASA Ames Research Park. We occupy one building – building 23. Building 23 is a 20,111 sq. ft. two-story historic building and is our main administrative and teaching building. It largely houses our academic space: 6 classrooms, 31 faculty and staff offices, 6 conference rooms, 2 kitchen/break rooms, 1 cafe lounge, and 1 multi-function lounge & event space. Located in the annex of Building 23 is the Carnegie Mellon Innovations Lab (CMIL), a 1,247 sq. ft. multi-use space.

Local housing

The CMU campus in Silicon Valley does not offer on-campus housing or off-campus housing services. Students need to find their own housing. There are many apartment complexes and/or room rentals within a commutable distance from the campus. Housing costs vary and most students choose to have roommates. View a range of housing prices in the Mountain View area.

While our student affairs office cannot act as a real estate agency or rental broker for you, we are happy to offer our advice or suggestions on locations that may be of interest to you. For questions, please contact the Assistant Dean of Student Affairs at student-services@sv.cmu.edu.

ECE Graduate Student Organizations

- EGO (ECE Graduate Student Organization) organizes academic and social events throughout the academic year.

For more information on graduate student organizations and opportunities for future involvement in the ECE department, please contact Brittany Bristoll, Student Organizations Advisor in Silicon Valley.

Press & Media Relations

Kimmy Nguyen acts as the point-of-contact between news media and the ECE Department, including faculty, students, and staff. Kimmy can also provide guidance on internal and external relations and can assist with publicizing programs, projects, events, and other ECE affiliated activity. Students should contact the department head's office with any questions related to the use of ECE brand and logos.

University Library

Silicon Valley Campus

Library and Resources CMU-SV does not operate a library on campus, but we do have specialized library resources available for students, faculty, and staff. However, the CMU Library (https://www.library.cmu.edu) offers many online resources. Additional resources include:

1. Interlibrary Loan
2. e-book developments
3. University Libraries Quick Links

Through the Interlibrary loan, students can request books, articles from journals and conferences, technical reports, or other materials to be sent to you. The materials may be from Carnegie Mellon libraries in the U.S. or other institutions worldwide. Electronic delivery for many articles is available. ILLiad is the system that our students use to request these items. What ILLiad can be used for:

- To request to borrow a book, a tech report, a thesis, copy of an article, etc.
- Check status of requests
- Edit requests
- Cancel requests
- Update your contact information or delivery preferences
- Request to renew an interlibrary loan

The ILLiad link can be found at https://illiad.library.cmu.edu/illiad/illiad.dll.
The first time you use the link you need to provide information about yourself. You only need to do this once. When completing the form, choose these options:

- For **Mailing Address**, state: **Silicon Valley campus**
- For **Delivery Location**, state: **E&S Library**

Ebook developments can be found on our website at http://guides.library.cmu.edu/svc.

A digital collection of science and engineering reference books. Carnegie Mellon Users Only (including Silicon Valley Campus). Our access to their new collection on Computer Hardware Engineering is now available! You'll also find the books listed in CAMEO - our online catalog.

University Quick Links can also be found on the website at http://guides.library.cmu.edu/svc. Here are examples of some quick links below:

- Articles & Databases
    - Alphabetical and subject listings of our available databases.
- Cybersecurity
- e-Journals A to Z List
    - Our automated (partially) method of finding e-Journals that we have access to - even if buried in a full-text database.
- ECE Library Guide
    - Library research guide for Electrical & Computer Engineering.
- Off-Campus / Wireless Access
    - EZ Proxy single sign on added as an option!
- University Libraries Home Page

Our home page has links to the simple and advanced search functions for CAMEO - our online catalog.

For additional questions regarding library resources, please contact Matt Marsteller, Head, CMU Science Libraries at matthewm@andrew.cmu.edu or by phone: 412-268-7212

PRE-MATRICULATION

Admissions Policies

For information about ECE's admission policies, including application requirements, application deadlines, and a link to apply, please visit these webpages:

- https://www.ece.cmu.edu/admissions/graduate-application-deadlines.html
- https://www.ece.cmu.edu/admissions/graduate-faq.html

English Language Requirements and Language Proficiency

Admission to Carnegie Mellon University graduate programs requires demonstration of completed, relevant undergraduate degree programs, as demonstrated by an original transcript from the degree-granting institution during the admission process. Domestic students who graduate from an accredited college or university in the US have demonstrated their English language facility and skill by their success and graduation from competitive undergraduate US institutions.

The DET, TOEFL or IELTS test is required of all international applicants whose native language is not English. Native language is defined as first language, or language spoken from birth. Language tests are not required if the applicant has graduated from a U.S. university or if the applicant is a CMU student or alumni. Please refer to the admissions FAQ for additional details.

Non-native English speakers may utilize Communications and Language Services Office for additional language support for nonnative English speakers: http://sv.cmu.edu/student-services/communication-language-services.html

Deferral

ECE generally does not allow admission deferrals because admission decisions are based on the current applicant pool. Therefore, students are admitted into the program for a particular semester only. If a student wishes to attend in a future semester, the student must reapply to the ECE program.

Integrated Master and Bachelor students (IMBs) will be permitted to take up to a two year deferral between their bachelor's degree and their master's degree only if they have completed a minimum of 24 units towards their master's degree at the time of their undergraduate graduation.

Final Undergraduate Transcripts

Applicants admitted to any ECE program (except for CMU alumni) must submit final official transcripts, properly sealed, upon completion of their undergraduate program from the institution conferring their degree as a condition of enrollment at Carnegie Mellon. Certificates of graduation and/or degree certificates should also be submitted if provided by the institution. Failure to provide such documents that confirm the completion of undergraduate requirements by the end of the first semester of study at Carnegie Mellon may prevent the MS degree from being certified.

Residency

MS programs in the Department of Electrical & Computer Engineering are in-person programs with required in-person expectation coursework. US Government rules require this of any program admitting F-1 and J-1 international students. At present there are no online or remote offerings of the MS programs.

For international students, access to individual remote courses is governed by the policies of the OIE: https://www.cmu.edu/oie/maintaining-status/students/course-load-modality.html

Responsible Conduct of Research (RCR) Education

The Office of Research Integrity and Compliance website (https://www.cmu.edu/research-compliance/index.html) describes the university's position on ethical research: "Carnegie Mellon University promotes the responsible conduct of research through high standards of ethics and accountability in planning, conducting and reporting research. The responsible conduct of research is demonstrated through behavior that meets generally accepted standards. These standards are set forth by state and federal regulations, institutional policies, professional codes of conduct and personal convictions."

In support of the university's position, ECE requires **all incoming students** to take the appropriate online training offered by the Collaborative Institutional Training Initiative (CITI). The CITI physical science module package is recommended rather than the module package for engineers, although both are acceptable. The courses are available via CITI through the Office of Research Integrity and Compliance website. Students should select Carnegie Mellon University as the participating institution when creating an account. Website: https://www.cmu.edu/research-compliance/responsible-conduct/training.html

The course(s) may take a few hours to complete but can be done over a period of time. Upon completion of the course(s), students will need to provide their certificate to the advising team. Instructions on how to submit this certificate are communicated prior to the beginning of the semester.

ENROLLMENT AND REGISTRATION

Overview

After matriculating into ECE, students should create an academic plan and register for courses. Students should actively engage in this process by reviewing degree requirements on the website and connecting with their academic advisor and faculty mentor. Once plans are firm, students can proceed by accessing Student Information Online (SIO).

SIO is an important online tool to use during the registration process, as well as throughout graduate school. Students can access SIO with their Andrew ID at The Hub.

Within SIO, students can use the Course Planning module to view and modify their proposed schedule before registering for courses. Once a schedule is developed, it is the student's responsibility to register for courses using their SIO. Students must be registered for every course that they plan to take for the semester, even if it is not taken for credit (e.g. audited courses).

After the first semester, a student's assigned registration time is determined by the number of completed units and cannot be changed. If a student's tuition balance and/or fees are greater than $0.00, the student will not be able to register until the balance is cleared.

Degree Progress and Planning

Student Responsibility

It is the sole responsibility of the student to manage the academic progression of their program. Students are expected to ensure that they are taking the necessary prerequisites and courses to complete degree requirements on time. Students have the ability to add courses, drop courses, and select units for variable unit courses through SIO. It is the students' responsibility to be aware of all academic deadlines, including the add deadline, the drop deadline, the pass/no-pass deadline, and the audit deadline. Academic deadline information can be found in the Academic Calendar: https://www.cmu.edu/hub/calendar/index.html

If a student is not progressing as expected, they are expected to seek advice and counsel from their academic advisor. If the student is concerned that they are unable to complete degree requirements, they should contact their academic advisor for assistance.

Degree Requirements Timeframe

The duration of all ECE MS programs for students starting the program in Spring 2020 or prior is three full-time semesters (fall-spring-fall or spring-fall-spring). Students matriculating in Fall 2020 through Spring 2023 can choose to join the Standard or Applied programs for 3 full-time semesters or the Advanced Study or Applied Advanced Study programs for 4 full-time semesters. Students matriculating Fall 2023 or later can choose to join the Standard program for 3 full-time semesters or the Advanced Study program for 4 full-time semesters. Students applying to the Artificial Intelligence in ECE or Software Engineering degree programs are expected to complete their degree requirements in 3 full-time semesters. In order to have full-time status, students must enroll in at least 36 units each semester. In order to complete program requirements, students may need to enroll in more than 36 units per semester. The maximum number of units allowed in a semester is 48 units. Students are responsible for completing their enrollment each

semester via their Student Information Online (SIO) portal. Students who are not enrolled by the add deadline will be withdrawn from the university.

Students must be physically present and attend classes at the start of the semester. If extenuating circumstances exist that prevent a student from attending class, a student must notify the academic advisor and instructors immediately. Not attending class from the start of the semester will have a detrimental effect on a student's progress in the program. ECE will make an effort to verify all students have arrived to begin their program and will consider a student as "withdrawn from the university" if they are not here by the add deadline as stated in the academic calendar.

International students will be given a 16 month I-20 or DS-2019. International students must consult with CMU's Office of International Education (OIE) for questions on extension of their visa documents or if they complete their degree requirements in fewer than three semesters. Please see details and relevant forms on OIE's website under Maintaining Legal Status: https://www.cmu.edu/oie/foreign-students/maintain-legal-status/index.html

Summer Registration

Students who matriculated prior to Fall 2023 in the Applied or Applied Advanced Programs are required to complete a summer internship in their first summer semester of the program. In any subsequent summers in the Applied or Applied Advanced Programs, and for any summer semester(s) in the Standard or Advanced programs, students are not required to continue their studies as the summer semester is considered a vacation semester. However, students may choose to take courses for academic credit or pursue an internship that is relevant to their MS degree if appropriate.

Eligible international students who are completing an internship in the United States must complete the paperwork for Curricular Practical Training (CPT). Academic and OIE advisors will provide students with information about CPT during the spring semester. For more information about internships and CPT, see the "Internship" section outlined in this handbook and OIE's website on Employment Options for international students: https://www.cmu.edu/oie/foreign-students/employment.html

Full- and Part-time Requirements

The MS degree program is a full-time program in which students complete a minimum of 36 units each semester (including summer if summer is a student's final semester). Students who are interested and qualified may take an accelerated course load and complete the degree in two semesters; these students should consult with their primary academic advisor.

For international students, part-time master's enrollment requires an approved Authorization for a Reduced Course Load from the Office of International Education. International students must work with their academic advisor to submit an Authorization for a Reduced Course Load form https://www.cmu.edu/oie/docs/reduced.pdf. Such authorization is granted only in extenuating circumstances. Please note: due to the structure of the MS programs in the Department of Electrical & Computer Engineering, the fourth selection on this form (Student's Final Semester) is not an option. Immigration regulations do not allow CMU to issue visa documents for a part-time program.

For domestic students, part-time master's enrollment in any non-terminal semester must receive departmental approval. Departmental approval requires submission of a detailed degree plan and is only granted in extenuating circumstances.

Campus Location Change

Students enrolled in the ECE Master's program at the Pittsburgh, Silicon Valley, or CMU-Africa locations may be eligible to request a change in residence to another campus after completing one semester of full-time study. Eligibility is determined by the details included in the student's admission offer and is explicitly stated in the admission offer letter. Due to limited space, location changes are not guaranteed and are subject to the discretion of the department. Students are responsible for all academic and financial impacts related to this change. Information about the location change process will be provided to eligible students.

International student internship eligibility will not be affected if students change location between Silicon Valley and Pittsburgh campuses. Location changes between U.S.-based campuses and CMU-Africa will have implications for internship eligibility for international students. Students should refer to OIE's website for employment options and consult with their OIE advisor for additional questions: https://www.cmu.edu/oie/foreign-students/employment.html

Change of Degree Program

Sometimes students begin their ECE master's program (M.S. ECE, M.S. AIE-ECE, or M.S. SE) and realize that they would like to transfer to a different degree program than the one they were admitted to. When this occurs, students may have the option of applying to transfer to another M.S. degree program within the ECE Department. Transfers may be possible from MS AIE-ECE or MS SE degree programs to the MS ECE degree program. Transfers from the MS ECE degree program to the MS AIE-ECE or MS SE degree programs require admission. Students must meet with their academic advisor to determine if this is possible. Information about the degree change application and process will be provided to the students at that time. All degree program change applications are reviewed by the ECE Admissions Committee and are subjected to the same admission standards as initial applications to the program. Program changes are not guaranteed. In the case where a program change will also result in a campus location change, students are subject to the same policies outlined in the Campus Location Change section in this handbook.

Students are not eligible to change degree programs until after they have successfully completed 36 units at CMU, and all applications will be considered for the following semester. Students are responsible for all academic and financial impacts related to the change. Prior to changing to a new M.S. degree program, international students should consult with OIE.

Changing between the MS ECE Standard, Applied, Advanced, or Applied Advanced programs is not allowed at any time. Similarly changes between MS SE Standard and Applied programs is not allowed at any time. Students will select their program upon acceptance of their admissions offer and must remain in their declared program until degree completion.

Internal Transfer to another Graduate Department within CMU

Students wishing to transfer to another graduate department within Carnegie Mellon University should consult with the admission staff of the intended transfer department for policies and procedures related to the potential transfer. Students should also alert their academic advisor regarding their intention to transfer. ECE shall share any necessary application materials (test scores, transcripts, recommendations, etc.) upon written request of the transferring student.

Courses Outside of Degree Requirements

Courses that do not satisfy degree requirements include StuCo courses (98-XXX), Physical Education course (69-XXX), audited courses, and pass/no-pass courses. Similar to courses taken for degree requirements, students must register for these courses and the units will count towards their course load for the semester. For a complete list of course restrictions, see the ECE website: https://www.ece.cmu.edu/academics/ms-ece/requirements.html.

Double Counting Courses

ECE follows the CIT Policy on double counting of courses. Students are required to notify the advising team prior to declaring a degree outside of ECE as this may have repercussions for units and coursework to date. Website: https://www.cit.cmu.edu/education/academic-policies/graduate-policies/registration-grading-credit.html#double-counting-of-course-units-for-m.s.-and-ph.d.-degrees

The same course taken two separate times will not count towards the ECE M.S. If a student takes the same course twice, only the course with the higher grade will be counted towards the ECE M.S. course requirements.

Maximum Units Allowed

Students who are pursuing the MS degree cannot register for their final semester if they have already completed 120 units (for a 3-semester program) or 156 units (for a 4-semester program) of coursework. These units include courses taken for audit or pass/no pass, and courses from which the student withdrew. Please refer to the CIT policy on MS degree units for additional information.

If it becomes clear that a student will exceed the maximum units and not be able to maintain the required 3.0 average, the student may be dismissed from the MS ECE, MS SE or MS AIE-ECE program.

Maximum Units Allowed Outside CIT

Students enrolled in a 3 semester MS ECE, MS SE, or MS AIE-ECE degree at all campuses may take no more than 12 units outside the College of Engineering towards meeting their degree requirements. Students enrolled in a 4 semester M.S. ECE degree may take no more than 36 units outside the College of Engineering towards meeting their degree requirements.

Courses will satisfy requirements based on the course number during the semester of registration. If a course number that is outside of CIT changes to be within CIT, the change will not be retroactive and the course will still qualify as being outside of CIT for all past semesters.

Retaking Courses

If a student does not pass a course, they should take a different course to fulfill the requirement. If a student is considering retaking a course, they should contact their academic advisor. Students may retake a prerequisite course in which they did not receive the minimum grade required to continue in a course sequence.

All grades are recorded on the transcript and factored into the cumulative QPA. However, only the best 97 that fulfill degree requirements are factored into the required 3.0 program QPA.

Auditing Courses

Auditing a course is registering for the course and being present in a classroom, without receiving academic credit or quality points. An audited course will appear on a student's transcript. Students may not regularly attend a course for which they are not registered.

A student who wants to audit a course is required to:

1. Register for the course in SIO.
2. Obtain permission from the instructor and ask the instructor to sign the course audit approval form: https://www.cmu.edu/hub/docs/course-audit.pdf
3. Submit the form to their academic advisor for approval.
4. If approved, the academic advisor will send the form to the HUB for processing.

Once a course audit approval form is submitted to the HUB, a letter grade ('A'-'R') will not be assigned for the course and the declaration cannot be reversed. Students can find the deadline for submitting this form on the Academic Calendar. After the deadline, students are not able to request the option to audit a course.

The extent of the student's participation must be arranged and approved by the course instructor. Typically, auditors are expected to attend class as though they are regular class members. Those who do not attend the class regularly or prepare themselves for class will receive a blank grade. Otherwise, the student receives the grade 'O', indicating an audit.

The units of audited courses count toward the maximum course load units, but do not count toward the degree requirements. If an audited course is outside the College of Engineering (CIT), those units count towards the limited units MS ECE students may take outside CIT. Any student may audit a course. For billing, an audited course is considered the same as traditional courses for tuition charges. If a part-time student audits a course, he/she will be charged part-time tuition based on the per-unit tuition rate for the course.

Pass/No Pass Courses

Students who wish to take a course pass/no pass are required to register for the course and submit the pass/no pass approval form (https://www.cmu.edu/hub/docs/pass fail.pdf) to their academic advisor for approval. If approved, the academic advisor will send the form to the HUB for processing.

Once a pass/no pass approval form is submitted to the HUB, a letter grade ('A' 'R') will not be assigned for the course and the declaration cannot be reversed. Passing work (letter grade 'A'

'C') is recorded as 'P' (passing grade) or 'S' (satisfactory) on the student's academic record, with both grades meaning the same thing. Work with a grade at or lower than 'C ' will not receive credit and will be recorded as 'N' (not passing grade) on the student's academic record. No quality points will be assigned to 'P'/'S' or 'N' grades; the units of 'P'/'S' or 'N' grades will not be factored into the student's semester, cumulative or program QPA.

The units of pass/no pass courses count toward the maximum course load units, but do not count toward the degree requirements. Students can find the deadline for submitting this form in the Academic Calendar. After the deadline, students are not able to request to take a course as pass/no pass.

Any student may take a course as pass/no pass. For billing, the course is considered the same as traditional courses for tuition charges. If a part time student takes a course pass/no pass, they are charged part time tuition based on the per unit tuition rate for the course.

COVID-19 Pass/No Pass Rule Exception

In response to the COVID-19 pandemic, the Provost's Office and Senior Leadership created a temporary modification to the grading policy for spring 2020. These changes were for the spring 2020 semester only and were made due to the impact of COVID-19. All undergraduate and graduate students were permitted to convert any spring 2020 semester-length or mini-4 course final grade to pass/no pass during the Special Pass/No Pass Election Period. Any course grade converted to passing in spring 2020 is eligible to count towards the MS degree.

Petition Process

Petitions to the Graduate Studies Committee (GSC) may include program changes or transfers, course substitutions, and any other changes outside of the policies stated in the handbook. Petitions are considered by the GSC for approval or denial. Students are advised to discuss petitions with their academic advisors.

The petition process is as follows:

1. Student completes the GSC Petition form (https://forms.gle/yeqdeHvkWp5gLhRe8) and notifies their academic advisor of their submission no later than 5pm EST on the Friday before a GSC meeting.
2. Academic advisor presents the petition to the GSC.
3. Students are notified of the outcome of their petition via an email from their academic advisor after the GSC has met. Generally, all GSC decisions are final.
4. Due to time constraints, some petitions may be tabled until the following GSC meeting. If this occurs, students will be notified via email.
5. Academic advisor saves a finalized version of the petition.

Course Transfer Request Policy and Process

Only one graduate-level course, or the equivalent of 12 units, can be transferred from another university as credit toward the degree requirements of any of ECE's MS programs. As a guideline, 3-credit courses from other universities equate to 9-unit CMU courses; a 4-credit course equates to a 12-unit CMU course.

The course being transferred in must:

- Fulfill an ECE degree course requirement and be equivalent to a CMU course
- Be considered a graduate level course at the university where it was taken (unless requesting transfer credit for the one allowed undergraduate course)
- Have not been used to fulfill requirements for any previously earned degree

Please note that this policy is more restrictive than the CIT transfer credit policy (https://www.cit.cmu.edu/education/academic-policies/graduate-policies/registration-grading-credit.html#transfer-credit-&-special-students). The student must have earned a grade of 'B' or better for the course to be transferred. The transfer credits will appear on the student's transcript and will not be factored into the cumulative or program QPA.

Transfer credit is not granted prior to admission and must be approved by the Graduate Studies Committee and CIT Dean's Office. Courses can only be requested for transfer after the student has successfully completed 36 units of coursework at CMU. After matriculating to CMU, ECE students should consult with their academic advisor before taking a course at another university with the intention of transferring it to the ECE degree.

Transfer courses will be reviewed for academic rigor and alignment with courses offered in ECE. The course description and syllabus, learning outcomes, delivery mode, and institutional accreditation will be considered when evaluating the course for transfer.

The process for requesting to transfer a course is as follows:

1. Meet with academic advisor to discuss the course transfer.
2. Complete and collect the following mandatory documents:
    a. Official transcript from previous institution
    b. Detailed course description/syllabus (should include grading scale, assignments required, mandatory books, and time required in class) of the course the student wishes to transfer
    c. Letter from the previous institution's registrar or academic advisor stating the course intended for transfer was not used towards a degree
    d. Email endorsement from the instructor of the CMU course the student believes the desired transfer course is most equivalent to
    e. CIT Graduate Transfer Credit Request form: https://engineering.cmu.edu/_files/documents/graduate-students/grad_transfer_credit_request.pdf
3. Submit the completed packet to the academic advisor via the online petition form (https://forms.gle/yeqdeHvkWp5gLhRe8).
4. The academic advisor will share the petition with the ECE Graduate Studies Committee.
5. If the petition is approved, the academic advisor will work with the student to complete the transfer request.
6. The academic advisor will present the transfer request to the CIT Dean's office and notify the student of the result.

ECE has not entered into an articulation or transfer agreement with any specific college or university. The transfer of credits from any college or university must follow the above policy and process. Additionally, ECE does not award credit for prior experiential learning.

Research for Credit

MS ECE students matriculating spring 2020 and prior can apply up to 27 units of research credit towards their MS degree requirements by registering for the MS Graduate Project course.

MS ECE students matriculating fall 2020 and later, and who select the course option, may only count 12 units of MS Graduate Project toward the core Graduate Coursework requirement. Up to an additional 15 units of MS Graduate Project can be counted toward the CIT Elective requirement, for a maximum of 27 units of research credit.

MS ECE students matriculating fall 2020 and later, and who select the project option, will be required to complete 36 units of research credit.

MS SE students can apply up to 27 units of research credit towards their degree requirements.

MS AIE-ECE students may only count 12 units of MS Graduate Project toward the core Graduate Coursework requirement via a domain specific research project approved by the department. Up to an additional 15 units can be counted toward the CIT Elective requirement, for a maximum of 27 units of research credit.

The number of research units for which a student is registered should equate to the number of hours students will complete each week. For example, 12 units of research means the student should complete 12 hours of research each week. Alternative accommodations should be worked out with the supervising faculty member.

MS Research Approval Process:

- As a student in the ECE department, you are able to view and apply for available research projects electronically, through the Student Project Tracker (SPT) system (https://www.ece.cmu.edu/apps/spt/). New students gain access to the system by the first day of classes in their first term of enrollment.
- Students can view the details of available research projects and submit applications.
- Student applications will be reviewed by the research instructor(s) to whose projects the student applies. Applications may also be reviewed by third parties working with or who may be interested in working with students on research projects, or with the research instructor(s) on a research project. This may include third party industry or government collaborators or sponsors of research projects. Students will be contacted by the research instructor (or someone from the research instructor's lab) if there is interest in their application.
- The research instructor will inform the student's academic advisor through the SPT system if an application is approved, and the academic advisor will register the student for the appropriate research units. Students will be registered for 18-980/18-981/18-982 based on the units reflected in the SPT system.

- If a student has already made plans to work on a research project with a faculty member, the project still needs to be created in the SPT system. Students must apply and be accepted by the faculty through this system.
- If a student is planning on conducting research with a non-ECE faculty member, the project must still be posted in the SPT system. The student and/or the research instructor must find an ECE faculty member who is willing to be a co-instructor for the project.

Registering for Courses

Academic Calendar

The Academic Calendar can be found at https://www.cmu.edu/hub/calendar/ and provides information on all deadlines, including registration dates, class start dates, add/drop deadlines, exam dates, and more. ECE adheres to the official CMU academic calendar. The Heinz College and the Tepper School (https://www.cmu.edu/tepper/academic-calendar.html) follow their own calendars with dates that may differ from the University's calendar for the add, drop, and pass/no pass/audit deadlines. ECE students must adhere to the deadlines set by the unit offering the courses for which they are registered. Some ECE graduate classes are offered to students in CMU-Africa and the United States with differing official holidays. These courses will prominently display exceptions to the official University calendar in the course schedule.

Stellic Degree Audit

Each student has access to the Stellic Degree Audit Application which includes degree planning tools that can show how courses, planned or scheduled, meet the degree requirements. Students can access Stellic through The Hub website at https://www.cmu.edu/es/stellic/index.html. Students should also meet with their academic advisor to review how their courses apply to the degree requirements.

Course Load

Due to the rigor of the ECE programs, students are advised to take 37 units of coursework in their first semester (36 units of coursework plus 18-989, Introduction to Graduate Studies) and 36 units of coursework each semester thereafter. However, the department recognizes that our student body is diverse, and that includes how each student handles their course load. While students may register for up to a maximum of 48 units each semester, we strongly recommend students take no more than 36 units each semester. Students unsure of whether they should take 48 units should schedule an appointment with their academic advisor to discuss their reasons for overloading and prepare a plan for handling the additional load.

IMB students in graduate status may request an overload if the four courses they opt to take exceed 48 units. In order for the overload to be considered, the following conditions must be met: 1) the overload request is only for four courses whose combined unit total exceeds 48, 2) as an undergraduate student, the IMB student overloaded in at least one semester and achieved a minimum QPA of 3.5 during that semester, and 3) the IMB student earned a minimum cumulative QPA of 3.75 in their undergraduate degree.

Adding Courses

Students can refer to the published Schedule of Classes for a list of classes being offered each semester. Students have the option to add courses to their schedule through SIO starting at their initial assigned registration time and ending at the add deadline. If a student wishes to be added to a course after the add deadline, the student must complete a Course Add Request Form (https://www.cmu.edu/hub/docs/late-add.pdf). If approved and signed by the course instructor, and providing that there is space in the desired course, the student must then submit the form to their academic advisor for approval. If approved, the academic advisor will send the form to the HUB for processing.

In the event that an ECE course (18-XXX) is crosslisted with a course from another department, ECE students must register for the ECE course number.

ECE students may be able to take courses in the Tepper School of Business and can register through Tepper's system, which is separate from SIO. Tepper publishes a list of available MBA courses for non-MBA students, and in order to register, students should visit the Tepper registration site: https://www.cmu.edu/tepper/programs/mba/curriculum/mba-course-requests/carnegie-mellon-graduate-students.html

Students taking undergraduate and master's level courses must follow the procedures and deadlines for adding, dropping, or withdrawing from courses as identified on the academic calendar. Information can be found at https://www.cmu.edu/hub/registrar/course-changes/index.html. There is a separate calendar for designated doctoral-level courses.

Course Locations

Courses will take place in various buildings and room locations across CMU campuses as assigned by the University Registrar's Office each academic semester. Some ECE courses are broadcast between different campus locations. Students may only register for courses offered in their program location as indicated in the official Schedule of Classes.

Dropping Courses

Students have the option of dropping courses from their schedule through SIO starting at their assigned registration time and ending at the drop deadline (see Academic Calendar). When a course is dropped before the drop deadline, it does not appear on the transcript. As a courtesy to others, students should drop a course as soon as they decide not to take it. This will likely allow another interested student to be enrolled and will limit disruptions to any team-based projects. If, as a result of dropping a course, a student drops below the 36 unit full time requirement, the student should discuss their overall plan with their academic advisor (see Full- and Part-time Requirements section).

Withdrawing from Courses

Students should remove themselves from a course before the drop deadline each semester. If a student chooses to leave a course after the drop deadline, the student must officially withdraw from the course and should consult with their academic advisor to discuss the withdrawal. Withdrawals may take place after the drop deadline up through the course withdrawal deadline. Students must complete and submit the Course Withdrawal Request Form

(https://www.cmu.edu/hub/docs/course-withdrawal.pdf) with their academic advisor in order to withdraw from a course. More information on withdrawal grades can be found on the CMU policy website under the grading policy (https://www.cmu.edu/policies/student-and-student-life/grading.html). Course withdrawals result in a "W" grade on the transcript, which is not factored into the QPA. However, withdrawn courses do count towards full-time status and the maximum 120 or 156 units and, if they are outside of the College of Engineering (CIT), towards the limited units students may take outside the College of Engineering (CIT).

Waitlists

It is typical for students to be on one or more waitlists at some point between the time of registration up until the add deadline. Waitlists may form for a variety of reasons, including as a common practice to ensure that students within a department have the opportunity to take the courses they need to graduate. To determine the likelihood of being registered from a waitlist for an ECE course, ECE students should email ece-waitlists@andrew.cmu.edu.

Once the semester begins, students may only attend courses for which they are registered, but may contact the instructor(s) of a course for which they are waitlisted to inquire about keeping up with class material. Being waitlisted for a course is not a guarantee that a student will eventually be enrolled. Students may only be waitlisted for a maximum of 5 courses.

If a student clears a waitlist but registering for the course would create a scheduling and/or max unit conflict, then the student will receive a timed invitation via email to resolve the conflict(s) and enroll in the course. The invitation window shrinks as the Add Deadline approaches, to a minimum of 24 hours. It is very important for students to monitor their university email at all times during the registration period. If an invitation expires, the student will be removed from the waitlist, and their prior waitlist position cannot be restored. Invitation windows cannot be extended.

As a courtesy, students should remove themselves from the waitlist and/or drop a course in which they are no longer interested in a timely fashion, so as to allow other students the opportunity to be removed from the waitlist and enrolled in a course.

Students should check their schedules frequently on SIO as they may be enrolled from a waitlist without being notified. In addition, during the registration process, the Registrar's Office will require students to "tag up" on their waitlists in order to confirm the desire to remain on the waitlist for a course. Failure to confirm a waitlist will result in being dropped from the waitlist, and the previous waitlist position cannot be restored.

It is strongly recommended that students have a back-up plan in case they are not removed from a waitlist by the add deadline.

Course Delivery Modalities

Course delivery modalities refer to how a course is offered by the instructor (i.e., in-person, remote). CMU courses may utilize a variety of course delivery modalities, which are displayed in SIO, the Schedule of Classes, and Stellic for students. Students are expected to adhere to all listed delivery modalities for each course section. Further information about the possible delivery modalities can be found on the Enrollment Services website. International students should be

mindful of visa implications that may accompany registering for courses with remote delivery modalities.

Courses with Time Conflicts

Students are generally not permitted to register for two courses whose scheduled meetings overlap, and will not be able to enroll in a course conflict in SIO. Registration may be possible with consent from both instructors, allowing the conflict and/or making suitable arrangements. Students must forward written permission from both instructors to their academic advisor in order to register for conflicting courses. If there is a pending invitation to enroll in a course from the waitlist, students must complete this process prior to the invitation expiration. Invitation windows cannot be extended.

Prerequisites

For graduate students, a course listed in SIO may have a published prerequisite which is strongly recommended as preparation for the course in question. All prerequisites will be listed and available for view in SIO.

While SIO allows graduate students to register for courses without the published prerequisite, it is the student's responsibility to confirm that they have adequate background knowledge to be successful in the subsequent course. This background knowledge may come in the form of a course taken at CMU or the student's undergraduate institution, or other work or research experience. Students should consult with the course instructor if they have any questions or concerns about their preparation.

For some ECE courses that require 18-613/18-213, the published prerequisite will be enforced for graduate students.

Antirequisites

An antirequisite is a course with content that is so similar to another existing CMU course that a student cannot receive credit for taking both.

For example, 15-513 (Introduction to Computer Systems) and 18-613 (Foundations of Computer Systems) are antirequisites. The content in these courses are so similar that the student would not gain sufficient new knowledge from taking both courses as to be worthy of receiving academic credit. As a result, a student may only receive credit towards their degree for taking one of them. All antirequisites are listed in SIO.

Corequisites

A corequisite is a course that must be taken at the same time as, or before, another course. All corequisites are listed in SIO.

Crosslisted Courses

A crosslisting involves two or more course numbers that are taught or co-taught by the same faculty, at the same time(s), and in the same room(s).

Crosslistings may occur between departments (such as an ECE course crosslisted with a course in the Computer Science department), or within the same department (such as an ECE undergraduate number crosslisted with an ECE graduate number), or both. ECE students are required to register for ECE course numbers, and ECE graduate students will have enrollment priority for ECE graduate course numbers. For ECE graduate course numbers crosslisted with ECE undergraduate course numbers, students enrolled in the graduate number will be expected to complete certain additional and/or more difficult requirements.

Selecting the appropriate section for crosslisted courses is imperative. Undergraduate course numbers (over 300-level) can only be counted as the one allowable undergraduate course toward the MS degree, and ECE graduate students will not receive enrollment priority in ECE undergraduate numbers, even if a crosslisting exists. Non-ECE course numbers do not count toward the ECE core degree requirement even if a crosslisting exists. Non-CIT course numbers count against the maximum allowable non-CIT coursework even if a crosslisting exists. The department(s) reserve the right to adjust a student's course registration as appropriate, which may include being removed from another department's course number and placed on the ECE waitlist.

Final Exams

All CMU students must attend final exams as scheduled by the university or individual course instructors. Each semester's final examination period will be published in the Academic Calendar every semester, and students are expected to avoid making end of term arrangements until the official final exam schedule is published for all courses. The ECE administration does not have control over the university's final examination period schedule. Please refer to Carnegie Mellon University Policies on Examinations and the university's Final Examination Conflict Guidelines for additional information.

Research Assistant & Teaching Assistant Positions

Research Assistant for Credit

See the Research for Credit section for more information about receiving academic credit for research.

Research Assistant for Pay

Students are permitted to pursue research opportunities for pay in any department. Students should contact faculty members individually to inquire about available opportunities and provide information on their background. The supervising faculty can provide further information about payroll procedures.

Teaching Assistant Assignments

Teaching Assistants are a vital part of successful ECE course delivery. All ECE students will receive an email each semester when applications open for the upcoming semester, typically around the date the Schedule of Classes is published. For complete information students can visit the Teaching Opportunities website: https://www.ece.cmu.edu/insider/teaching-opportunities.html. Students are encouraged to communicate with the faculty of any course(s)

they are interested in supporting, who can discuss the course expectations and staffing needs. However, please note that the application and hiring process is entirely managed through ECE's online TAPS system: https://www.ece.cmu.edu/apps/taps/.

Teaching Assistant Training Workshops

https://www.ece.cmu.edu/insider/teaching-opportunities.html

ECE is committed to providing a high level of teaching excellence and ensuring a positive student learning experience. When serving as Teaching Assistants for ECE courses, students are extensions of the department charged with representing these values. Students are therefore required to complete training during the first semester in which they are hired to work as a TA. The TA training is not part of ECE degree requirements but is necessary to serve as an ECE TA. It is also separate from the language certification and language workshops offered by the Student Academic Success Center which may also be required. Once a student has fulfilled the training requirement, participation is not required again. If a student has served as a TA previously but has never completed the training, it will be required before beginning the next ECE assignment. Hired Teaching Assistants will be contacted about the training requirements prior to the start of classes. Students are expected to plan their time accordingly.

Evaluation and Certification of English Fluency for Instructors

Graduate students are required to have a certain level of fluency in English before they can instruct in Pennsylvania, as required by the English Fluency in Higher Education Act of 1990. For more information about requirements, see Evaluation & Certification of English Fluency for Instructors in the University Policies of this handbook.

Enrollment Verifications

The Hub is the primary contact for students or alumni who would like to request a transcript, enrollment verification, or other information related to their time in ECE. Students can visit their website for more information: https://www.cmu.edu/hub/registrar/student-records/verifications/

ECE may verify some limited information in the form of a letter, which may be suitable for some purposes. Students should contact their academic advisor for more information. A common verification request, of skills students acquired through the ECE programs can only be performed by the Hub.

Leave of Absence

Occasionally, students must pause their degree program due to personal, professional, or academic reasons. A student who is considering a leave of absence should speak to their academic advisor prior to taking a leave of absence in order to ensure their understanding of the leave of absence policy and its ramifications.

Leaves of absence are capped at 2 calendar years total throughout the MS program. In extreme cases, a student may request additional leave time via a petition to the GSC.

If the student does not return within two academic years, they will be administratively withdrawn from the graduate program. IMB students who have declared their graduate degree but left CMU after completing their BS degree before having graduate status must also abide by this policy. Any student intending to return to the program outside of the 2-year leave (including CMU graduates with ECE BS degrees who have not declared for the IMB prior to graduation) must reapply to the graduate program. The University Process for taking a Leave of Absence can also be found at https://www.cmu.edu/hub/registrar/leaves-and-returns/index.html.

Once a student decides to take a leave of absence, they should complete the Leave of Absence form (https://www.cmu.edu/hub/docs/loa.pdf) and bring it to their academic advisor for additional processing.

Returning from a Leave of Absence

A student intending to return from leave must submit the Petition to Return from Leave of Absence form (https://www.cmu.edu/hub/docs/return-loa.pdf) to their academic advisor at least 30 days prior to the start of the semester in which they plan to return. A student's return must coincide with the start of a new semester (fall, spring, or summer). Students cannot return from a leave of absence mid-semester, with the exception of summers. International students who wish to return from leave in a summer term must register full time for that summer term.

Per the university policy on student leaves: "Students on leave are not permitted to live in university housing, attend classes, or maintain employment as students at Carnegie Mellon while their leave is in effect" (https://www.cmu.edu/policies/student-and-student-life/student-leave.html).

More information about the University's Leave of Absence and Withdrawal policies can be found here: https://www.cmu.edu/hub/registrar/leaves-and- withdrawals/.

Degree Certification Process and Commencement

A student must satisfy all degree requirements and achieve a minimum of 3.0 QPA in the courses applied towards the required 97 units to be eligible for degree certification. In addition, students must have provided a final copy of their undergraduate transcript(s) and must have a tuition balance of $0.00 to receive a diploma.

Once a student completes their degree requirements, their degree must be certified. Certification will occur regardless of whether or not a student has taken their maximum allowed units.

Carnegie Mellon Commencement only occurs at the end of spring semester. ECE holds a diploma ceremony at the end of spring semester as well. Students who are certified in the summer or fall semesters are invited to attend the next commencement ceremony. Spring graduates are invited to the spring commencement ceremony.

Before graduation, students should update their contact information, such as mailing address and e-mail address, within SIO. Also, students should review a proxy of their diploma in SIO to verify the information displayed there, such as the spelling of their name. Degree titles are listed above in the section titled Graduate Degrees and Programs Offered.

ACADEMIC STANDARDS

Grades

CIT Grading Policy

ECE follows the CIT letter grade scale. The letter grade scale is 'A' (highest for CIT students), 'A-', 'B+', 'B', 'B-', 'C+', 'C', 'C-', 'D+', 'D', and 'R' (lowest). CIT students cannot receive an 'A+' grade on their transcript, even if a course was taken from another college where 'A+' is given. Grades lower than 'C', meaning 'C-' or below, are considered failure in CIT and will not count toward degree requirements. For more information, please see CIT's website: https://engineering.cmu.edu/education/academic-policies/graduate-policies/registration-grading-credit.html

Incomplete Grade

Incomplete grades may be assigned at the discretion of the course instructor, per the university grading policy: https://www.cmu.edu/policies/student-and-student-life/grading.html. Students should expect to establish a mutually agreed-upon plan for the completion of the remaining coursework with the course instructor. Typically, incomplete grades will only be considered if 75% or more of the coursework has been completed to date, and has been of passing quality. Students must complete the required coursework no later than the end of the following academic semester, or sooner if required by prior agreement. Students who receive an 'I' (for 'Incomplete') grade will also be given a stated default grade. The default grade will be automatically posted to the transcript if the deadline to resolve the Incomplete grade passes without the student completing the agreed-upon work.

Withdrawal Grade/Withdrawing from Courses

Students can withdraw from a course after the drop deadline until the course withdrawal deadline. This will result in a 'W' on the transcript, which is not factored into the QPA. To withdraw, the course withdrawal request form (https://www.cmu.edu/hub/docs/course-withdrawal.pdf) must be completed and submitted to the academic advisor for approval. If approved, the academic advisor will send the form to the HUB for processing.

For the process for 'Withdrawal' from a program, students can visit: https://www.cmu.edu/hub/registrar/leaves-and-withdrawals/

Academic Performance

Quality Point Average

In order to graduate, each student must have a Quality Point Average (QPA) of at least 3.0 in the courses being used towards the required 97 units. Coursework or graduate project units with a grade lower than 'C' will not be considered toward graduate degree requirements. However, they will be calculated into the student's cumulative QPA.

Quality Point Average (QPA) Calculations

Carnegie Mellon University defines a quality point as a point value times units for a given course. QPAs are calculated according to the following formula:

> ***Semester QPA:*** quality points divided by factorable units for a given semester
>
> ***Cumulative QPA:*** total quality points divided by total factorable units

See the CMU Grading Policies for grades not factorable into QPA. Courses taken while in undergraduate status are not factorable into the QPA for graduate students. A separate cumulative QPA is calculated for undergraduate and graduate records.

In order to graduate from the Department of Electrical & Computer Engineering, each student must have a **program QPA** of at least 3.0, defined as follows:

> ***Program QPA:*** quality points divided by factorable units in those courses being used towards the required units (97 or 133 units depending on program)

Coursework or graduate project units with a grade lower than 'C' will not be considered toward graduate degree requirements or factored into the program QPA. However, they will be factored into the student's cumulative QPA and total units.

Academic Probation

In the event that a student's semester QPA OR cumulative QPA falls below a 3.0, regardless of program QPA, that student will be placed on academic probation for the following term and will receive a Probation Letter from the department alerting them. While on probation, students must meet with their academic advisor and comply with their recommendations.

Based on the result of the probationary term:

- If semester QPA meets or exceeds 3.0 AND cumulative QPA meets or exceeds 3.0, the student has cleared probation.
- If semester QPA meets or exceeds 3.0 but cumulative QPA is below 3.0 for a second consecutive term, the student will be placed on Continuing Probation, regardless of program QPA, and will receive a Continuing Probation Letter.
- If semester QPA is below 3.0 for a second term, this is **grounds for dismissal,** regardless of program QPA. The student will receive a *Notice of Failure to Clear Probation, Academic Action Pending* Letter after receipt of final grades and prior to the Probation Review, the date of which will be stated in the letter. Students wishing to remain in the master's program should meet with their advisor and must prepare a petition for consideration at the Probation Review, which the advisor will present on their behalf. Following the Probation Review, the student will receive a Dismissal Letter if dismissed, or a Continuing Probation Letter if allowed to remain in the program.

Continuing Probation is rare and students may wish to consider alternatives to continuing in the degree program. For any student on **Continuing Probation**, based on the result of the continued probationary term:

- If semester QPA meets or exceeds 3.0 AND cumulative QPA meets or exceeds 3.0, the student has cleared probation.
- If semester QPA is below 3.0 OR cumulative QPA is below 3.0 for a third consecutive term, this is **grounds for dismissal,** regardless of program QPA. The student will receive a Notice of Failure to Clear Probation, Academic Action Pending Letter after receipt of final grades and prior to the Probation Review, the date of which will be stated in the letter. The student has the opportunity to meet with their advisor and, if desired, present a petition for consideration at the Probation Review. Following the Probation Review, the student will receive a Dismissal Letter if dismissed, or a Continuing Probation Letter if allowed to remain in the program.

Probation and Continuing Probation statuses are internal and will not be listed on the official transcript. If a student is on Probation or Continuing Probation in their final academic term but achieves all graduation requirements in that term, the student will have earned their degree. They will not be subject to a Probation Review and will have their degree certified.

Students may appeal any/all Academic Action decisions as outlined in the Summary of Graduate Student Appeal and Grievance Procedures.

Academic Integrity

Please review the University Policy on Academic Integrity (https://www.cmu.edu/policies/student-and-student-life/academic-integrity.html). The policy includes the University expectations around academic integrity and provides definitions of cheating, plagiarism, and unauthorized assistance.

A review of the University's Academic Disciplinary Actions procedures (https://www.cmu.edu/student-affairs/theword/academic-discipline/index.html) is also recommended. These procedures outline the process for investigating, reporting, and adjudicating violations of the University Policy on Academic Integrity. The procedures also outline the appeal process.

Penalties for Violating Academic Integrity

Should an instructor believe that an academic integrity violation has occurred, they may consult with the Office of Community Standards & Integrity, who will assist the faculty member in handling a possible academic integrity violation and, if a student is found responsible for violating academic integrity policies, determining possible sanctions. In accordance with the university's policy, a student who violates the academic integrity policy will not be permitted to drop the course in which the offense occurred in order to avoid penalty. If the student attempts to drop the course, they will be reenrolled.

After a second academic integrity violation, the ECE Department will recommend to the Academic Review Board that you will be dismissed from ECE. For more information on the policies and procedures surrounding academic integrity, please see the website for the Office of Community Standards & Integrity.

Disciplinary Probation

Students who have committed an academic integrity violation are placed on disciplinary probation within the department for the remainder of their academic program. While on probation, students are allowed to continue with the program but must meet with their academic advisor.

M.S. DEGREE REQUIREMENTS

This section outlines the degree requirements for the Master's of Science in Electrical & Computer Engineering in Silicon Valley and the Master's of Science in Software Engineering in Silicon Valley. ECE course list and course descriptions are available on the ECE course website: https://courses.ece.cmu.edu.

M.S. in Software Engineering – effective Fall 2020

MS SE - Standard

The M.S. in SE standard program is a three-semester program that is comprised of 97 units of graduate course work (600 level and above).

SE Core Courses: 60 units

The SE standard program requires 60 units (for the course option) and 48 units (for the project option) of core coursework that may not be waived or substituted. Students are required to take 18-652 Foundations of Software Engineering in their first semester. To complete the remaining required units of core coursework, please choose from the core offerings below:

- Required: 18-652 Foundations of Software Engineering (12 units)
- 18-653 Software Architecture & Design (12 units)
- 18-654 Software Verification & Testing (12 units)
- 18-657 Decision Analysis and Engineering Economics for Software Engineers (12 units)
- 18-658 Software Requirements & Interaction Design (12 units)
- 18-659 Software Engineering Methods (12 units)
- 18-668 Data Science for Software Engineering (12 units)

CIT Elective Courses: 24 units

24 units (for the course option only) must be graduate coursework (600 level or above) within CIT from the following departments

ECE (18)

- Carnegie Institute of Technology (CIT) (39)
- Biomedical Engineering (42)
- Chemical Engineering (06)
- Civil & Environmental Engineering (12)
- Engineering & Public Policy (19)
- Information Network Institute (14)
- Integrated Innovation Institute (49)

- Materials Science & Engineering (27)
- Mechanical Engineering (24)
- CMU-Africa (04)

EXCEPTIONS – The following CIT courses may not be counted toward CIT Elective Coursework. They may be counted toward General Technical Elective Coursework.

- Engineering & Public Policy (19) - 19-602, 19-655
- Integrated Innovation Institute (49) – 49-750, 49-751, 49-761, 49-762, 49-763, 49-764, 49-765, 49-766, 49-767, 49-770, 49-771, 49-772, 49-773, 49-774, 49-775, 49-780, 49-781, 49-782, 49-788, 49-790, 49-791, 49-792, 49-793
- Mechanical Engineering (24) – 24-792
- CMU-Africa (04) – 04-601, 04-602, 04-605, 04-900, 04-980

General Technical Elective Courses: 12 units

12 units of coursework (600 level or above) can be from the following programs (shown under their parent college) or individually approved courses:

Dietrich College of Humanities and Social Sciences

- Statistics (36)
- Center for the Neural Basis of Cognition (86)
- Heinz School of Information Systems (95)
- Heinz College-Wide Courses (94)

Mellon College of Science (MCS)

- Biological Sciences (03)
- Chemistry (09)
- Mathematical Sciences (21)
- Physics (33)

School of Computer Science (SCS)

- Computational Biology (02)
- Computer Science (15)
- Entertainment Technology Center (53)
- Institute for Software Research (08)
- Robotics Institute (16)
- Human-Computer Interaction Institute (05)

- Language Technologies Institute (11)
- Machine Learning (10)
- Software Engineering (17)

Tepper School of Business (TEP)

- Tepper School of Business (45)

Additional courses outside of these programs that are approved to be counted toward General Technical Elective Coursework:

- 46-926, 46-929
- 47-830, 47-834
- 51-882
- 57-947
- 80-713
- 84-688
- 90-756, 90-808
- 93-711

Introduction to Graduate Studies (18989): 1 unit

Preparatory Exception: Up to 12 units of undergraduate course work (300 level and above) may be substituted as part of the 96 core and elective units.

MS SE – Applied Study[*]

The M.S.-AP in SE is a three-semester program that is comprised of 97 units of graduate course work (600 level and above).

SE Core Courses: 60 units

The SE applied program requires 60 units (for the course option) and 48 units (for the project option) of core coursework that may not be waived or substituted. Students are required to take: 18-652 Foundations of Software Engineering in their first semester. To complete the remaining required units of core coursework, please choose from the core offerings below:

- Required: 18-652 Foundations of Software Engineering (12 units)
- 18-653 Software Architecture & Design (12 units)
- 18-654 Software Verification & Testing (12 units)

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[*] Available to students matriculating Fall 2020 to Spring 2023.

- 18-657 Decision Analysis and Engineering Economics for Software Engineers (12 units)
- 18-658 Software Requirements & Interaction Design (12 units)
- 18-659 Software Engineering Methods (12 units)
- 18-668 Data Science for Software Engineering (12 units)

CIT Elective Courses: 24 units

24 units (for the course option only) must be graduate coursework (600 level or above) within CIT from the following departments

- ECE (18)
- Carnegie Institute of Technology (CIT) (39)
- Biomedical Engineering (42)
- Chemical Engineering (06)
- Civil & Environmental Engineering (12)
- Engineering & Public Policy (19)
- Information Network Institute (14)
- Integrated Innovation Institute (49)
- Materials Science & Engineering (27)
- Mechanical Engineering (24)
- CMU-Africa (04)

EXCEPTIONS – The following CIT courses may not be counted toward CIT Elective Coursework. They may be counted toward General Technical Elective Coursework.

- Engineering & Public Policy (19) - 19-602, 19-655
- Integrated Innovation Institute (49) – 49-750, 49-751, 49-761, 49-762, 49-763, 49-764, 49-765, 49-766, 49-767, 49-770, 49-771, 49-772, 49-773, 49-774, 49-775, 49-780, 49-781, 49-782, 49-788, 49-790, 49-791, 49-792, 49-793
- Mechanical Engineering (24) – 24-792

CMU-Africa (04) – 04-601, 04-602, 04-605, 04-900, 04-980

General Technical Elective Courses: 12 units

12 units of coursework (600 level or above) can be from the following programs (shown under their parent college) or individually approved courses:

Dietrich College of Humanities and Social Sciences (DC)

- Statistics (36)
- Center for the Neural Basis of Cognition (86)

Heinz College (HNZ)

- Heinz School of Information Systems (95)
- Heinz College-Wide Courses (94)

Mellon College of Science (MCS)

- Biological Sciences (03)
- Chemistry (09)
- Mathematical Sciences (21)
- Physics (33)

School of Computer Science (SCS)

- Computational Biology (02)
- Computer Science (15)
- Entertainment Technology Center (53)
- Institute for Software Research (08)
- Robotics Institute (16)
- Human-Computer Interaction Institute (05)
- Language Technologies Institute (11)
- Machine Learning (10)
- Software Engineering (17)

Tepper School of Business (TEP)

- Tepper School of Business (45)

Additional courses outside of these programs that are approved to be counted toward General Technical Elective Coursework:

- 46-926, 46-929
- 47-830, 47-834
- 51-882
- 57-947
- 80-713
- 84-688
- 90-756, 90-808
- 93-711

Introduction to Graduate Studies (18989): 1 unit

Summer Internship (18993)

Preparatory Exception: 12 units of undergraduate course work (300 level and above) may be substituted as part of the 96 core and elective units.

M.S. in Electrical & Computer Engineering

Fall 2020 and later

This section outlines the degree requirements for all students who entered one of the four possible Master of Science in Electrical & Computer Engineering programs in Fall 2020 or later. A list of ECE courses and course descriptions are available on the ECE course website: https://courses.ece.cmu.edu.

MS in ECE - Standard

The M.S. in ECE standard program is a three-semester program that is comprised of 97 units of graduate course work (600 level and above). The Standard Program has two available options detailed below. The course option is available to students at both the Pittsburgh and Silicon Valley campuses. The project option is only available to students at the Pittsburgh campus.

ECE Core Graduate Coursework: 60 units

The MS in ECE – Standard Program (course option) requires 60 units of core coursework that may not be waived or substituted. These courses must be in the ECE Department (18) at the 600-level or above. For exceptions to the rule, please visit the MS ECE Course Requirements webpage: https://www.ece.cmu.edu/academics/ms-ece/standard-program.html

Only 12 units of MS Graduate Research Project (18-980) can be counted towards the core Graduate Coursework requirement.

CIT Elective Courses: 24 units

The MS in ECE – Standard Program (course option) requires 24 units of CIT Elective coursework that may not be waived or substituted. These courses must be in the College of Engineering (CIT) at the 600-level or above. For a list of departments within CIT and for exceptions to the rule, please visit the MS ECE Course Requirements webpage: https://www.ece.cmu.edu/academics/ms-ece/standard-program.html

Three units of internship (18-994 Internship for Electrical and Computer Engineering Graduate Students) or professional development (39-699 CIT Professional Development Course) coursework may also count toward CIT Electives.

Up to 15 units of MS Graduate Research (18-980/18-981) can be counted towards the CIT Elective Coursework requirement.

General Technical Elective Courses: 12 units

The MS in ECE – Standard Program (course option) requires 12 units of General Technical Elective coursework that may not be waived or substituted. These courses must be at the 600-level or above from the departments listed above as well as many additional departments listed on the

MS ECE Course Requirements webpage: https://www.ece.cmu.edu/academics/ms-ece/standard-program.html

Introduction to Graduate Studies (18-989): 1 unit

All incoming MS ECE students must take the one-unit Introduction to Graduate Studies course (18-989) in their first semester.

Preparatory Exception: Up to 12 units of undergraduate course work (300-level or higher) can qualify to be substituted toward the 96 units of core or elective requirements. Qualifying coursework must be offered by the same department as either an approved core or elective course.

MS-AP in ECE – Applied Study[*]

The M.S.-AP in ECE is a three-semester program that is comprised of 97 units of graduate course work (600 level and above). The Applied Program has two available options detailed below. The course option is available to students at both the Pittsburgh and Silicon Valley campuses. The project option is only available to students at the Pittsburgh campus.

ECE Core Graduate Coursework: 60 units

The MS-AP in ECE (course option) requires 60 units of core coursework that may not be waived or substituted. These courses must be in the ECE Department (18) at the 600-level or above. For exceptions to the rule, please visit the MS ECE Course Requirements webpage: https://www.ece.cmu.edu/academics/ms-ece/standard-program.html

Only 12 units of MS Graduate Research Project (18-980) can be counted towards the core Graduate Coursework requirement.

CIT Elective Courses: 24 units

The MS-AP in ECE (course option) requires 24 units of CIT Elective coursework that may not be waived or substituted. These courses must be in the College of Engineering (CIT) at the 600-level or above. For a list of departments within CIT and for exceptions to the rule, please visit the MS ECE Course Requirements webpage: https://www.ece.cmu.edu/academics/ms-ece/standard-program.html

Three units of professional development (39-699 CIT Professional Development Course) coursework may also count towards the CIT Elective.

Up to 15 units of MS Graduate Research (18-980/18-981) can be counted towards the CIT Elective Coursework requirement.

General Technical Elective Courses: 12 units

The MS-AP in ECE (course option) requires 12 units of General Technical Elective coursework that may not be waived or substituted. These courses must be at the 600-level or above from the

[*] Available to students matriculating Fall 2020 to Spring 2023.

departments listed above as well as many additional departments listed on the MS ECE Course Requirements webpage: https://www.ece.cmu.edu/academics/ms-ece/standard-program.html

Introduction to Graduate Studies (18-989): 1 unit

All incoming MS ECE students must take the one-unit Introduction to Graduate Studies course (18-989) in their first semester.

Required Summer Internship (18-993)

ECE students who are in the Applied or Applied Advanced Study Program are required to participate in a summer internship. This internship can be either on- or off-campus and does not need to be a paid position.

ECE will enroll all students who are pursuing the required internship for a 0-unit internship course (18-993 Internship for Electrical and Computer Engineering Graduate Students), which can be taken once throughout the student's MS ECE degree program of study and is offered only during the summer. This internship will appear on a student's transcript, though no tuition will be assessed. The work for the internship must be appropriate to the goals of the academic program.

Internships should be at least 20 hours per week and last for at least 10 weeks. Deviation from this internship length is possible with faculty approval. In any semester prior to the summer internship, students are required to complete the prerequisite course 39-699 (Career & Professional Development for Engineering Masters Students). This course will assist students with applying for and securing external internships. If an external internship cannot be secured by the student, ECE faculty advisors will assist in assigning a departmental internship project to meet this requirement.

You may not end your program on the summer internship. The required 0-unit internship must be taken before you meet the program's course unit requirements. For example, if you will complete all 97 units by Spring 2021, you cannot conduct your required internship during Summer 2021.

Preparatory Exception: Up to 12 units of undergraduate course work (300-level or higher) can qualify to be substituted toward the 96 units of core or elective requirements. Qualifying coursework must be offered by the same department as either an approved core or elective course.

Course Restrictions

Courses in which more than 50% of the course grade is based on a group project or more than 20% is based on attendance cannot be used towards the required units for any MS program in the department of Electrical and Computer Engineering. Mini courses worth 12 units cannot be used towards the required units. Students are responsible for checking the syllabi for classes to ensure their courses meet these requirements. For a complete list of all course restrictions, please visit the program websites:

M.S. ECE http://www.ece.cmu.edu/programs-admissions/masters/ms-requirements.html

M.S. SE https://www.ece.cmu.edu/academics/ms-se/requirements.html

For restrictions on the number of units taken outside the College of Engineering, see the section on Maximum Units Allowed Outside CIT.

Internship Course Option

ECE students who are not in the Applied or Applied Advanced Study Program may wish to participate in optional paid internships at off-campus organizations during the summer months.

ECE will enroll all students who are pursuing an optional internship for a 3-unit credit bearing internship course (18-994 Internship for Electrical and Computer Engineering Graduate Students), which can be taken once throughout the student's MS ECE degree program of study, and is offered only during the summer. This internship will appear on a student's transcript and tuition will be charged for 3 units. Please see details for CIT cost of attendance on HUB's website. The work for the internship must be appropriate to the goals of the academic program and units can be applied to the less restricted elective requirement (for Spring 2020 students and prior) or the General Technical Elective requirement (for Fall 2020 students and later). The units earned are graded on the basis of a student written report. Guidelines for the report are shared with students using the 18994 Canvas page.

Eligible international students who are interested in pursuing off-campus internships must meet with departmental and OIE representatives. For additional information, please refer to OIE's website on Employment Options for international students. Academic and OIE advisors will provide students with information about CPT during the spring semester. Students are not eligible to use Curricular Practical Training authorization after they have completed all of their degree requirements.

POST-MATRICULATION GUIDELINES

Return of University Property

ECE students must return all borrowed ECE and university materials—such as software, manuals, library books/materials, or any other Carnegie Mellon University property—prior to their departure from the program.

Career Services Employment Outcomes

ECE students are asked to complete and return a survey for Career Services updating CMU on their employment outcomes after graduation. Information about the survey is communicated in the students' final semester.

"Grandfather" Clause

When policies are changed, it is because the department believes the new rules offer an improvement; any such changes will be communicated to students. In case degree requirements are changed and certain courses are no longer offered, the department will try to find some compromise that allows those students to satisfy the original requirements.

TUITION AND FEES

As indicated in your admission offer letter, ECE does not offer financial assistance for our master's students. Unless otherwise arranged and approved in advance, ECE students are full-time and will be charged full-time ECE tuition. Total charges for a period of attendance and estimated schedule of total charges for entire educational program can be found at the following website: https://www.cmu.edu/sfs/tuition/graduate/cit.html

Estimated charges for ECE M.S. degree:

			MS ECE/SE **entire program estimated**	**MS ECE/SE** **first semester**
		semesters	*3*	
Type	***FY24 $***	***Frequency***		
Application Fee*	$75	one time	$75	$75
Registration Fee	$0	n/a	$0	$0
Enrollment Deposit	$0	n/a	$0	$0
M.S. Tuition	$28,718	per semester	$86,154	$28,718
Activity Fee	$122	per semester	$366	$122
Technology Fee	$235	per semester	$705	$235
Transportation Fee	$131	per semester	$393	$131
Books and Supplies	$1,106	per semester	$3,318	$1,106
Student Tuition Recovery (STRF)	$0	n/a	$0	$0
			$91,011	**$30,387**

Tuition Billing & Payments

The tuition rate for students entering ECE programs is set in the spring for the class entering in the following fall semester. Tuition for a student's second year will likely increase in accordance with any university tuition increase for a new academic year. The tuition will increase approximately 3% each academic year.

Students will be charged tuition per semester for each semester in which they are enrolled. Summer courses, if taken, are charged additional per unit tuition. The tuition billing and payment process for all ECE students is handled centrally by The HUB. For university billing and payment policies, please refer to The HUB's Billing and Payments website.

Part-Time Students

Part-time students will be charged tuition at the per unit rate. Arranging to pay per unit is a convenience and not intended to reduce the overall costs of the program. Students intending to be enrolled part-time should be certain their schedule reflects this by the tenth day of classes.

If a student is planning to pursue part-time coursework (< 36 units), in the event that the student registers full-time (> 35 units) at any point in that semester, they will be assessed the full-time

tuition rate and no refund will be granted. Students pursuing part-time coursework should consult with their academic advisor before changing their course schedule.

Office of the Dean of Student Affairs Emergency Support Funding

Graduate students who find themselves in need of immediate funds for emergency situations should contact the Office of the Dean of Student Affairs (see Appendix A), https://www.cmu.edu/student-affairs/index.html, to inquire about the types of emergency funding available to enrolled students.

Student Financial Obligation

ECE students are subject to and must be aware of the Carnegie Mellon policy regarding student financial obligation (https://www.cmu.edu/sfs/billing/sfo.html).

CAREER SERVICES

The Student Affairs team at CMU Silicon Valley serves to provide students with guidance during their job and internship searches. The services available to students include resume reviews, mock interviewing, salary negotiation, career exploration consultation, internship and job consultation, workshops/events and employer relations. This team is also heavily involved in organizing campus-wide job fairs and bringing employers to campus.

Handshake is Carnegie Mellon's online recruiting system. Through Handshake, employers can request accounts to post jobs, request interviews and information sessions, and review student resumes. Students and alumni can apply to positions, sign up for interviews and find contact information for thousands of recruiters. Handshake can be accessed here: https://www.cmu.edu/career/handshake/.

Career Consultants

ECE has assigned career consultants who provide guidance through one-on-one appointments. Students in Silicon Valley can meet with Assistant Director of Career Services Leigh Mason or peer career consultants (PCCs). Appointments with Leigh or PCCs can be made through Handshake. They will also hold open student hours, which will be communicated at the beginning of each semester.

Job Search Guidelines

ECE strives to play a supportive role in the career pursuits of students, but maintains the priority of academics. It is not acceptable for students to skip classes or assignments in order to attend job interviews. Students should conduct job searches in a manner that does not impede the academic progress through their graduate program.

It is also important for students to understand how to conduct a job search. When applying for jobs, students are expected to exhibit certain ethical behavior, such as arriving on time for interviews, being truthful about their qualifications, and honoring their agreements with recruiters. Students should not continue looking and interviewing for positions after they have accepted an offer.

The CPDC reserves the right to limit access for any users who do not follow their ethical job/internship search policy. Students who do not follow such guidelines may forfeit their on-campus interviewing and/or resume submission privileges.

Job Classification and Salary Structure

Below are the job classification(s) for which the MS ECE and SE programs prepare graduates:

Program	CIP	SOC	
Software Engineering	14.0903	11-9041	Architectural and Engineering Managers
		15-1243	Database Architects
		15-1252	Software Developers

		15-1253	Software Quality Assurance Analysts and Testers
		25-1032	Engineering Teachers, Postsecondary
Electrical Engineering	14.1001	11-9041	Architectural and Engineering Managers
		17-2011	Aerospace Engineers
		17-2061	Computer Hardware Engineers
		17-2071	Electrical Engineers
		17-2072	Electronics Engineers, Except Computer
		25-1032	Engineering Teachers, Postsecondary

UNIVERSITY POLICIES

Evaluation & Certification of Fluency for Instructors

Graduate students are required to have a certain level of fluency in English before they can instruct in Pennsylvania, as required by the English Fluency in Higher Education Act of 1990. Through this Act, all institutions of higher education in the state are required to evaluate and certify the English fluency of all instructional personnel, including teaching assistants and interns. The full university policy can be reviewed at: https://www.cmu.edu/policies/faculty/evaluation-certification-english-fluency-instructors.html

The fluency of all instructional personnel will be rated by Language Support in the Student Academic Success Center to determine at what level of responsibility the student can TA. In addition to administering the International Teaching Assistant (ITA) Test (a mandatory screening test for any non-native speaker of English), Language Support in the Student Academic Success Center helps teaching assistants who are non-native English speakers develop fluency and cultural understanding to teach successfully at Carnegie Mellon. Visit the Student Academic Success Center website for additional information: www.cmu.edu/student-success

Retention of Student Records

Carnegie Mellon University has an official policy on the retention of student records.
Please visit this website for the University's policy: https://www.cmu.edu/es/docs/record-retention-policy.pdf

Suspension/Required Withdrawal Policy

University suspension is a forced, temporary leave from the university. A student may be suspended for academic, disciplinary, or administrative reasons. Additional information is available at the following link: http://www.cmu.edu/policies/student-and-student-life/suspension-required-withdrawal-policy.html

Withdrawal from Program

Students are able to withdraw from the department at any time. Prior to withdrawing, students should discuss their decision with their faculty advisor(s) and the Graduate Affairs Office. Students will be required to fill out the Withdrawal form located on The Hub website. International students must consult with OIE prior to filing a withdrawal form as there will be visa repercussions.

University Grievances

Students are encouraged to discuss any concerns or grievances informally within ECE. If a student is not satisfied with the results of informal discussion or formal appeal at the department level, he or she may follow the guidelines on Graduate Student Appeal and Grievance Procedures. Students are likewise encouraged to speak directly to their graduate student's representatives and to the president of the Graduate Student Assembly (GSA). The complete reference to this policy is available at: http://www.cmu.edu/graduate/policies/appeal-grievance-procedures.html

Summary of Graduate Student Appeal and Grievance Procedures

Graduate students will find the Summary of Graduate Student Appeal and Grievance Procedures on the Graduate Education Resource webpage. This document summarizes processes available to graduate students who seek review of academic and non-academic issues. Generally, graduate students are expected to seek informal resolution of all concerns within the applicable department, unit, or program before invoking formal processes. When an informal resolution cannot be reached, however, a graduate student who seeks further review of the matter is to follow the formal procedures outlined here. These appeal and grievance procedures shall apply to students in all graduate programs of the University. Students should refer to the department specific information in this handbook for department and college information about the administration and academic policies of the program. https://www.cmu.edu/graduate/policies/appeal-grievance-procedures.html

Verification of Employment

Carnegie Mellon University employees or former employees are required to use Employment Verification Request Form to request employment verification. Vendors, such as mortgage companies, may continue to use standard formats with a signed authorization. Details and forms are available at https://www.cmu.edu/hr/resources/hr-partners/hr-services/.

APPENDIX A

2024-2025

Highlighted University Resources for Graduate Students and The WORD, Student Handbook

Key Resources for Graduate Student Support

Office of Graduate and Postdoc Affairs

www.cmu.edu/graduate; grad-ed@cmu.edu

The Office of Graduate and Postdoctoral Affairs provides university-wide support for all graduate students and academic programs, with a focus on supporting graduate student success at Carnegie Mellon. Examples of resources offered through the Office of Graduate and Postdoctoral Affairs include, but are not limited to:

- Website with university resources, contact information for CMU programs and services, calendar of events related to graduate students
- Bi-monthly newsletter to all graduate students with information on activities, resources and opportunities
- Professional Development Seminars and Workshops
- GSA/Provost Conference Funding Grants
- GSA/Provost Small Research Grants (GuSH)
- Consultations on issues related to the graduate student experience

The Office of Graduate and Postdoc Affairs also works with the colleges and departments by informing and assisting in developing policy and procedures relevant to graduate students and working with departments on issues related to graduate students. Additionally we partner with many other offices and organizations, such as the Graduate Student Assembly, to support the holistic graduate student educational experience.

Office of the Dean of Students

https://www.cmu.edu/student-affairs/dean

The Office of the Dean of Students provides central leadership of the metacurricular experience at Carnegie Mellon including the coordination of student support. Vice President of Student Affairs and Dean of Students Gina Casalegno leads the Division of Student Affairs which includes the offices and departments listed below (not an exhaustive list).

Graduate students will find the enrollment information for Domestic Partner Registration and Childbirth/Maternity Accommodations in the Office of the Dean of Students or on their website. This Office also manages the Student Emergency Support Funding process. There are three forms of support funding for enrolled students: emergency student loans, maternity loans, and the Tartan Emergency Support Fund. These funds are made available through generous gifts of alumni and friends of the university as well as support from student organizations,

Undergraduate Student Senate and the Graduate Student Assembly. Students will be provided with additional information about the various types of funding during a consultation meeting with a member of the Dean of Students team. Tuition costs are not eligible for Student Emergency Support funding.

Additional resources for graduate students include College Liaisons and the Student Support Resources team. College Liaisons are senior members of the Division of Student Affairs who work with departments and colleges addressing student concerns across a wide range of issues. College Liaisons are identified on the student SIO page in the Important Contacts list. The Student Support Resources team offers an additional level of support for students who are navigating any of a wide range of life events. Student Support Resources staff members work in partnership with campus and community resources to provide coordination of care and support appropriate to each student's situation.

The Division of Student Affairs includes (not an exhaustive list):

- Athletics, Physical Education and Recreation
- Career and Professional Development Center (CPDC)
- Center for Student Diversity and Inclusion
- Cohon University Center
- Counseling & Psychological Services (CaPS)
- Dining Services
- Office of Community Standards and Integrity (OCSI)
- Office of Student Leadership, Involvement, and Civic Engagement (SLICE)
- University Health Services (UHS)
- Wellness Initiatives

Center for Student Diversity & Inclusion
https://www.cmu.edu/student-diversity/

Assistance for Individuals with Disabilities
http://www.cmu.edu/disability-resources/

The Office of Disability Resources at Carnegie Mellon University has a continued mission to provide physical, digital, and programmatic access to ensure that students with disabilities have equal access to their educational experience. We work to ensure that qualified individuals receive reasonable accommodations as guaranteed by the Americans with Disabilities Act (ADA) and Section 504 of the Rehabilitation Act of 1973. Students who would like to receive accommodations can begin the process through Disability Resources' secure online portal or email access@andrew.cmu.edu to begin the interactive accommodation Process.

Students with physical, sensory, cognitive, or emotional disabilities are encouraged to selfidentify with the Office of Disability Resources and request needed accommodations. Any questions about the process can be directed to access@andrew.cmu.edu, or call (412) 268- 6121.

Eberly Center for Teaching Excellence & Educational Innovation
www.cmu.edu/teaching
We offer a wide variety of confidential, consultation services and professional development programs to support graduate students as teaching assistants or instructors of record during their time at Carnegie Mellon University and as future faculty members at other institutions. Regardless of one's current or future teaching context and duties, our goal is to disseminate evidence-based teaching strategies in ways that are accessible and actionable. Programs and services include campus-wide Graduate Student Instructor Orientation events and our Future Faculty Program, both of which are designed to help participants be effective and efficient in their teaching roles. The Eberly Center also assists departments in creating and conducting customized programs to meet the specific needs of their graduate student instructors. Specific information about Eberly Center support for graduate students is found at www.cmu.edu/teaching/graduatestudentsupport/index.html.

Graduate Student Assembly
www.cmu.edu/stugov/gsa/index.html

The Graduate Student Assembly (GSA) is the branch of Carnegie Mellon Student Government that represents, and advocates for the diverse interests of all graduate students at CMU. GSA is composed of representatives from the different graduate programs and departments who want to improve the graduate student experience at the different levels of the university. GSA is funded by the Student Activities Fee from all graduate students. GSA passes legislation, allocates student activities funding, advocates for legislative action locally and in Washington D.C. on behalf of graduate student issues and needs, and otherwise acts on behalf of all graduate student interests. Our recent accomplishments are a testament to GSA making a difference, and steps to implementing the vision laid out by the strategic plan. https://www.cmu.edu/stugov/gsa/About-the-GSA/Strategic-Plan.html.

GSA offers an expanding suite of social programming on and off-campus to bring graduate students from different departments together and build a sense of community. GSA is the host of the Graduate Student Lounge on the 3rd floor of the Cohon University Center- a great place to study or meet up with friends. GSA also maintains a website of graduate student resources on and off-campus. Through GSA's continued funding for professional development and research conferences, the GSA/Provost Conference Funding Program and GSA/Provost GuSH Research Grants are able to run, as managed by the Graduate Education Office. As we move forward, GSA will continue to rely on your feedback to improve the graduate student experience at CMU. Feel free to contact us at gsa@cmu.edu to get involved, stop by our office in the Cohon University Center Room 304 or become a representative for your Department.

Conference Funding is a funding application process provided by GSA and the Provost's Office for students, student work groups or groups to attend a conference, whether as a participant or as a presenter. The process is managed by the Graduate Education Office. Students can find more information about the application process and deadlines at:
https://www.cmu.edu/graduate/professionaldevelopment/index.html

GuSH Research Funding is a source of small research grant funds provided by the Graduate Student Assembly (GSA) and the Provost's Office and managed by the Office of Graduate and Postdoc Affairs. Students can find more information about the application process and deadlines at: https://www.cmu.edu/graduate/professional-development/research-funding/index.html

Office of International Education (OIE)

http://www.cmu.edu/oie/

Carnegie Mellon hosts international graduate and undergraduate students who come from more than 90 countries. The Office of International Education (OIE) is the liaison to the University for all non-immigrant students and scholars, as well the repository for study abroad opportunities and advisement. OIE provides many services including: advising on personal, immigration, study abroad, academic, and social and acculturation issues; presenting programs of interest such as international career workshops, tax workshops, and cross-cultural and immigration workshops; international education and statistics on international students in the United States; posting pertinent information to students through email and the OIE website, and conducting orientation and pre-departure programs.

Veterans and Military Community

http://www.cmu.edu/veterans/

Military veterans are a vital part of the Carnegie Mellon University community. Graduate students can find information on applying for veteran education benefits, campus services, veteran's groups at CMU, and non-educational resources through the Veterans and Military Community website. There are also links and connections to veteran resource in the Pittsburgh community. The ROTC and Veteran Affairs Coordinator can be reached at urovaedbenefits@andrew.cmu.edu or 412-268-8747.

Carnegie Mellon Ethics Hotline

https://www.cmu.edu/hr/resources/ethics-hotline.html

The health, safety and well-being of the university community are top priorities at Carnegie Mellon University. CMU provides a hotline that all members of the university community should use to confidentially report suspected unethical activity, violations of university policy, or violations of law.

Topic areas for reporting may include, but are not limited to:

- Academic and Student Life
- Bias Reporting
- Discriminatory Harassment / Sexual Misconduct / Title IX
- Employee Misconduct
- Employment Related
- Environmental Health and Safety / Pandemic Safety
- Financial Matters
- Health and Wellness
- Information Systems and Data Privacy
- Public Safety & Criminal Activity

• Research & Intellectual Property

Students, faculty and staff can anonymously file a report by calling 1-844-587-0793 or visiting cmu.ethicspoint.com. All submissions are reported to appropriate university personnel and handled discreetly.

The hotline is NOT an emergency service. For emergencies, call University Police at 412-268-2323.

Policy Against Retaliation
It is the policy of Carnegie Mellon University to protect from retaliation any individual who makes a good faith report of a suspected violation of any applicable law or regulation, university Policy or procedure, any contractual obligation of the university, and any report made pursuant to the Carnegie Mellon University Code of Business Ethics and Conduct.

Additional details regarding the Policy Against Retaliation are available at https://www.cmu.edu/policies/administrative-and-governance/whistleblower.html

Key Offices for Academic & Research Support

Computing and Information Resources
www.cmu.edu/computing
Computing Services maintains and supports computing resources for the campus community, including the campus wired and wireless networks, printing, computer labs, file storage, email and software catalog. As members of this community, we are all responsible for the security of these shared resources. Be sure to review the Safe Computing (https://www.cmu.edu/computing/safe/) section and the University Computing Policy (https://www.cmu.edu/policies/information-technology/computing.html)

Visit the Computing Services website (https://www.cmu.edu/computing/) to learn more. For assistance the Computing Services Help Center is available at 412-268-4357 (HELP) or ithelp@cmu.edu.

Student Academic Success Center
https://www.cmu.edu/student-success/
Student Academic Support Programs

Communication and Language Support
Communication Support: The program offers free consultations for all CMU students on their written, oral, and visual projects. Our trained communication consultants help communicators convey ideas clearly and effectively on a variety of STEM and humanities topics. Consultants support communication excellence on essays, technical reports, oral presentations, slides, data visualization, advanced English language learning, and many other project types. Clients can bring in a project at any stage including brainstorming ideas, organizing thoughts, responding to instructor feedback, or putting finishing touches on the final draft.

Support is offered in several modes:

- *One-on-one communication tutoring* (in-person or Zoom synchronous meeting) – Clients meet with a consultant to improve the logic, clarity, and flow of writing or presentation and receive expert feedback that will strengthen a project. When making an appointment, clients upload a draft, instructor prompts, and rubrics so consultants can use specific criteria to give relevant feedback. See the appointment types offered.
- *Video response* (asynchronous) – Clients upload documents in advance, then receive a 20- to 30-minute recorded video with a consultant's feedback. The feedback video will be received within 5 days after the scheduled appointment.
- *Group appointments* – Participate with your group to accomplish peer reviews or focus on collaborative presentation strategies.
- Workshops – Workshops are available on a variety of topics and help attendees learn research-backed communication strategies.
- Resources – An online collection of handouts and videos that concisely explain specific communication strategies are available.

Language and Cross-cultural Support:
More than 60% of graduate students at Carnegie Mellon are international students, and others are nonnative speakers of English who have attended high school or undergraduate programs in the US. Many of these students want to hone their language and cross-cultural skills for academic and professional success. Students can make an appointment with a Language Development Specialist to get individualized coaching on language or cross-cultural issues. Students can choose from sessions on

- giving a strong presentation,
- writing academic emails,
- analyzing expectations and strategies for clear academic writing,
- talking how to talk about oneself as a professional in the U.S.,
- developing clearer pronunciation,
- using accurate grammar,
- building fluency, and more.

Students can make an appointment with a Language Development Specialist to get individualized coaching on language or cross-cultural issues.
The Student Academic Success Center is also charged with certifying the language of International Teaching Assistants (ITAs), ensuring that nonnative English speakers have the language proficiency needed to succeed as teaching assistants in the Carnegie Mellon classroom.

Students preparing to do an ITA Certification should plan to take classes offered by the language support team at the SASC from the beginning of their first semester. Start by contacting the language support team at the SASC website or attend a Language Support Orientation at the SASC or in your department.

Learning Support

Academic Coaching: Academic Coaching provides holistic one-on-one peer support and group workshops to help students find and implement their conditions for success. We assist students in improving time management, productive habits, organization, stress management, and study skills. Students will request support through the Academic Success Center website and attend in-person meetings or meet using video and audio conferencing technology to provide all students with support.

Peer Tutoring: Weekly Tutoring Appointments are offered in a one-on-one and small group format to students from any discipline who need assistance with a course that may not be supported by our other services. Weekly appointments give students the opportunity to interact regularly with the same tutor to facilitate deeper understanding of concepts. Students can register online through the Student Academic Success website.

"Just in Time" Workshops: The Student Academic Success team is available to partner with instructors and departments to identify skills or concepts that would benefit from supplemental offerings (workshops, boot camps) to support students' academic success and learning. We are eager to help convene and coordinate outside of the classroom skill-building opportunities that can be open to any student interested in building skill or reinforcing course concept mastery.

University Libraries

www.library.cmu.edu

The University Libraries offers a wide range of information resources and services supporting graduate students in course-work, research, teaching, and publishing. The library licenses and purchases books, journals, media and other needed materials in various formats. Library liaisons, consultants and information specialists provide in-depth and professional assistance and advice in all-things information - including locating and obtaining specific resources, providing specialized research support, advanced training in the use and management of data. Sign up for workshops and hands-on topic-specific sessions such as data visualization with Tableau, cleaning data with OpenRefine, and getting started with Zotero. Weekly drop-in hours for Digital Humanities and for Research Data Research Management are scheduled during the academic year. Start at the library home page to find the books, journals and databases you need; to identify and reach out to the library liaison in your field; to sign up for scheduled workshops; and to connect with consultants in scholarly publishing, research data management, and digital humanities.

Research at CMU

www.cmu.edu/research/index.shtml

The primary purpose of research at the university is the advancement of knowledge in all fields in which the university is active. Research is regarded as one of the university's major contributions to society and as an essential element in education, particularly at the graduate level and in faculty development. Research activities are governed by several university policies. Guidance and more general information is found by visiting the Research at Carnegie Mellon website.

Office of Research Integrity & Compliance
www.cmu.edu/research-compliance/index.html
The Office of Research Integrity & Compliance (ORIC) is designed to support research at Carnegie Mellon University. The staff work with researchers to ensure research is conducted with integrity and in accordance with federal and Pennsylvania regulation. ORIC assists researchers with human subject research, conflicts of interest, responsible conduct of research, export controls, and institutional animal care & use. ORIC also provides consultation, advice, and review of allegations of research misconduct.

Key Offices for Health, Wellness & Safety

Counseling & Psychological Services
https://www.cmu.edu/counseling/
Counseling & Psychological Services (CaPS) affords the opportunity for students to talk privately about academic and personal concerns in a safe, confidential setting. An initial consultation at CaPS can help clarify the nature of the concern, provide immediate support, and explore further options if needed. These may include a referral for counseling within CaPS, to another resource at Carnegie Mellon, or to another resource within the larger Pittsburgh community. CaPS also provides workshops and group sessions on mental health related topics specifically for graduate students on campus. CaPS services are provided at no cost. Appointments can be made in person, or by telephone at 412-268-2922.

Health Services
www.cmu.edu/HealthServices/
University Health Services (UHS) is staffed by physicians, advanced practice clinicians and registered nurses who provide general medical care, allergy injections, first aid, gynecological care and contraception as well as on-site pharmaceuticals. The CMU Student Insurance Plan covers most visit fees to see the physicians and advanced practice clinicians & nurse visits. Fees for prescription medications, laboratory tests, diagnostic procedures and referral to the emergency room or specialists are the student's responsibility and students should review the UHS website and their insurance plan for detailed information about the university health insurance requirement and fees.
UHS also has a registered dietician and health promotion specialists on staff to assist students in addressing nutrition, drug and alcohol and other healthy lifestyle issues. In addition to providing direct health care, UHS administers the Student Health Insurance Program. The Student Health Insurance plan offers a high level of coverage in a wide network of health care providers and hospitals. Appointments can be made by visiting UHS's website, walk-in, or by telephone, 412-268-2157.

Campus Wellness
https://www.cmu.edu/wellness/
At Carnegie Mellon, we believe our individual and collective well-being is rooted in healthy connections to each other and to campus resources. The university provides a wide variety of wellness, mindfulness and connectedness initiatives and resources designed to help students

thrive inside and outside the classroom. The BeWell@CMU e-newsletter seeks to be a comprehensive resource for CMU regarding all wellness-inspired events, announcements and professional and personal development opportunities. Sign up for the Be Well monthly newsletter via https://bit.ly/BeWellNewsletter or by contacting the Program Director for Student Affairs Wellness Initiatives, at alusk@andrew.cmu.edu.

Religious and Spiritual Life Initiatives (RSLI)
www.cmu.edu/student-affairs/spirituality
Carnegie Mellon is committed to the holistic growth of our students, including creating opportunities for spiritual and religious practice and exploration. We have relationships with local houses of worship from various traditions and many of these groups are members of CMU's Council of Religious Advisors. We also offer programs and initiatives that cross traditional religious boundaries in order to increase knowledge of and appreciation for the full diversity of the worldview traditions. Our RSLI staff are here to support students across the spectrum of religious and spiritual practice and would be more than happy to help you make a connection into a community of faith during your time at CMU.

University Police
http://www.cmu.edu/police/
412-268-2323
The University Police Department is located at 4551 Filmore Street. The department's services include police patrols and call response, criminal investigations, fixed officer and foot officer patrols, event security, and crime prevention and education programming as well as bicycle and laptop registration. Visit the department's website for additional information about the staff, emergency phone locations, crime prevention, lost and found, finger print services, and annual statistic reports. Carnegie Mellon University publishes an annual campus security and fire safety report describing the university's security, alcohol and drug, sexual assault, and fire safety policies and containing statistics about the number and type of crimes committed on the campus and the number and cause of fires in campus residence facilities during the preceding three years. Graduate students can obtain a copy by contacting the University Police Department at 412- 268-2323. The annual security and fire safety report is also available online at https://www.cmu.edu/police/annualreports/.

Shuttle and Escort Services
Parking and Transportation coordinates the Shuttle Service and Escort Service provided for CMU students, faculty, and community. The Shuttle & Escort website has full information about these services, stops, routes, tracking and schedules.

The WORD

http://www.cmu.edu/student-affairs/theword//
The WORD is Carnegie Mellon University's online student handbook and serves as the foundation for the department (and sometimes college) handbook. The WORD contains university-wide academic policy information and resources, community policies and resources, and describes the university level procedures used to review possible violations of these standards. It is designed

to provide all students with the tools, guidance, and insights to help you achieve your full potential as a member of the Carnegie Mellon community. Information about the following is included in The WORD (not an exhaustive list) and graduate students are encouraged to bookmark this site and refer to it often. University policies can also be found in full text at: http://www.cmu.edu/policies/.

APPENDIX B: ADDITIONAL INFORMATION FOR CALIFORNIA PROGRAMS

Carnegie Mellon University is a private, non-profit institution, approved to operate in California by the California Bureau for Private Post-Secondary Education. Approval to operate means compliance with state standards as set forth in the California Private Postsecondary Education Act of 2009.

Any questions a student may have regarding this catalog that have not been satisfactorily answered by the institution may be directed to the Bureau for Private Postsecondary Education at 1747 North Market Blvd, Suite 225, Sacramento, CA 95834, www.bppe.ca.gov, toll-free telephone number (916) 574-8900.

As a prospective student, you are encouraged to review this catalog prior to signing an enrollment agreement. You are also encouraged to review the School Performance Fact Sheet, which must be provided to you prior to signing an enrollment agreement.

A student or any member of the public may file a complaint about this institution with the Bureau for Private Postsecondary Education by calling (888) 370-7589 toll-free or by completing a complaint form, which can be obtained on the bureau's internet website, at www.bppe.ca.gov.

Class session will be held:

Carnegie Mellon University
NASA Ames Research Park
Bldg. 23
P.O. Box 98
Moffett Field, CA 94035-0001
(650) 603-7032
www.cmu.edu/silicon-valley

STUDENT'S RIGHT TO CANCEL (WITHDRAWAL/LEAVES OF ABSENCE)

A student has the right to cancel the student's Enrollment Agreement by either taking a leave of absence from the Program (leaving Carnegie Mellon University temporarily with the firm and stated intention of returning) or by withdrawing from the Program (leaving Carnegie Mellon University with no intention of returning). If the student withdraws or take a leave of absence from Carnegie Mellon University, the student may be eligible for a tuition adjustment or a refund of certain fees (excluding any Application Fee, Registration Fee and Enrollment Deposit).

To cancel the student's Enrollment Agreement and take a leave of absence or withdraw, the student must complete Carnegie Mellon University's Leave of Absence or Withdrawal form, as applicable, and return it to Carnegie Mellon University's Registrar's Office, at 5000 Forbes Ave., Warner Hall A12, Pittsburgh, PA 15213. The Leave of Absence and Withdrawal forms, and additional information about leaves of absence and withdrawal, can be found on Carnegie Mellon University's website at https://www.cmu.edu/hub/registrar/leaves-and-withdrawals/.

If the student notifies Carnegie Mellon University of the student's intent to withdraw or take a leave of absence, the student's official date of withdrawal or leave of absence is the earliest of:

- The date the student began the student's withdrawal or leave of absence process at Carnegie Mellon University;
- The date the student notified the student's home department at Carnegie Mellon University;
- The date the student notified the associate dean of the student's College at Carnegie Mellon University; or
- The date the student notified the Carnegie Mellon University Dean of Student Affairs.

If the student does not notify Carnegie Mellon University of the student's intent to withdraw or take a leave of absence, the student's official date of withdrawal or leave of absence is:

- The midpoint of the relevant semester in which the student withdraws or takes a leave of absence;
- The last date the student attended an academically-related activity such as an exam, tutorial or study group, or the last day the student turned in a class assignment.

REFUND POLICY

1. Refunds in General. Students who withdraw from the Program or take a leave of absence after having paid the current semester's tuition and fees or receiving financial aid are subject to the following refund and repayment policies. No other charges are refundable.

2. Exit Counseling. All borrowers of Federal student loans must complete a Federally mandated exit counseling session when graduating or dropping to less than half-time enrollment status, including by withdrawing or taking a leave of absence. Exit counseling prepares students for repayment. Students must complete an exit counseling session in its entirety, with complete and correct information; otherwise, the student's degree, diploma and official transcripts may be withheld. Information about exit counseling sessions can be found on Carnegie Mellon University's website at https://www.cmu.edu/sfs/financial-aid/exit-counseling.html.

3. Withdrawals/Leaves On or Before 10th Class Day (during the Cancellation Period). Students who withdraw or take a leave of absence on or before the 10th class day of the relevant semester will receive a refund of 100% of tuition and fees (excluding any Application Fee or Registration Fee and Enrollment Deposit).

4. Withdrawals/Leaves after 10th Class Day (after the Cancellation Period). Students who withdraw or take a leave of absence after the 10th class day of the relevant semester but before completing 60% of the semester will be assessed tuition based on the number of days completed within the semester. This includes calendar days, class and non-class days, from the first day of classes to the last day of final exams. Breaks which last five days or longer, including the preceding and subsequent weekends, are not counted. Thanksgiving and Spring Break are not counted. STRF will be adjusted accordingly with any adjustment of tuition. There is no tuition adjustment after 60% of the semester is completed. There is no refund of University fees after the 10th class day of the relevant semester.

5. Tuition Adjustment Appeals. Students may appeal to have tuition adjustments for their leave of absence or withdrawal if they feel that they have extenuating circumstances. These appeals will be reviewed in the context of Carnegie Mellon University's tuition adjustment policy, as stated above. These appeals must be made in writing to Carnegie Mellon University's Registrar using Carnegie Mellon University's Tuition Appeal Adjustment form. Information about Carnegie Mellon University's tuition adjustment policy and tuition adjustment appeals can be found on Carnegie Mellon University's website at https://www.cmu.edu/sfs/tuition/adjustment.

6. Repayment to Lenders/Third Parties. If any portion of refundable tuition and/or fees was paid from the proceeds of a loan or third party, the refund may be sent to the lender, third party or, if appropriate, to the Federal or state agency that guaranteed or reinsured the loan, as required by law and/or Carnegie Mellon University policy. Any amount of the refund in excess of the unpaid balance of the loan shall be first used to repay any student financial aid programs from which the student received benefits, in proportion to the amount of the benefits received, and any remaining amount shall be paid to the student.

7. Responsibility for Loan. If the student obtains a loan to pay for an educational program, the student will have the responsibility to repay the full amount of the loan plus interest, less the amount of any refund. If the student has received Federal student financial aid funds, the student is entitled to a refund of moneys not paid from Federal student financial aid program funds. If the student is eligible for a loan guaranteed by the Federal or state government and the student defaults on the loan, both of the following may occur: 1) The Federal or state government or a loan guarantee agency may take action against the student, including applying any income tax refund to which the person is entitled to reduce the balance owed on the loan. 2) The student may not be eligible for any other Federal student financial aid at another institution or other government assistance until the loan is repaid.

Meeting the cost of a graduate education is a significant investment. Carnegie Mellon University is committed to making it financially possible for graduate students to enhance educational development and reach their career goals. There are many financial aid resources available to students pursuing graduate studies at Carnegie Mellon University. Carnegie Mellon University participates in a number of Federal and state financial aid programs. Information about these financial aid programs can be found on Carnegie Mellon University's website, at http://www.cmu.edu/finaid/index.html.

If you obtain a loan to pay for the M.S. in Electrical and Computer Engineering or Software Engineering degree programs on the Silicon Valley campus, you will have the responsibility to repay the full amount of the loan plus interest, less the amount of any refund. If you have received federal student financial aid funds, you are entitled to a refund of moneys not paid from federal student financial aid program funds.

Carnegie Mellon University does not have a pending petition in bankruptcy, is not operating as a debtor in possession, and has not filed a petition in bankruptcy within the preceding 5 years, nor has Carnegie Mellon had a petition in bankruptcy filed against it within the preceding 5 years that resulted in re-organization under Chapter 11 of the United States Bankruptcy Code.

The State of California established the Student Tuition Recovery Fund (STRF) to relieve or mitigate economic loss suffered by a student in an educational program at a qualifying institution, who is or was a California resident while enrolled, or was enrolled in a residency program, if the student enrolled in the institution, prepaid tuition, and suffered an economic loss. Unless relieved of the obligation to do so, you must pay the state-imposed assessment for the STRF, or it must be paid on your behalf, if you are a student in an educational program, who is a California resident, or are enrolled in a residency program, and prepay all or part of your tuition.

You are not eligible for protection from the STRF and you are not required to pay the STRF assessment, if you are not a California resident, or are not enrolled in a residency program.

It is important that you keep copies of your enrollment agreement, financial aid documents, receipts, or any other information that documents the amount paid to the school. Questions regarding the STRF may be directed to the Bureau for Private Postsecondary Education, 1747 North Market Blvd, Suite 225, Sacramento, CA 95834, (916) 574-8900 or (888) 370-7589.

To be eligible for STRF, you must be a California resident or are enrolled in a residency program, prepaid tuition, paid or deemed to have paid the STRF assessment, and suffered an economic loss as a result of any of the following:

1. The institution, a location of the institution, or an educational program offered by the institution was closed or discontinued, and you did not choose to participate in a teach-out plan approved by the Bureau or did not complete a chosen teach-out plan approved by the Bureau.
2. You were enrolled at an institution or a location of the institution within the 120 day period before the closure of the institution or location of the institution, or were enrolled in an educational program within the 120 day period before the program was discontinued.
3. You were enrolled at an institution or a location of the institution more than 120 days before the closure of the institution or location of the institution, in an educational program

offered by the institution as to which the Bureau determined there was a significant decline in the quality or value of the program more than 120 days before closure.
4. The institution has been ordered to pay a refund by the Bureau but has failed to do so.
5. The institution has failed to pay or reimburse loan proceeds under a federal student loan program as required by law, or has failed to pay or reimburse proceeds received by the institution in excess of tuition and other costs.
6. You have been awarded restitution, a refund, or other monetary award by an arbitrator or court, based on a violation of this chapter by an institution or representative of an institution, but have been unable to collect the award from the institution.
7. You sought legal counsel that resulted in the cancellation of one or more of your student loans and have an invoice for services rendered and evidence of the cancellation of the student loan or loans.

To qualify for STRF reimbursement, the application must be received within four (4) years from the date of the action or event that made the student eligible for recovery from STRF.

A student whose loan is revived by a loan holder or debt collector after a period of noncollection may, at any time, file a written application for recovery from STRF for the debt that would have otherwise been eligible for recovery. If it has been more than four (4) years since the action or event that made the student eligible, the student must have filed a written application for recovery within the original four (4) year period, unless the period has been extended by another act of law.

However, no claim can be paid to any student without a social security number or a taxpayer identification number.

NOTICE CONCERNING TRANSFERABILITY OF CREDITS AND CREDENTIALS EARNED AT OUR INSTITUTION The transferability of credits you earn at Carnegie Mellon University is at the complete discretion of an institution to which you may seek to transfer. Acceptance of the M.S. degree you earn in Electrical and Computer Engineering or Software Engineering is also at the complete discretion of the institution to which you may seek to transfer. If the credits or degree that you earn at this institution are not accepted at the institution to which you seek to transfer, you may be required to repeat some or all of your coursework at that institution. For this reason you should make certain that your attendance at this institution will meet your educational goals. This may include contacting an institution to which you may seek to transfer after attending Carnegie Mellon University to determine if your credits or degree will transfer.

Carnegie Mellon University is accredited through a voluntary, peer-review process coordinated by the Middle States Commission on Higher Education (MSCHE or Middle States). MSCHE is one of six regional accrediting agencies in the United States, each accrediting institutions of higher education within a specific geographic region. Middle States is recognized by the U.S. Department of Education. This recognition enables MSCHE's member institutions to establish eligibility to participate in federal financial aid programs (e.g., federal loans, grants, and work-study) administered by the U.S. Department of Education. Carnegie Mellon University has been accredited by Middle States since 1921.

Please visit http://www.cmu.edu/middlestates/ to learn more about accreditation standards and processes and to view the University's reaccreditation reports.

The address and telephone number for the Middle States Commission on Higher Education is 3624 Market Street, 2nd Floor West, Philadelphia, PA 19104, (267) 284-5000.

The Office of Student Assistance and Relief is available to support prospective students, current students, or past students of private postsecondary educational institutions in making informed decisions, understanding their rights, and navigating available services and relief options. The Office may be reached by calling (888) 370-7589 or by visiting https://www.osar.bppe.ca.gov/.

APPENDIX C: LIST OF PROGRAM COURSES

Entrepreneurship and Innovation in Technology (18-601) – 12 Units
Have an idea you want to bring to the world? Ever want to start a company?? Do you wonder what it takes to be an entrepreneur? Then this is the class for you. Entrepreneurship and Innovation in Technology is an introductory course in entrepreneurship for graduate students. The course targets non-business students and assumes no background in business. Students are exposed to fundamental concepts and issues around innovation and entrepreneurship. The course provides a foundation for starting a new venture and innovating new technologies and products within existing organizations. Topics covered will include: identifying a business opportunity, acquiring customers, building a team, developing a business model, understanding investment, managing risk, and achieving differentiation. Emphasis will be on team projects, including developing an investor pitch for an original idea.

Fundamentals of Modern CMOS Devices (18-610) – 12 Units
This course is intended to provide a foundation in device operation for circuit designers working in today's sub-micron CMOS. This course will also provide advanced understanding of CMOS technology for those interested in integrated circuit process technology and device physics. We review semiconductor device physics, including carrier dynamics and the basic equations of semiconductor device physics. The operation of the p-n junction diode is also reviewed. The course includes a description of integrated circuit fabrication technology and how it is used to fabricate CMOS devices. With this foundation, we then discuss the MOS capacitor (including its application as a varactor). The theory of the MOS transistor will then be developed, followed by a discussion of important phenomena in sub-micron devices such as: velocity saturation; breakdown; drain-induced barrier lowering; random dopant fluctuations, etc. The student will learn the relationship between device geometry, e.g. length, and fabrication, e.g. doping, and the corresponding circuit performance. The course will primarily be lecture-based, with some selected simulation exercises. Students are expected to be acquainted with the basic concepts of electrical circuits; electromagnetic fields at the level of a sophomore level physics course, and to have adequate preparation in mathematics (basic differential equations and MATLAB or similar applications). Prior coursework in device physics is helpful but not required for graduate students. Lecture: 4 hrs

Neural Technology: Sensing and Stimulation (18-612) – 12 Units
This course gives engineering insight into the operation of excitable cells, as well as circuitry for sensing and stimulation nerves. Initial background topics include diffusion, osmosis, drift, and mediated transport, culminating in the Nernst equation of cell potential. We will then explore models of the nerve, including electrical circuit models and the Hodgkin-Huxley mathematical model. Finally, we will explore aspects of inducing a nerve to fire artificially, and cover circuit topologies for sensing action potentials and for stimulating nerves. If time allows, we will discuss other aspects of medical device design. Students will complete a neural stimulator or sensor design project. Although students in 18-612 will share lectures and recitations with students in 18-412, students in 18-612 will receive distinct homework assignments, distinct design problems,

and distinct exams from the ones given to students in 18-412 and will be graded on a separate curve from students taking 18-412.

Foundations of Computer Systems (18-613) – 12 Units
This course provides a programmer's view of how computer systems execute programs, store information, and communicate. It enables students to become more effective programmers, especially in dealing with issues of performance, portability and robustness. It also serves as a foundation for courses on compilers, networks, operating systems, and computer architecture, where a deeper understanding of systems-level issues is required. Topics covered include: machine-level code and its generation by optimizing compilers, performance evaluation and optimization, computer arithmetic, processor architecture, memory organization and management, networking technology and protocols, and supporting concurrent computation. This course is modeled after 15-213/18-213/15-513, and is intended for ECE MS students with expanded course contents presented at the graduate level. It prepares students for other graduate level computer systems courses as well as working in the industry. Anti-requisites: 15213, 18213, 15513

Microelectromechanical Systems (18-614) – 12 Units
This course introduces fabrication and design fundamentals for Microelectromechanical Systems (MEMS): on-chip sensor and actuator systems having micron-scale dimensions. Basic principles covered include microstructure fabrication, mechanics of silicon and thin-film materials, electrostatic force, capacitive motion detection, fluidic damping, piezoelectricity, piezoresistivity, and thermal micromechanics. Applications covered include pressure sensors, micromirror displays, accelerometers, and gas microsensors. Grades are based on exams and homework assignments. 4 hrs. lec.

Micro and Nano Systems Fabrication (18-615) – 12 Units
This is a new course intended to introduce students to the process flow and design methodology for integrated systems fabrication. The course will present this material through two paths. Lectures will be presented on the basic unit processes of micro and nanosystems fabrication: deposition, patterning, and etching. Lectures will draw on examples from: Semiconductor device fabrication; Microelectromechanical systems (MEMS) fabrication; Magnetic device fabrication; and Optical device fabrication. Problem sets will be given based on this lecture material to allow students to quantitatively analyze certain process steps in detail. The second path for material presentation will be through a series of labs that allow students to design, fabricate and test an integrated device. These laboratories will be scheduled at regular meeting times, and will use research facilities within the ECE department. This is a PhD level course. MS or senior students must obtain permission from the instructor to be registered.

Nano-Bio-Photonics (18-616) – 12 Units
Light can penetrate biological tissues non-invasively. Most of the available bio-optic tools are bulky. With the advent of novel nanotechnologies, building on-chip integrated photonic devices for applications such as sensing, imaging, neural stimulation, and monitoring is now a possibility. These devices can be embedded in portable electronic devices such as cell phones for point of

care diagnostics. This course is designed to convey the concepts of nano-bio-photonics in a practical way to prepare students to engage in emerging photonic technologies. The course starts with a review of electrodynamics of lightwaves. The appropriate choice of wavelength and material platform is the next topic. Then optical waveguides and resonators are discussed. Resonance-based sensing is introduced followed by a discussion of the Figure of Merits (FOMs) used to design on-chip sensors. Silicon photonics is introduced as an example of a CMOS-compatible platform. On-chip spectroscopy is the next topic. The second part covers nano-plasmonics for bio-detection and therapy. The design methods are discussed, followed by an overview of nanofabrication and chemical synthesis, and then a discussion of applications. The last part of this course will be dedicated to a review of recent applications such as Optogenetic neural stimulation, Calcium imaging, Cancer Imaging and Therapy. Senior or graduate standing required. This course is cross-listed with 18416. Although students in 18-616 and 18-416 will share the same lectures and recitations, students in 18-616 will receive distinct course projects. Students in 18-416 and 18-616 will be graded on separate curves.

Smart Grids and Future Electric Energy Systems (18-618) – 12 Units

The course offers an advanced presentation of modern electric power systems, starting from a brief review of their structure and their physical components, through modeling, analysis, computation, sensing and control concepts. Great care is taken to avoid presenting "practical" techniques built on dubious theoretical foundations and also to avoid building elaborate "mathematical" models whose physical validity and relevance may be questionable. Mastering both principles and relevant models is important for those who wish to seriously understand how today's electric power grids work and their challenging technical issues. This prepares students for working on applying many novel information processing concepts for designing and operating more reliable, secure, and efficient electric energy systems. Students interested in both applied physics and signals and systems should consider taking this subject. Once the fundamentals of today's power systems are understood, it becomes possible to consider the role of smart electric power grids in enabling evolution of future electric energy systems. Integration of intermittent energy resources into the existing grid by deploying distributed sensors and actuators at the key locations throughout the system (network, energy sources, consumers) and changes in today's Supervisory Control and Data Acquisition (SCADA) for better performance become well-posed problems of modeling, sensing and controlling complex dynamic systems. This opens opportunities to many innovations toward advanced sensing and actuation for enabling better physical performance. Modeling, sensing and control fundamentals for possible next generation SCADA in support of highly distributed operations and design are presented. Prior knowledge in 18-418 or 18-771 is highly recommended.

Digital Integrated Circuit Design (18-622) – 12 Units

This course covers the design and implementation of digital circuits in a modern VLSI process technology. Topics will include logic gate design, functional unit design, latch/flip-flop design, system clocking, memory design, clock distribution, power supply distribution, design for test, and design for manufacturing. The lab component of the course will focus on using modern computer aided design (CAD) software to design, simulate, and lay out digital circuits. The final project for the course involves the design and implementation to the layout level of a small

microprocessor. 18-240 and 18-320 or equivalent background material with permission of the instructor. Although students in 18-422 and 18-622 will share lectures, labs, and recitations, students in 18-422 and 18-622 will receive different homework assignments, design projects, and exams, and in some cases 18-622 students will also have different or additional lab sessions.

Analog Integrated Circuit Design (18-623) – 12 Units

Some form of analog circuit design is a critical step in the creation of every modern IC. First and foremost, analog circuits act as the interface between digital systems and the real world. They act to amplify and filter analog signals, and to convert signals from analog to digital and back again. In addition, high performance digital cell design (either high speed or low power) also invokes significant analog circuit design issues. The goal of this course is to teach students some of the methods used in the design and analysis of analog integrated circuits, to illustrate how one approaches design problems in general, and to expose students to a broad cross-section of important analog circuit topologies. The course will focus on learning design through carrying out design projects. Design and implementation details of wide-band amplifiers, operational amplifiers, filters and basic data converters will be covered. Example topics to be covered include transistor large- and small-signal device models, small-signal characteristics of transistor-based amplifiers, large-signal amplifier characteristics and nonidealities, operational amplifier design, basic feedback amplifier stability analysis and compensation, and comparator design. The course will focus primarily on analog CMOS, but some aspects of BJT design will be discussed. 18-290 and 18-320 or equivalent background material with permission of the instructor. Although students in 18-623 will share Lectures and Recitations with students in 18-421, students in 18-623 will receive distinct homework assignments, distinct design problems, and distinct exams from the ones given to students in 18-421 and will be graded on a separate curve from students taking 18-421.

ULSI Mobile Platform and Server Product Design (18-625) – 12 Units

The objective of this class is to design an ULSI (Ultra Large Scale Integrated) mobile platform and a server product in two scenarios: System on Chip (SoC) and System in Package (SiP). State-of-the-art 2016 technology nodes (28nm, 20nm or 14nm) will be assumed for the SoC scenario and full 3-D integration with Through Silicon Vias (TSV) will be pursued for the 2020 SiP scenario. Students will be given all the necessary technology data (device performance, interconnect parasitics, wafer and TSV/packaging costs, and also the expected yield data). The design objective is to deliver a product competitive to the leading products available on the market or anticipated in 5 years. The complete product design will be carried out focusing on the processor cores, graphics and the embedded memories (including new generation memories in the 2020 scenarios). System performance and power will be estimated using provided simulators for specified benchmarks. The goal is to minimize the product cost by maximizing the number of good die per wafer while achieving competitive product performance and power objectives. Prerequisites: 18664 or instructor permission

Introduction to Information Security (18-631) – 12 Units

Our growing reliance on information systems for daily activities, ranging from remote communications to financial exchanges, has made information security a central issue of our critical infrastructure. The course introduces the technical and policy foundations of information security. The main objective of the course is to enable students to reason about information systems from a security engineering perspective, taking into account technical, economic and policy factors. Topics covered in the course include elementary cryptography; access control; common software vulnerabilities; common network vulnerabilities; policy and export control laws, in the U.S., Japan, and elsewhere; privacy; management and assurance; economics of security; and special topics in information security. Prerequisites: The course assumes a basic working knowledge of computers, networks, C and UNIX programming, as well as an elementary mathematics background, but does not assume any prior exposure to topics in computer or communications security. Students lacking technical background (e.g., students without any prior exposure to programming) are expected to catch up through self-study.

Introduction to Hardware Security (18-632) – 12 Units
This course covers basic concepts in the security of hardware systems. Topics covered include active and passive attacks, reverse engineering, counterfeiting, and design of hardware security primitives (e.g., random number generators, physical unclonable functions, crypto-processors). Lab sessions will give students hands on experience with performing attacks, developing countermeasures, and implementing secure hardware building blocks. Students are expected to have basic knowledge of digital logic and Register-Transfer Level (RTL) design, but no specific background in security/cryptography is necessary.

Browser Security (18-636) – 12 Units
The Web continues to grow in popularity as platform for retail transactions, financial services, and rapidly evolving forms of communication. It is becoming an increasingly attractive target for attackers who wish to compromise users' systems or steal data from other sites. Browser vendors must stay ahead of these attacks by providing features that support secure web applications. This course will study vulnerabilities in existing web browsers and the applications they render, as well as new technologies that enable web applications that were never before possible. The material will be largely based on current research problems, and students will be expected to criticize and improve existing defenses. Topics of study include (but are not limited to) browser encryption, JavaScript security, plug-in security, sandboxing, web mashups, and authentication. The course will involve an intensive group research project focusing on protocols/algorithms, vulnerabilities, and attacks as well as several individual homework and programming tasks. Groups will perform a sequence of cumulative tasks (literature review, analysis, simulation, design, implementation) to address aspects of their chosen topic, occasionally reporting their results to the class through brief presentations, leading to a final report.

Wireless Security (18-637) – 12 Units
With the surge of mobile device use, embedded system deployment, and development of always-connected devices, the underlying wireless communication and network systems are becoming more critical for everyday use. Even though security and privacy have emerged as important focus areas for modern technology, the wireless links that connect our pervasive devices are still

less understood from the perspectives of security and privacy than other system aspects. This course will focus on the challenges in providing secure communication and network services in a variety of wireless systems and current and past approaches to manage these challenges. Topic coverage will include vulnerabilities, attacks, security mechanisms, and trade-offs at various layers of the network protocol stack, from aspects of physical communication to application and service security issues; examples include jamming, MAC-layer misbehavior, selective packet dropping, decentralized trust and reputation, and cross-layer holistic attacks. Systems of interest include (but are not limited to) personal devices, connected vehicles, embedded and IoT systems, wireless infrastructure, and ad hoc networks. Class material will be largely based on recent and current research. In addition to individual homework assignments, students will participate in an intensive group project involving significant research, development, and experimentation. Graduate standing is required to register for this course.

Mobile and IoT Security (18-638) – 12 Units

For many people, mobile and embedded devices have become an essential part of life and work. As such devices represent many and varied combinations of technologies, they have unique security and privacy issues that potentially impact users, developers, service providers, manufacturers, and regulators. This course will focus on various aspects of security and privacy that are faced by mobile and Internet of Things devices, including aspects of wireless communication and networking, mobile computing, data analytics, security, and privacy. The course will include studies of security and privacy aspects of networking (including telecom, enterprise, personal, etc.), applications, and data analytics as relevant to mobile and embedded/IoT devices. One of the main goals of the course is to improve knowledge and awareness of security issues faced by mobile application developers, embedded system builders, and smart system designers. Material will cover standards, best practices, and research challenges in both deployed and emerging systems. Topics of study include (but are not limited to) telecom protocols and vulnerabilities; mobile/IoT network security; security and privacy in edge computing; mobile application security; and location and activity privacy. In addition to individual homework assignments, students will participate in an intensive group project involving significant research, development, and experimentation. Graduate standing is required to register for this course.

Policies of the Internet (18-639) – 12 Units

This course will address public policy issues related to the Internet. This may include policy issues such as network neutrality and the open Internet, Internet governance and the domain name system (and the role of the United Nations), copyright protection of online content, regulation of indecency and pornography, universal access to Internet and Internet as a "human right," government surveillance of the Internet, Internet privacy and security, and taxation of electronic commerce. It will also teach some fundamentals of Internet technology. Because these are inherently interdisciplinary issues, the course will include detailed discussions of technology, economics, and law, with no prerequisites in any of these areas. Senior or graduate standing required.

Hardware Arithmetic for Machine Learning (18-640) – 12 Units

In this course, students explore the techniques for designing high-performance digital circuits for computation along with methods for evaluating their characteristics. We begin by reviewing number systems and digital arithmetic along with basic arithmetic circuits such as ripple-carry adders. From there, we move to more complex adders (carry-look-ahead, carry-skip, carry-bypass, etc.), multipliers, dividers, and floating-point units. For each circuit introduced, we will develop techniques and present theory for evaluating their functionality and speed. Other methods will be described for analyzing a circuit's power consumption, testability, silicon area requirements, correctness, and cost. In addition, we will utilize various CAD tools to evaluate the circuits described. Finally, advanced timing and clocking concepts will be investigated. For example, the notion of clock skew will be introduced and its impact on clock period for sequential circuits will be analyzed. We will also learn how to analyze and design asynchronous circuits, a class of sequential circuits that do not utilize a clock signal. Course projects focus on key arithmetic aspects of various machine learning algorithms including: K-nearest neighbors, neural networks, decision trees, and support vector machines.

*Note: Although students in 18-340 and 18-640 will share lectures, labs, and recitations, students in 18-340 and 18-640 will receive different homework assignments, design projects, and exams. In some cases 18-640 students will also have different or additional lab sessions. The homework assignments, design projects, and exams that are given to the students registered for 18-640 will be more challenging than those given to the students registered for 18-340 in that they will have more complex designs, involve additional theoretical analysis, and have more stringent specifications (e.g., in area, power, performance, and robustness).

Design Patterns for Smartphone Development (18-641) – 12 Units
This course provides an intensive exploration of computer programming by reviewing the basics of Object-Orientated programming and moving quickly to advanced programming using design patterns and a multi-tiered architecture. As part of the course work, students will learn smartphone development and how to apply the learned programming techniques to create extensible, reusable and quality software. It is intended for master's students who have had some prior, but perhaps limited, programming experience in Java or another object-oriented programming language; it is not intended as a first course in programming.

Embedded System Software Engineering (18-642) – 12 Units
In a very real sense, embedded software is what makes our everyday world function. From self-driving cars to chemical processing plant equipment, and from medical devices to the electric grid, embedded software is everywhere. You already know how to write code for a microcontroller. Now, learn software quality, safety, and security skills that are required to make embedded systems that can handle the messiness of the real world. This course provides in-depth coverage of the topics that are essential to the success of embedded software projects based on case studies of industry project teams that have suffered or failed. Students will learn about a variety of topics including: lightweight but high quality embedded software processes, technical best practices for embedded software, effective testing and validation, causes of software system failures, software for safety-critical systems, and embedded-specific aspects of software security. The material will generally be broken up into a set of four related topics each

week, with one assignment per topic weekly, involving a combination of programming assignments, tool use experiences, and research questions to get hands-on experience at dealing with the types of problems that are encountered in industry embedded projects. We assume you already know how to code in C and understand the basics of microcontrollers. This course is about getting you ready to build industry-strength embedded projects. Undergraduate students are required to take 18349 prior to enrolling in this course. Graduate students are strongly encouraged to take 18-600/15-213/15-513/18-213 before or concurrently with this course.

Reconfigurable Logic: Technology, Architecture and Applications (18-643) – 12 Units
Three decades since its original inception as a lower-cost compromise to ASIC, modern Field Programmable Gate Arrays (FPGAs) are versatile and powerful systems-on-a-chip for many applications that need both hardware level efficiency and the flexibility of reprogrammability. More recently, FPGAs have also emerged as a formidable computing substrate with applications ranging from data centers and mobile devices. This course offers a comprehensive coverage of modern FPGAs in terms of technology, architecture and applications. The coverage will also extend into on-going research investigations of future directions. Students will take part in a substantial design projects applying the latest FPGA platforms to compute acceleration. Register-Transfer Level (RTL) hardware design experience is required.

Special Topics in Computer Systems (18-644) – 12 Units
This course covers applications of mobile hardware systems and the hardware associated with these systems. The course enables students 1) to analyze the implications of mobile hardware capabilities and restrictions in order to plan and develop mobile applications, 2) to propose and justify new ideas in the mobile space, and 3) to expose students to a range of mobile systems. Students will be able to devise and interface simple hardware additions to enable new applications. The course covers the elements of embedded systems development, such as hardware fundamentals, system development, as well mobile topics such as power management, machine-to-machine communication, and applications. Student teams will undertake small HW/SW interfacing projects on Arduino to sharpen their experience, and shape and build a novel application with the faculty. Unlike a conventional hardware course, the course would instead focus on the system and software implications, rather than the hardware components (i.e. CPU and radio). Prerequisites: Some understanding of basic electrical terminology; Java programming and C programming desired

How to Write Fast Code (18-645) – 12 Units
The fast evolution and increasing complexity of computing platforms pose a major challenge for developers of high performance software for engineering, science, and consumer applications: it becomes increasingly harder to harness the available computing power. Straightforward implementations may lose as much as one or two orders of magnitude in performance. On the other hand, creating optimal implementations requires the developer to have an understanding of algorithms, capabilities and limitations of compilers, and the target platform's architecture and microarchitecture. This interdisciplinary course introduces the student to the foundations and state-of-the-art techniques in high performance software development using important functionality such as linear algebra kernels, transforms, filters, and others as examples. The

course will explain how to optimize for the memory hierarchy, take advantage of special instruction sets, and how to write parallel code for multicore, manycore, and cluster platforms, based on state-of-the-art research. Further, a general strategy for performance analysis and optimization is introduced that the students will apply in group projects that accompany the course. Finally, the course will introduce the students to the recent field of automatic performance tuning. Prerequiste: Senior ECE or CS undergraduate student or higher, solid C programming skills.

Low-Power System-on-Chip Architecture (18-646) – 12 Units
This course provides the architectural foundations for low-power systems out of which sensors, low power embedded systems, internet of things devices and the like are created. It includes microarchitecture, energy-aware programming, energy harvesting, energy management, and real-time measurement and abstraction of energy usage at runtime. As a part of the course, we will naturally build embedded systems at a level where energy usage can be measured and controlled.

Embedded Real-Time Systems (18-648) – 12 Units
Real-time embedded systems pervade many aspects of modern life ranging from household appliances, transportation and motion control systems, medical systems and devices, robotics, multimedia and mobile communications, video-games, energy generation/distribution/management, to aerospace and defense systems. This course has three complementary goals. One, it will cover the core concepts and principles underlying these systems, including resource management, scheduling, dependability and safety. Implications to multi-core platforms, SoCs, networks and communication buses will also be discussed. Mathematical models and analysis techniques will be presented. Two, the course will offer hands-on experience with implementing real-time embedded systems on realistic platforms. This will be facilitated by detailed discussions of hardware-software interfaces, concurrency and communications. Finally, application-level concepts such as signal processing, image processing, computer vision, sensor fusion and feedback control will complete an overview of the breadth and depth of real-time embedded systems. Knowledge of the C programming language, basic computer architecture and an assembly language will be assumed.

Distributed Embedded Systems (18-649) – 12 Units
Embedded computers seem to be everywhere, and are increasingly used in applications as diverse as transportation, medical equipment, industrial controls, and consumer products. This course covers how to design and analyze distributed embedded systems, which typically consist of multiple processors on a local area network performing real time control tasks. The topics covered will include issues such as communication protocols, synchronization, real-time operation, fault tolerance, distributed I/O, design validation, and industrial implementation concerns. The emphasis will be on areas that are specific to embedded distributed systems as opposed to general-purpose networked workstation applications. This course assumes that students already know fundamental topics such as interrupts, basic I/O, and uniprocessor scheduling that are commonly taught in introduction-level embedded system courses such as 18-348 and 18-349. Any graduate student who has not taken one of the pre-requ isites is responsible

for understanding relevant material necessary for this course. Additionally, all students are responsible for knowing or learning on their own intermediate-level programming in Java. Prerequisites: 18348 or 18349 and senior or graduate standing.

Policies of Wireless Systems (18-650) – 12 Units

This course will address public policy issues related to wireless systems. It investigates policies related to a wide variety of emerging wireless systems and technologies, including current and next-generation cellular systems, wifi and white space devices, emerging methods of accessing spectrum, communications systems for emergency responders (firefighters, police, emergency medical services), current and next-generation television, and satellite communications. This can include the government role in facilitating the creation of infrastructure, in advancing competition among broadcasters and communications service providers, in using scarce spectrum efficiently, in promoting public safety and homeland security, and in protecting privacy and security. Because these are inherently interdisciplinary issues, the course will include detailed discussions of technology, economics, and law, with no prerequisites in any of these areas. This course is cross-listed as 18-650, 19-403, 19-713, and 95-824. Senior or graduate standing required.

Networked Cyber-Physical Systems (18-651) – 12 Units

Cyber-physical systems (CPS) represent a new class of systems that bring together sensing, computation, communication, control and actuation to enable continuous interactions with physical processes. This integration of networked devices, people, and physical systems provides huge opportunities and countless applications in biology and healthcare, automotive and transportation, power grids and smart buildings, social and financial markets, etc. Hence, CPS need to provide real-time efficiency, adaptability, optimality, security and robustness to natural disasters or targeted attacks. While the focus on embedded systems relies on building computational models for specific applications, CPS need a multidisciplinary approach and a more general computational paradigm such that more-direct interactions between the system and physical world become possible. This course is primarily an in-depth introduction to networked CPS with an emphasis on methods for modeling, design, and optimization. Focus is on the dominant design paradigms like low-power and communication-centric design. Topics to be covered include: physical processes, models of concurrency, sensing and workload modeling, human behavior modeling, data-driven modeling, networking at micro- and macro-scale, system-wide resources management, programming, validation and integration. From a practical standpoint, students will directly experiment with hardware prototypes and software tools to explore concrete CPS examples. By structure and contents, this class is primarily targeted to ECE students; it can also provide a valuable basis for interdisciplinary research to students in CS and related disciplines.

Foundations of Software Engineering (18-652) – 12 Units

In this course, you will learn about software engineering paradigms that have shaped the software industry over the past few decades. You will be exposed to fundamental disciplines of software engineering as well as engineering practices that crosscut system, project, and user perspectives. You will learn to iteratively define requirements, and architect, design, implement,

integrate, test, and deploy a solution. You will work on self-organizing teams and manage the work collaboratively. You will also learn to solve a real problem subject to multiple constraints while keeping the stakeholders involved throughout the lifecycle and balancing the underlying engineering tradeoffs. The topics are applied in the context of a semester-long group project. Please note that this course is intended for ECE master students with a concentration in Software Engineering and will satisfy the "Software Engineering and Design" course area requirement. Prerequisites: Basic software development experience with proficiency in at least one modern programming language and modern programming concepts. Prior to admission, students must successful complete a programming assignment to demonstrate familiarity with required software technologies. Students who have successfully completed 18-652, Foundations in Software Engineering, are not eligible to take this course.

Software Architecture and Design (18-653) – 12 Units

Software Architecture and Design is a one-semester course, aiming to train our graduate students from software engineers toward becoming a Software Architect, who is the ¿Technical Lead¿ of a software project team. The primary objective of the course is to help students develop skills in designing, developing, and justifying reasonable software architecture for enterprise-scale software-intensive systems, considering both functional and non-functional requirements as well as contextual system environments. Core topics include: overview of software architecture, micro architectural patterns (so-called design patterns) and macro architectural patterns (i.e., modern patterns), service oriented architecture, architectural modeling, viewpoints and perspectives, architectural analysis techniques, architectural tactics (QoS), agile architecture, and some advanced topics. Literature survey and study of state-of-the-art technologies, as well as both individual and group project work, are essential ingredients of this class. Research and practical projects build upon one another. Please note that this course is intended for ECE master students with a concentration in Software Engineering and will satisfy the Software Engineering and Design requirement. Anti-requisites: 17-655 from CS Dept. Pre-requisites: 18-652

Software Verification and Testing (18-654) – 12 Units

Verification and testing (V&T) support software engineers and development teams in their endeavor to build dependable systems. These interrelated activities form the backbone of a high-quality software solution that performs its function as intended. V&T is no longer considered an exclusively backend phase undertaken by a separate quality assurance unit, vulnerable to availability of discretionary resources near project end. Rather, V&T is a cross-functional discipline applied throughout the software lifecycle from beginning to end. As such V&T is an integral and essential part of any sensible software development process. This course introduces the students to concepts, principles, theory, types, tools, and techniques of V&T with exposure to both modern, widely-applicable approaches and traditional, formal techniques. Students will acquire sufficient depth and breadth in V&T through a balanced coverage of topics. The course syllabus spans fundamentals such as V&T principles, systematic testing, input space analysis, and test coverage; practical strategies such as test-driven development, unit testing, and test design; and formal approaches such as abstraction, model checking, static analysis, and symbolic execution. Please note that this course is intended for ECE master students with a concentration in Software Engineering and will satisfy the ¿Analysis¿ area core course requirement. Please

note that this course is intended for ECE master students with a concentration in Software Engineering and will satisfy the Analysis area core course requirement.

Decision Analysis and Engineering Economics for Software Engineers (18-657) – 12 Units
Engineering software systems entails continuously making resource and technical decisions at multiple levels subject to different sources of uncertainty, cost-benefit tradeoffs, historical data, and flexibility demands. This course will develop quantitative and modeling skills for economics-based and decision-theoretic reasoning in software engineering through a repertoire of techniques from several fields. Special consideration will be given to reasoning under uncertainty and empirical approaches to tackle a variety of software engineering decision-making problems, including technology, architecture, design, product, and process decisions. The analysis techniques covered will be illustrated through domain-specific examples. Analysis techniques that will be covered include Monte Carlo Simulation, Net Present Value, Expected Value of Information, Decision Tree Analysis, Real Options Theory, Utility Theory, and Analytic Hierarchy Process. Basic data analysis concepts, including descriptives, linear regression, correlation, and hypothesis testing will be explained and used. Examples and fully-developed case studies will illustrate how these techniques can be combined to best leverage their strengths. The course has a practical focus, but includes coverage of the necessary background theories. Orientation is distinctly quantitative. Knowledge of basic probability is required. Pre-requisites: 18-652 (can be taken concurrently)

Software Requirements and Interaction Design (18-658) – 12 Units
Good software systems should be engineered with user experience in mind. How can we design software systems that are at once useful, usable, and enjoyable to use?
This course addresses these challenges by integrating two disciplines: requirements engineering and interaction design. Students learn to combine user research, design-based ideation and validation, and requirements definition, within an agile software development process.
Students apply this knowledge during a semester-long project. Their goal is to envision and implement the first version of an innovative software system that could make a unique contribution to society. The system should address a real problem, satisfy real stakeholders' needs, and provide a superior user experience. Students collaborate closely with their stakeholders throughout the project for needs elicitation, design concepts validation, and usability testing.
This course is intended for ECE master students with a concentration in Software Engineering. It is a core course of the MS-SE program satisfying the "Software Engineering and Design" course area requirement.

Software Engineering Methods (18-659) – 12 Units
There has been a rapid evolution of software engineering development methods over the past decades. From Waterfall to Iterative and Incremental, to Agile and Lean, we have witnessed waves of new methods, each adding significant value to the field. However, the plethora of available methods poses a challenge for software practitioners: Which method should be adopted on a specific software project? Software Engineering Methods addresses this challenge by introducing students to emerging approaches for developing software-intensive systems.

Given the vast spectrum of software development endeavors, these approaches aim at defining custom hybrid methods by focusing on software development principles and practices together with their applicability to specific project contexts. Students learn to analyze the context of a software project and recommend a custom hybrid development method that satisfies the project's specific needs. Students apply this knowledge in the context of a semester-long project where the entire class works together as a team of teams. They define the optimal software development method for their project aimed at evolving an existing software system. They build new system increments by adopting their own method. They monitor their progress and reflect on the effectiveness of their approach and the need for continuous improvement. This course is intended for ECE master students with a concentration in Software Engineering and will satisfy the "Systems" course area requirement. Prerequisites: 18652 or instructor permission

Optimization (18-660) – 12 Units

Many design problems in engineering (e.g., machine learning, finance, circuit design, etc.) involve minimizing (or maximizing) a cost (or reward) function. However, solving these problems analytically is often challenging. Optimization is the study of algorithms and theory for numerically solving such problems, and it underpins many of the technologies we use today. This course is an introduction to optimization. Students will: (1) learn about common classes of optimization problems, (2) study (and implement) algorithms for solving them, and (3) gain hands-on experience with standard optimization tools. We will focus on convex optimization problems, but will also discuss the growing role of non-convex optimization, as well as some more general numerical methods. The course will emphasize connections to real-world applications including machine learning, networking, and finance. The course will involve lectures, homework, exams, and a project.

This course is crosslisted with 18460. Although students in 18460 will share lectures with students in 18660, students in 18460 will receive distinct homework assignments, distinct design problems, and distinct exams from the ones given to students in 18660. Specifically, the homework assignments, design problems and exams that are given to the 18660 students will be more challenging than those given to the 18460 students.

Introduction to Machine Learning for Engineers (18-661) – 12 Units

This course provides an introduction to machine learning with a special focus on engineering applications. The course starts with a mathematical background required for machine learning and covers approaches for supervised learning (linear models, kernel methods, decision trees, neural networks) and unsupervised learning (clustering, dimensionality reduction), as well as theoretical foundations of machine learning (learning theory, optimization). Evaluation will consist of mathematical problem sets and programming projects targeting real-world engineering applications.

Hardware Architectures for Machine Learning (18-663) – 12 Units

Machine learning is poised to change the landscape of computing in more ways than its broad societal applications. Indeed, hardware architectures that can efficiently run machine learning face increasing challenges due to power consumption or run time constraints that technology,

platforms, or users impose. This course provides an overview of current advances in hardware architectures that can enable fast and energy efficient machine learning applications from the edge to the cloud. Topics include hardware accelerators, hardware-software co-design, and general or application specific system design and resource management for machine learning applications.

ULSI Technology Status and Roadmap for System on Chips and System in Package (18-664) – 12 Units

This course provides the necessary background for the state-of-the art technologies utilized by the leading edge products covering full spectrum of market drivers from mobile platforms, microprocessors, game chips to the highest performance systems for enterprise solutions computing. We will present all key components of such systems, i.e., logic, analog/RF and embedded memories. Then we present the technology roadmap for the upcoming generations in terms of device architecture options for logic devices (FinFET, Nanowire and Tunnel FET) and memories (Phase Change Memory , Resistive RAM and Magnetic RAM/Spin-Transfer Torque RAM) from the device level all the way to the system level specifications. The last part of the class will be devoted to the system integration issues, namely 3-dimensional integration approaches. This course is designed for MS and PhD students from diverse areas: System/Hardware Design, Circuits and Devices/Nanofabrication and is aimed at bridging the gap among these areas.

Analytical Performance Modeling & Design of Computer Systems (18-687) – 12 Units

In designing computer systems one is usually constrained by certain performance requirements. For example, certain response times or throughput might be required of the system. On the other hand, one often has many choices: One fast disk, or two slow ones? What speed CPU will suffice? Should we invest our money in more buffer space, or a faster processor? Which migration policy will work best? Which task assignment policy will work best? How can we redesign the scheduling policy to improve the system performance? Often answers to these questions are counter-intuitive. Ideally, one would like to have answers to these questions before investing the time and money to build a system. This class will introduce students to analytic stochastic modeling with the aim of answering questions such as those above. Topics covered include Operational Laws, Markov Chain Theory, Queuing Theory, Modeling Empirical Loads, Simulations, and Management of Server Farms.

Introduction to Neuroscience for Engineers (18-690) – 12 Units

The first half of the course will introduce engineers to the neurosciences from the cellular level to the structure and function of the central nervous system (CNS) vis-à-vis the peripheral nervous system (PNS) and include a study of basic neurophysiology; the second half of the course will review neuroengineering methods and technologies that enable study of and therapeutic solutions for diseases or damage to the CNS. A goal of this course is to provide a taxonomy of neuroengineering technologies for research or clinical application in the neurosciences. This course is cross listed with 42-630

Statistical Discovery and Learning (18-697) – 12 Units

This course is designed to give students a thorough grounding in the methods, theory, mathematics and algorithms needed to do research and applications in machine learning. The topics of the course draw from machine learning, classical statistics, data mining, Bayesian statistics and information theory and other areas. This course is project-oriented and is intended to give students abundant hands-on experience with different machine learning algorithms. Students who have already taken CS 10-701/15-781 Machine Learning should not take this course.

Neural Signal Processing (18-698) – 12 Units
The brain is among the most complex systems ever studied. Underlying the brain's ability to process sensory information and drive motor actions is a network of roughly 1011 neurons, each making 103 connections with other neurons. Modern statistical and machine learning tools are needed to interpret the plethora of neural data being collected, both for (1) furthering our understanding of how the brain works, and (2) designing biomedical devices that interface with the brain. This course will cover a range of statistical methods and their application to neural data analysis. The statistical topics include latent variable models, dynamical systems, point processes, dimensionality reduction, Bayesian inference, and spectral analysis. The neuroscience applications include neural decoding, firing rate estimation, neural system characterization, sensorimotor control, spike sorting, and field potential analysis. Prerequisites: 18-290; 36-217, or equivalent introductory probability theory and random variables course; an introductory linear algebra course; senior or graduate standing. No prior knowledge of neuroscience is needed

Technical Writing for Engineers: Linguistic Foundations (18-701) – 6 Units
Mini 1 (Linguistic Foundations) is designed for engineering students who are preparing for taking Qualifying exams. We will review the structure of Quals that have succeeded and Quals that have been less successful. Students will learn the linguistic foundations of successful overview papers (like those required in Qualifying exams). They will learn the linguistic basis of appropriate citation and the competent elaboration of the work of others. They will learn effective linguistic practices of transitioning from the work of others to their own work and elaborating their own work. They will learn principles of concision, character/action, topical coherence, cohesion, and emphasis, principles that work together to provide the written portion of a Qualifying exam with an easy flow and readability. They will learn how this system of principles can help them detect gaps in knowledge they will need to fill in by the time of the oral examination, if not in the written portion of the Qual itself. To the greatest extent possible, students will learn to apply these linguistic principles on the written portion of the Quals they are preparing that semester or have prepared in previous semesters. Prerequisites: ECE PhD standing is required.

Technical Writing for Engineers: Genre Foundations (18-702) – 6 Units
Mini 2 (Genre Foundations) is designed for engineering students ready to focus on archival genres that report new knowledge, genres including but not limited to conference papers and journal publications. Students will learn principles of academic novelty and its history in the Royal Society. We will use customized software that give students a "zoomed-in" look at the impressive variety through which introductions establish significance and how they open a "gap" that the author's research was designed to fill. We will overview the important genre features and

functions of the various sections of the archival paper. Students are expected to bring to the course archival documents they are currently preparing to submit. Students will use the mini to execute a systematic revision of their document based on the genre functions and features discussed. Prerequisites: ECE PhD standing is required.

Managing and Leading Research and Development (18-703) – 12 Units

This course will provide an insider's look at issues in industrial research and development laboratories that future industrial R&D personnel are likely to face.

The instructor, Prof. Mark Kryder spent nine years as Chief Technical Officer and Senior Vice President, Research for Seagate Technology, the largest disk drive manufacturer in the world. In the course, he will try to give students an improved understanding of how research and development are done in a major high-tech firm today.

The course is built around the instructor's personal experiences, but also draws heavily from business management literature and business case studies. It is expected that the course will make the transition from the university to industry easier and faster for students who have taken it and enable them to become more effective in an industrial setting in a shorter period of time.

Examples of issues to be discussed will be the impact of various organizational structures upon R&D; What characteristics are desired in a research staff member vs. a staff development engineer?, What is the importance of diversity in a R&D setting? What are the relative importances of technology, marketing expertise and corporate business models in determining success of a product?; What is meant by "corporate culture" and how does it get defined?; How important are collaboration and teamwork in R&D and are they different?; What is Six Sigma and how important is it in today's business world?; How do you measure performance in R & D?, how do you effectively transfer technology from research to development?; how can you effectively leverage university research and industrial consortia?: How important is intellectual property in various industries? How important is corporate size?: What is the role of technology vision?; What are the effects of globalization on R&D?; What is a technology steering council and how can it be used to facilitate technology transfer and development?

Advanced Cloud Computing (18-709) – 12 Units

Computing in the cloud has emerged as a leading paradigm for cost-effective, scalable, well-managed computing. Users pay for services provided in a broadly shared, power-efficient datacenter, enabling dynamic computing needs to be met without paying for more than needed. Actual machines may be virtualized into machine-like services, abstract programming platforms, or application-specific services, with the cloud infrastructure managing sharing, scheduling, reliability, availability, elasticity, privacy, provisioning and geo-replication.

This course will survey the aspects of cloud computing through about 30 papers and articles, executing cloud computing tasks on a state-of-the-art cloud computing service, and implementing a change or feature in a state-of-the-art cloud computing framework. There will be no final exam, but there will be one or two in-class exams. Grades will be about 50% project work and about 50% examination results.

Elements of Photonics for Communication Systems (18-712) – 12 Units

The aim of this course is to provide students with a basic understanding of the elements of photonics, including the necessary primary devices that form the building blocks of modern optical communication systems. The photon is the fundamental unit particle of light, with frequencies in the range of several hundred Terahertz (~100 x 1012 Hz). It is a fact of the fundamental theorem of communication that information capacity increases directly with frequency. It is no wonder then that photonic communication systems have become the backbone of modern, ultra-fast and high capacity communication networks. The use of light in communication systems involves the generation, transmission, and detection of photons, along with the encoding (modulation) of signals of interest onto the light carrier wave, and the subsequent decoding (de-modulation) at the destination.

This course begins with an introduction to basic electromagnetic theory (in the frequency range that corresponds to light). The introduction includes Maxwell's equations in both free space and dielectric media. The scalar wave equation derived from the vector Maxwell equations is solved in free space as well as in dielectric media, taking into account the boundary conditions that affect the transmission and reflection of light at the dielectric interfaces. This background is then used in the discussion of the dielectric slab and the related fiber-optic waveguide that is used in the transmission of optical signals in short- and long-haul communication systems.

The course continues with a discussion of semiconductor light generators, with a particular focus on edge-emitting and surface-emitting lasers. Photon detectors—of the semiconductor variety—are then discussed. The course ends with a discussion of other important optical components such as modulators, filters, couplers, multiplexers and demultiplexers. Prerequisites: 18-300 and 18-310 and (18-402 or 33-439) and senior or graduate standing.

Physics of Applied Magnetism (18-715) – 12 Units

In this course we address the physics of magnetism of solids with emphasis on magnetic material properties and phenomena which are useful in various applications. Various applications of magnetism are used to motivate the understanding of the physical properties and phenomena. The content of this course includes the origins of magnetism at the atomic level and the origins of magnetic ordering (ferro-, ferri-, and antiferro-magnetism), magnetic anisotropy, magnetic domains, domain walls, spin dynamics and electronic transport at the crystalline level. The principles of magnetic crystal symmetry, tensors, and energy minimization are utilized to explore magnetic properties such as resonance, domain structures, magnetocrystalline anisotropy, magnetostriction and magnetoelasticity, and susceptibility. Phenomenological properties, such as the technical magnetization process, are used to describe mechanisms of coercivity, eddy current effects and losses, while energy minimization and relaxation are used to explain properties such as single domain particle behavior, memory mechanisms, magnetic aftereffects and thermal stability. Prerequisite: 18-300 or equivalent background in electromagnetic fields; Senior level solid state physics and materials, or the equivalent, and a senior or graduate student standing.

Advanced Analog Integrated Circuits Design (18-721) – 12 Units

This course will familiarize students with advanced analog integrated circuit design issues. Analog circuit design issues play an important role in creating modern ICs. First and foremost, analog circuits act as the interface between digital systems and the real world. They act to amplify and filter analog signals, and to convert signals from analog to digital and back again. These analog interfaces appear in all communications devices (e.g., cell phones) both to condition the "transmitted" signal and as sensitive "receivers." In addition, these analog interfaces appear in sensors (e.g., accelerometer). The goal of this course is to familiarize students with some of the advanced analog circuit design ideas that are involved in these tasks. Specific topics will include analog filtering (continuous-time and discrete-time), sample-and-hold amplifiers, analog-to-digital converters, digital-to-analog converters. Prerequisites: 18-623 (was 18-523 before Fall 2005) and senior or graduate standing.

RFIC Design and Implementation (18-723) – 12 Units
This course covers the design and analysis of radio-frequency integrated systems at the transistor level using state of the art CMOS and bipolar technologies. It focuses on system-level trade-offs in transceiver design, practical RF circuit techniques, and physical understanding for device parasitics. Accurate models for active devices, passive components, and interconnect parasitics are critical for predicting high-frequency analog circuit behavior and will be examined in detail. The course will start with fundamental concepts in wireless system design and their impact on design trade-offs in different transceiver architectures. Following that, RF transistor model, passive matching networks will be discussed. Noise analysis and low-noise amplifier design are studied next. The effects of nonlinearity are treated along with mixer design techniques. Practical bias circuit for RF design will be illustrated. Then, the importance of phase noise and VCO design will be considered together. The course will conclude with a brief study of frequency synthesizer and power amplifier design. Senior or graduate standing required.

Advanced Digital Integrated Circuit Design (18-725) – 12 Units
The purpose of this course is to study the design process of VLSI CMOS circuits. This course covers all the major steps of the design process, which include: logic, circuit and layout design. A variety of computer-aided tools are discussed and used in class. The main objective of this course is to provide VLSI design experience that includes design of basic VLSI CMOS functional blocks, verification of the design, testing and debugging. During the course, one complex VLSI project is submitted for fabrication. 4 hrs. lec.

Introduction to Computer Security (18-730) – 12 Units
This course provides a principled introduction to techniques for defending against hostile adversaries in modern computer systems and computer networks. Topics covered in the course include operating system security; network security, including cryptography and cryptographic protocols, firewalls, and network denial-of-service attacks and defenses; user authentication technologies; security for network servers; web security; and security for mobile code technologies, such as Java and Javascript. More advanced topics will additionally be covered as time permits, such as: intrusion detection; techniques to provide privacy in Internet applications; and protecting digital content (music, video, software) from unintended use. Anti-requisites: 18-631 and 18-487

Network Security (18-730) – 12 Units
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to advance attacks on end systems. This course provides an in-depth study of network attack techniques and methods to defend against them. Topics include firewalls and virtual private networks; network intrusion detection; denial of service (DoS) and distributed denial-of-service (DDoS) attacks; DoS and DDoS detection and reaction; worm and virus propagation; tracing the source of attacks; traffic analysis; techniques for hiding the source or destination of network traffic; secure routing protocols; protocol scrubbing; and advanced techniques for reacting to network attacks. Prerequisite: 18-630 OR 18-730, and senior or graduate standing.

Secure Software Systems (18-732) – 12 Units
Poor software design and engineering are the root causes of most security vulnerabilities in deployed systems today. Moreover, with code mobility now commonplace--particularly in the context of web technologies and digital rights management--system designers are increasingly faced with protecting hosts from foreign software and protecting software from foreign hosts running it. This class takes a close look at software as a mechanism for attack, as a tool for protecting resources, and as a resource to be defended. Topics covered include the software design process; choices of programming languages, operating systems, databases and distributed object platforms for building secure systems; common software vulnerabilities, such as buffer overflows and race conditions; auditing software; proving properties of software; software and data watermarking; code obfuscation; tamper resistant software; and the benefits of open and closed source development. Senior or graduate standing required.

Applied Cryptography (18-733) – 12 Units
A wide array of communication and data protections employ cryptographic mechanisms. This course explores modern cryptographic (code making) and cryptanalytic (code breaking) techniques in detail. This course emphasizes how cryptographic mechanisms can be effectively used within larger security systems, and the dramatic ways in which cryptographic mechanisms can fall vulnerable to cryptanalysis in deployed systems. Topics covered include cryptographic primitives such as symmetric encryption, public key encryption, digital signatures, and message authentication codes; cryptographic protocols, such as key exchange, remote user authentication, and interactive proofs; cryptanalysis of cryptographic primitives and protocols, such as by side-channel attacks, differential cryptanalysis, or replay attacks; and cryptanalytic techniques on deployed systems, such as memory remanence, timing attacks, and differential power analysis. Senior or graduate standing required.

Foundation of Privacy (18-734) – 12 Units
Privacy is a significant concern in modern society. Individuals share personal information with many different organizations - healthcare, financial and educational institutions, the census bureau, web services providers and online social networks - often in electronic form. Privacy violations occur when such personal information is inappropriately collected, shared or used. We

will study privacy in a few settings where rigorous definitions and enforcement mechanisms are being developed - statistical disclosure limitation (as may be used by the census bureau in releasing statistics), semantics and logical specification of privacy policies that constrain information flow and use (e.g., by privacy regulations such as the HIPAA Privacy Rule and the Gramm-Leach-Bliley Act), principled audit and accountability mechanisms for enforcing privacy policies, anonymous communication protocols - and other settings in which privacy concerns have prompted much research, such as in social networks, location privacy and Web privacy (in particular, online tracking & targeted advertising).

Special Topics in Computer Systems: Engineering Safe Software Systems (18-737) – 12 Units
Modern software systems suffer from poor reliability and security due to overwhelming complexity. Traditional software testing and debugging, which account for more than half the cost of software development, often fail to find critical bugs in software. In recent years there has been an increasing interest in developing automated techniques for improving software reliability. These techniques combine ideas from program analysis, constraint solving, and model checking and have shown great promises in making software more reliable and secure. In this course, we will study these new techniques, with emphasis on automated test-case generation based on symbolic execution and fuzz testing. We will see how these techniques can be used for detecting bugs in software, finding performance bottlenecks, detecting and preventing security vulnerabilities, and analyzing the reliability of software components. We will further study component-based verification and emerging techniques for automated software repair. Finally, we will discuss challenges related to the analysis of systems with deep learning components, which have a simpler structure than more traditional software but tend to be massive in scale. Senior or graduate standing required.

Sports Technology (18-738) – 12 Units
The course's lecture content will cover background material on key aspects of sports technology, including topics such as computer vision, artificial intelligence, data mining, the physics of sports and understanding of real-world systems and guest lectures from experts in the field. The topics covered in depth will include the types of sensors and algorithms used in real-world systems deployments today, as well as new applications of the Internet of Things to different aspects of sports, including training, performance, coaching, etc.
This course also comprises a semester-long project experience and research paper geared towards the development of skills to design realistic and practical embedded/mobile systems and applications that enhance various aspects of the training, coaching, playing and scouting of different sports, including football, hockey, baseball, soccer, etc. Students will work in teams on a project that will involve the hands-on design, configuration, engineering, implementation and testing of an embedded-system prototype of an innovative sports technology of their choice. Students will be expected to leverage proficiency and background gained from other courses, particularly with regard to embedded real-time principles, software systems and embedded programming. The project will utilize a synergistic mixture of skills in system architecture, modular system design, software engineering, subsystem integration, debugging and testing. From inception to demonstration of the prototype, the course will follow industrial project

practices, such as version control, design requirements, design reviews, user studies and quality assurance plans. Advanced undergraduate or graduate standing required.

Computer Architecture – (18-740) – 12 Units
The Internet has transformed our everyday lives, bringing people closer together and powering multi-billion dollar industries. The mobile revolution has brought Internet connectivity to the last-mile, connecting billions of users worldwide. But how does the Internet work? What do oft repeated acronyms like "LTE", "TCP", "WWW" or a "HTTP" actually mean and how do they work? This course introduces fundamental concepts of computer networks that form the building blocks of the Internet. We trace the journey of messages sent over the Internet from bits in a computer or phone to packets and eventually signals over the air or wires. We describe concepts that are common to and differentiate traditional wired computer networks from wireless and mobile networks. Finally, we build up to exciting new trends in computer networks such as the Internet of Things, 5-G and software defined networking. Topics include: physical layer and coding (CDMA, OFDM, etc.); data link protocol; flow control, congestion control, routing; local area networks (Ethernet, Wi-Fi, etc.); transport layer; and introduction to cellular (LTE) and 5-G networks. A final project asks you to a build a HTTP video server of your own. This course is cross-listed with 18-441 - both editions will share Lectures and Recitations. However, students in the two courses will receive different exams and will have a different project. The students in the two versions of the course will be graded on a separate curve.

Computer Architecture and Systems (18-742) – 12 Units
Historically, the performance and efficiency of computers has scaled favorably (according to "Moore's Law") with improvements at the transistor level that followed a steady trend (so-called "Dennard scaling"). Unfortunately, device scaling has hit a limit on performance and power improvements dictated by physical device properties. To continue to make systems capable, fast, energy efficient, programmable, and reliable in this "post-Dennard" era, computer architects must be creative and innovate across the layers of the system stack. This course begins with a recap of conventional, sequential computer architecture concepts. We will then discuss the end of convention, brought about by the end of Dennard Scaling and Moore's Law, and several trends that these changes precipitated. The first trend is the wholesale shift to parallel computer architectures and systems, covering parallel hardware and software execution models, cache coherence, memory consistency, synchronization, transactional memory, and architecture support for programming, debugging, and failure avoidance. The second trend is the shift to incorporating specialized, heterogeneous components into parallel computer architectures. Topics will include reconfigurable architectures, FPGAs in the datacenter, ASIC accelerators, GPGPU architectures, and the changes to the system stack that these components demand. The third trend is the emergence of newly capable hardware and software systems and new models of computation. Topics will include approximate and neuromorphic computing, intermittent computing, emerging non-volatile memory and logic technologies, and analog and asynchronous architectures, and may include future emerging topics.

Energy Aware Computing (18-743) – 12 Units

This course provides a comprehensive coverage of topics related to energy aware and green computing. While it is widely recognized that power consumption has become the limiting factor in keeping up with increasing performance trends, static or point solutions for power reduction are beginning to reach their limits. This course is intended to provide an insight into: (i) power and energy consumption modeling and analysis; (ii) energy aware computing, i.e., how various power reduction techniques can be used and orchestrated such that the best performance can be achieved within a given power budget, or the best power efficiency can be obtained under prescribed performance constraints; and (iii) green computing in the context of large scale computing systems or smart grid-aware computing. Recommended: basic VLSI design, basic computer system organization, basic compiler design and OS knowledge. Prerequisites: Senior or Graduate Standing.

Connected Embedded Systems Architecture (18-744) – 12 Units

Connected Embedded Systems Architecture (CESA) is a one-semester lab-based course that addresses the core concepts of modern embedded systems with a particular emphasis on the emerging field of apps that span small, embedded devices (including wearable electronics, so-called Internet of Things devices, and mobile phones) to the cloud. We will examine the evolution of the nature of IoT from the early days of wireless sensor networks to the future vision of federated, time-synchronized, scalable, virtualized "fog computing" platforms.

The course is designed to take a systems approach and, as such, will include relevant topics from both software (cloud, network, device) and hardware (network and device). The course content is aimed at systems engineers who wish to architect, develop and deploy cloud-connected embedded systems in which the "apps" change, mature and evolve over time. The course stresses the creation of engineering frameworks in which tradeoffs can be rationally made between computing and storage that should be done on coin-cell-powered devices vs. computing and storage that should be done in the network or in the cloud.

Rapid Prototyping of Computer Systems (18-745) – 12 Units

This is a project-oriented course which will deal with all four aspects of project development; the application, the artifact, the computer-aided design environment, and the physical prototyping facilities. The class, in conjunction with the instructors, will develop specifications for a mobile computer to assist in inspection and maintenance. The application will be partitioned between human computer interaction, electronics, industrial design, mechanical, and software components. The class will be divided into groups to specify, design, and implement the various subsystems. The goal is to produce a working hardware/software prototype of the system and to evaluate the user acceptability of the system. We will also monitor our progress in the design process by capturing our design escapes (errors) with the Orthogonal Defect Classification (ODC). Upon completion of this course the student will be able to: generate systems specifications from a perceived need; partition functionality between hardware and software; produce interface specifications for a system composed of numerous subsystems; use computer-aided design tools; fabricate, integrate, and debug a hardware/software system; and evaluate the system in the context of an end user application. This course is cross-listed as 18540.

Storage Systems (18-746) – 12 Units
This course covers the design, implementation, and use of storage systems, from the characteristics and operation of individual storage devices through the OS, database, and networking approaches involved in tying them together and making them useful to key applications' demands and technology trends. Topics to be covered include: network-attached storage, disk arrays, storage networking, storage management, advanced file systems, disk performance enhancement, wide-area data sharing, and storage security. 3 hrs. lec. The class will continue to be like previous years, with the same advanced content and high-level expectations.

Wireless Device Architecture (18-747) – 12 Units
Growth of the Internet of Things depends on semiconductor devices ¿ systems-on-chip (SoC) ¿ with significant computational, communications and sensing capabilities. Integration of entire systems on one or a very small number of dies has made it possible to deploy hundreds of billions of end-points that will link the cyber world with the physical world. At this scale, a key design requirement is that such devices can be handled at most once during their lifetime. Batteries should be life-long, and reprogramming should be over-the-air. How then should such devices be architected? We begin by examining modern digital communications including modulation and coding schemes, basic RF subsystems and antennas. We examine the computational structures that allow us to reduce communication to computation. Anticipating that such devices will need to be highly programmable, we consider concepts from traditional computer architecture and their applicability to this energy-constrained domain. We also examine the rapid evolution of transducer technologies and how these are being integrated into SoCs. Then, we consider how an architect can make tradeoffs across these domains to meet design objectives. Students will take advantage of a purpose-built experimental platform called PowerDué that enables deep exploration of these topics in realistic applications. Background in computer architecture, signals and systems, and E&M field theory is recommended. Graduate standing is required to register for this course.

Wireless Sensor Networks (18-748) – 12 Units
The use of distributed wireless sensor networks have surged in popularity in recent years with applications ranging from environmental monitoring, to people- and object-tracking in both cooperative and hostile environments. This course is targeted at understanding and obtaining hands-on experience with the state of the art in such wireless sensor networks which are often composed using relatively inexpensive sensor nodes that have low power consumption, low processing power and bandwidth. The course will span a variety of topics ranging from radio communications, network stack, systems infrastructure including QoS support and energy management, programming paradigms, distributed algorithms and example applications. Some guest lectures may be given. Each discussion-oriented lecture will be preceded by the reading of 1-2 papers, resulting in a rich collection of papers by the end of the semester. Early in the semester, hands-on exercises will be used to teach the programming of FireFly sensor nodes by using the 'nano-RK' power-aware sensor real-time operating system (RTOS) and using 802.15.4 radio communications. Then, project groups of no more than 3 students will define, design, implement and test a sensor network project. Final in-class project presentations will be

supplemented by a written report. A final exam may be conducted to evaluate the students' understanding of the materials covered. Grading criteria will include classroom participation, course project content and report, and a final exam. Class size will be limited to 20 students or less. Hands-on experience with network programming, operating systems and assembly language are essential. Exceptions only with explicit permission of instructor. Prerequisites: 15-213 and ((18-348 or 18-349) or 15-410), and senior or graduate standing.

Building Reliable Distributed Systems (18-749) – 12 Units

The course provides an in-depth and hands-on overview of designing and developing reliable distributed systems, throughout a system?s lifecycle, starting from fault-tolerant design and execution (replication, group communication, databases) to fault-recovery (fault-detection, logging, check-pointing, failure-diagnosis) for various classes of faults (crashes, communication errors, software upgrades). The course will cover real-world practices for reliability, supplemented by case studies of large-scale downtime incidents. The concepts will be taught in the context of contemporary cloud-computing platforms, and the course will include a hands-on project that involves the design, implementation and empirical evaluation of a reliable distributed cloud-based system. Students will be taught to write, review, and present a conference-style research paper by the end of the semester, with the goal of documenting the design, lessons learned and experimental results of their team project. Students can expect to learn about the reliability issues underlying cloud computing, the tools and best practices for implementing and evaluating reliability, and the strengths and weaknesses of current cloud-computing platforms from the perspective of reliability. Prerequisites: Graduate standing or instructor permission

Wireless Networks and Applications (18-750) – 12 Units

This course introduces fundamental concepts of wireless networks. The design of wireless networks is influenced heavily by how signals travel through space, so the course starts with an introduction to the wireless physical layer, presented in a way that is accessible to a broad range of students. The focus of the course is on wireless MAC concepts including CSMA, TDMA/FDMA, and CDMA. It also covers a broad range of wireless networking standards, and reviews important wireless network application areas (e.g., sensor networks, vehicular) and other applications of wireless technologies (e.g., GPS, RFID, sensing, etc.). Finally, we will touch on public policy issues, e.g., as related to spectrum use. The course will specifically cover: Wireless networking challenges Wireless communication overview Wireless MAC concepts Overview of cellular standards and LTE Overview of wireless MAC protocols WiFi, bluetooth and personal area networks, etc. Wireless in today's Internet: TCP over wireless, mobility, security, etc. Advanced topics, e.g., mesh and vehicular networks, sensor networks, DTNs, localization, sensing, etc. Although students in 18-750 will share Lectures and Recitations with students in 18-452, they will receive distinct homework assignments and exams from students in 18-452. The main project will also be different. The students in the two version of the course will also be graded on a separate curve.

Applied Stochastic Processes (18-751) – 12 Units

Basic probability concepts : Probability space, simple and compound events, statistical independence, and Bayes Rule. Total Probability Concept; Bernoulli trials; Poisson Law. De Moivre-Laplace Theorem. Definition of a Random Variable (RV); Probability distribution of an RV: cumulative distribution function (CDF) and probability density function (PDF). Two Random Variables; several Random Variables. Functions of RV?s; conditional distributions; conditional expectations; joint distributions. Moments, generating functions, and characteristic functions of RVs. Chebyshev inequality. Estimation; linear estimation; minimum mean square estimation; and orthogonality principle. Limit theorems; Central Limit Theorem; Law of Large Numbers (both strong LLN and Weak LLN). Definition of a Random Process (RP). Different notions of stationarity. Poisson and Gaussian processes. Autocorrelation and Power Spectral Density (PSD) of an RP. Processing of random (stochastic) processes by linear systems. Ergodicity. Spectral analysis. Matched Filtering. Selected applications from telecommunications, data networking (queuing), Kalman filtering.

Estimation, Detection and Learning (18-752) – 12 Units

This course discusses estimation, detection, identification and machine learning, covering a variety of methods, from classical to modern. In detection, the topics covered include hypothesis testing, Neyman-Pearson detection, Bayesian classification and methods to combine classifiers. In estimation, the topics include maximum-likelihood and Bayesian estimation, regression, prediction and filtering, Monte Carlo methods and compressed sensing. In identification and machine learning, topics include Gaussian and low-dimensional models, learning with kernels, support vector machines, neural networks, deep learning, Markov models and graphical models.

Information Theory (18-753) – 12 Units

The first half of the course comprises of the concepts of entropy, mutual information, the Asymptotic Equipartition property, applications to source coding (data compression), applications to channel capacity (channel coding), differential entropy and its application to waveform channel capacities, and a subset of advanced topics such as network information theory, or rate-distortion theory, as time permits. The second half of the course comprises finite-field algebra, Hamming codes, cyclic codes (CRC and BCH codes), a brief introduction to Reed-Solomon codes, and perhaps universal codes (Lempel-Ziv coding). Prerequisites: 36-217 and senior or graduate standing.

Error Control Coding: Theory and Applications (18-754) – 12 Units

Modern digital communication systems and digital data storage systems owe their success, in part to the use of error control coding. By careful insertion of redundant bits or symbols in the transmitted or stored bit streams, the receiver can detect and correct errors induced by channel impairments such as noise, inter-symbol interference and noise. For example, compact disc (CD) owes its ruggedness to the use of cross-interleaved Reed-Solomon (CIRC) code. High-speed networks employ Cyclic Redundancy Check (CRC) to ensure that the data was transmitted accurately. This course is aimed at introducing the basic theory and select applications of error control coding (ECC). Towards that goal, following topics will be covered. Mathematical background Linear block codes Low density parity check (LDPC) codes Cyclic codes Reed-Solomon

(RS) codes Convolutional codes Turbo codes Example application of ECC in digital communications Example application of ECC in digital data storage.

Networks in the Real World (18-755) – 12 Units
18-755 is a graduate-level course that focuses on networks and their applications to various natural and technological systems. Specifically, this class delves into the new science behind networks and their concrete applications technological, biological, and social systems, as well as various design synergies that exist when looking at these systems from a cyber-physical perspective. By scope and contents, this is not just another class on ?networks?. Want to know how complex networks dominate our world? How communities arise in social networks? How group behavior dominates Twitter? How swarms of bacteria can navigate inside the human body? How patterns of interaction can be identified in hardware and software systems? Want to work on cutting edge projects involving systems and synthetic biology? Or social networks? Or networks-on-chip and internet-of-things? Then this class is for you! Course requirements consist of a few homework assignments, a semester-long project, and in-class presentations of relevant papers. By structure and contents, this class targets primarily the computer engineering and computer science students, but it also provides a valuable foundation for interdisciplinary research to students in related disciplines. Senior or graduate standing standing is required to take this course.

Packet Switching and Computer Networks (18-756) – 12 Units
This course is designed to provide graduate students an understanding of the fundamental concepts in computer networks of the present and the future. In the past, the scarce and expensive resource in communication networks has been the bandwidth of transmission facilities. Accordingly, the techniques used for networking and switching have been chosen to optimize the efficient use of this resource. These techniques have differed according to the type of information carried: circuit switching for voice and packet switching for data. It is expected that elements of circuit and packet switching will be used in the integrated networks. This course focuses on packet switching for computer networks and protocol design. Topics in the course include: computer networks over-view; OSI layers, queuing theory; data link protocol; flow control; congestion control; routing; local area networks; transport layer. The current networks and applications will be introduced through the student seminars in the last weeks of the course. 4 hrs. lec. Prerequisites: 18-345 and senior or graduate standing.

Network Management and Control (18-757) – 12 Units
This course provides an understanding of the principles of broadband networks. The broadband networks differ from currently existing communication networks in many aspects and these issues will be dealt with in the course. Broadband networks are designed to support many different services, ranging from low bandwidth (telemetry) to high bandwidth applications (digitized video). The course will cover the underlying concepts of the broadband networks, and expose the research problems in next generation networks. Many concepts (ATM, SONET, MPLS, high-speed switching architecture, high-speed network control, unified control plane (GMPLS), and optical networks) will be discussed. The course project will explore latest network

technologies, design networking systems, and evaluate via simulation techniques. 4 hrs. lec. Prerequisites: A course in probability; 18-756 and senior or graduate standing.

Wireless Communications (18-758) – 12 Units
In this course, the communication problem will be introduced, and channel impairments such as noise, inter-symbol interference and fading will be described. Solutions to combat these impairments, based on digital communication theory, will be described. These will include signal space analysis, detection, equalization, coding and diversity. Examples drawn from communication standards will illustrate how the theory is implemented in practical communication systems.

Wireless Networks (18-759) – 12 Units
In this course, we will do a quick review of wireless communications and networking principles which will be the basis of more advanced work and research. The emphasis will be on understanding the impact of mobility and connectivity that can be provided or supported by different wireless networks. To this end, wireless communications standards such as GSM (2G), 3G, 4G, and the ongoing work on 5G in addition to key wireless technologies such as Bluetooth, WiFi, Zigbee, RFID, and WiMax will be reviewed. Then, we will study the key papers in the following hot topics in wireless networking: 1) Ad Hoc Wireless Networks and Sensor Networks; 2) Self-organizing networks and adaptive complex networks; 3) Cognitive Networks; 4) Vehicular Ad Hoc Networks; 5) Social Networks; 6) The challenges of 5G wireless networks; 7) Internet of Things (IoT); 8) Role of Artificial Interference (AI) and Machine Learning (ML) in wireless networks.

VLSI CAD: Logic to Layout (18-760) – 12 Units
A large digital integrated circuit (IC) may require 100,000 lines of high-level description in a hardware modeling language, which then turns into 10,000,000 logic gates, which ultimately end up as 1 billion polygons on the masks that define the integrated circuit. This course describes in detail the important CAD tools that perform the many steps of the transformation from Boolean equations to fabrication masks. We focus on mathematical models, algorithms, and data structures. We will write programs for simple versions of these tools. We will look at, and experiment with, a few real tools. The course covers a review of Boolean algebra, followed by (i) synthesis tools for 2-level and multi-level logic, that transform Boolean equations and finite state machine descriptions into optimized logic, and (ii) verification tools that decide whether the logic you built does the same thing as the specification you started with. Finally, the course covers geometric layout synthesis tools for component partitioning, placement, and wire routing and timing verification tools that determine if performance constraints are met. The CAD algorithms covered in the lectures are applicable not only to VLSI systems, but also to non-silicon applications (e.g., social computing, biology, financial).

Circuit Simulation: Theory and Practice (18-762) – 12 Units
This course explores the models, numerical methods and algorithms that are used for simulation and optimization of circuits. The course begins with coverage of the algorithms that are used in the ubiquitous SPICE program and its many variants. This is followed by an overview of the

numerous analog and digital simulation techniques that have followed since the introduction of SPICE. The course further covers some of the most recent modeling and simulation work including, but not limited to, model order reduction, harmonic balance methods, nonlinear macromodeling, compact device modeling, and statistical timing analysis. Finally, the use of circuit simulation algorithms for non-circuit problems will be explored. 4 hrs. lec.

Digital System Testing and Testable Design (18-675) – 12 Units

For this course, time- and topic-indexed videos of lecture, homework, projects, etc. will be available from the online learning portal/website. In addition to these resources, two 1-hour live sessions are scheduled per week for recitation. Each student is strongly urged to attend one of these two sessions each week, either remotely or in the classroom on the Carnegie-Mellon Pittsburgh campus. This course examines in depth the theory and practice of fault analysis, test generation, and design for testability for digital ICs and systems. The topics to be covered include circuit and system modeling; fault sources and types; the single stuck-line (SSL), delay, and functional fault models; fault simulation methods; automatic test pattern generation (ATPG) algorithms for combinational and sequential circuits, including the D-algorithm, PODEM, FAN, and the genetic algorithm; testability measures; design-for-testability; scan design; test compression methods; logic-level diagnosis; built-in self-testing (BIST); VLSI testing issues; and processor and memory testing. Advance research issues, including topics on MEMS and mixed-signal testing are also discussed. 4 hours of lecture per week Prerequisites: 18-240 and 15-211 and (18-340 or 18-341) Senior or graduate standing required.

Linear Systems (18-771) – 12 Units

A modern approach to the analysis and engineering applications of linear systems. Modeling and linearization of multi-input-- multi-output dynamic physical systems. State-variable and transfer function matrices. Emphasis on linear and matrix algebra. Numerical matrix algebra and computational issues in solving systems of linear algebraic equations, singular value decomposition, eigenvalue-eigenvector and least-squares problems. Analytical and numerical solutions of systems of differential and difference equations. Structural properties of linear dynamic physical systems, including controllability, observability and stability. Canonical realizations, linear state-variable feedback controller and asymptotic observer design. Design and computer applications to electronic circuits, control engineering, dynamics and signal processing. 4 hrs. lec. Pre-Reqs: 18-470 or 18-474 and Graduate standing in CIT or MCS.

Non Linear Control (18-776) – 12 Units

This course provides an introduction to the analysis and design of nonlinear systems and nonlinear control systems; stability analysis using Lyapunov, input-output and asymptotic methods; and design of stabilizing controllers using a variety of methods selected from linearization, vibrational control, sliding modes, feedback linearization and geometric control. 4 hrs. lec.

Complex Large-Scale Dynamic Systems (18-777) – 12 Units

This course is motivated by the ever-growing complexity of man-made dynamic systems and the need for flexible monitoring, operations and design techniques for such systems. Of particular interest are systematic model-based methods for relating the key real-life problems for such

systems and the state-of-the-art techniques for large-scale dynamic systems. Examples of such real-life complex systems are critical man-made infrastructure systems (electric power systems, gas networks, transport industries, data networks, and their interdependencies) as well as large-scale systems on chips. In this course we will first review the traditional large-scale methods for model simplification (aggregation), time scale separation of sub-processes and singular perturbation techniques to account for these, stability analysis, and estimation and control. In the second, novel part of this course, we recognize the highly interactive nature of the evolving complex systems, in which much monitoring, data gathering, and decision making is made at the lower, physical levels of the system, and some coordination exists at the higher system level at which physical layers interact. Several conceptual challenges are posed for minimal coordination of such decision makers under high uncertainties, in order to have predictable performance. These concepts will be illustrated using the same man-made network systems of interest introduced at the beginning of the course. Requirements: Some background in dynamic systems is highly desirable. Students interested in large-scale real-life complex systems, their relation to the state-of-the-art methods available and new research challenges will gain from taking this course. 4 hrs lec. Prerequisites: senior or graduate standing.

Speech Recognition and Understanding (18-781) – 12 Units

The technology to allow humans to communicate by speech with machines or by which machines can understand when humans communicate with each other is rapidly maturing. This course provides an introduction to the theoretical tools as well as the experimental practice that has made the field what it is today. We will cover theoretical foundations, essential algorithms, major approaches, experimental strategies and current state-of-the-art systems and will introduce the participants to ongoing work in representation, algorithms and interface design. This course is suitable for graduate students with some background in computer science and electrical engineering, as well as for advanced undergraduates. Prerequisites: Sound mathematical background, knowledge of basic statistics, good computing skills. No prior experience with speech recognition is necessary. This course is primarily for graduate students in LTI, CS, Robotics, ECE, Psychology, or Computational Linguistics. Others by prior permission of instructor.

Machine Learning (18-782) – 12 Units

Machine Learning is a foundational discipline of the Information Sciences. It combines elements from Mathematics, Computer Science, and Statistics with applications in Biology, Physics, Engineering and any other area where automated prediction is necessary. The aim of the course is to present some of the topics which are at the core of modern Machine Learning, from fundamentals to state-of-the-art methods. Emphasis will be put both on the essential theory and on practical examples and lab projects. Each exercise has been carefully chosen to reinforce concepts explained in the lectures or to develop and generalize them in significant ways. This course is directed both at students without previous knowledge in Machine Learning, and at those wishing to broaden their expertise in this area. The course assumes some basic knowledge of probability theory and linear algebra. Nevertheless, the first module of the course will revisit these topics. Students are also expected to have knowledge of basic computer science principles and skills, at a level sufficient to write a reasonably non-trivial computer program. Students who have already taken CS 10-701/15-781 or ECE 18-697 should not take this course.

Data, Inference, and Applied Machine Learning (18-785) – 12 Units
Please see the ECE website https://www.ece.cmu.edu/ for more information. This course will provide the methods and skills required to utilize data and quantitative models to automate predictive analytics and make improved decisions. From descriptive statistics to data analysis to machine learning the course will demonstrate the process of collecting, cleaning, interpreting, transforming, exploring, analyzing and modeling data with the goal of extracting information, communicating insights and supporting decision-making. The advantages and disadvantages of linear, nonlinear, parametric, nonparametric and ensemble methods will be discussed while exploring the challenges of both supervised and unsupervised learning. The importance of quantifying uncertainty, statistical hypothesis testing and communicating confidence in model results will be emphasized. The advantages of using visualization techniques to explore the data and communicate the outcomes will be highlighted throughout. Applications will include visualization, clustering, ranking, pattern recognition, anomaly detection, data mining, classification, regression, forecasting and risk analysis. Participants will obtain hands-on experience during project assignments that utilize publicly available datasets and address practical challenges.

Wavelets and Multiresolution Techniques (18-790) – 12 Units
The goal of this course is to expose students to multiresolution signal processing methods and their use in real applications as well as to guide them through the steps of the research process. All the necessary mathematical tools are introduced with an emphasis on extending Euclidean geometric insights to abstract signals; the course uses Hilbert space geometry to accomplish that. With this approach, fundamental concepts---such as properties of bases, Fourier representations, sampling, interpolation, approximation, and compression---are often unified across finite dimensions, discrete time, and continuous time, thus making it easier to focus on the few essential differences. The course covers signal representations on sequences, specifically local Fourier and wavelet bases and frames. It covers the two-channel filter bank in detail, and uses this signal-processing device as the implementation vehicle for all sequence representations that follow. The local Fourier and wavelet methods are presented side-by-side, without favoring any one in particular. Through the project, students will learn how to choose an appropriate representation and apply it to the specific problem at hand. There will be 2-3 hours of pre-recorded video per week that can be viewed online at any time. There will also be two 1-hour sessions in person that are not mandatory and can be viewed later online. The instructor will also be available for meetings in person or online as needed. The total amount of work per week is expected to be around 12 hours on average Pre-requisite: 18-491. Students are expected to have a good background in basic engineering mathematics, signal processing and linear algebra. This course is cross listed with 42-732

Methods in Medical Image Analysis (18-791) – 12 Units
Students will gain theoretical and practical skills in medical image analysis, including skills relevant to general image analysis. The fundamentals of computational medical image analysis will be explored, leading to current research in applying geometry and statistics to segmentation, registration, visualization, and image understanding. Student will develop practical experience

through projects using the National Library of Medicine Insight Toolkit (ITK), a popular open-source software library developed by a consortium of institutions including Carnegie Mellon University and the University of Pittsburgh. In addition to image analysis, the course will include interaction with clinicians at UPMC. It is possible that a few class lectures may be videoed for public distribution. Prerequisites: Knowledge of vector calculus, basic probability, and either C++ or python.

Advanced Digital Signal Processing (18-792) – 12 Units
This course will examine a number of advanced topics and applications in one-dimensional digital signal processing, with emphasis on optimal signal processing techniques. Topics will include modern spectral estimation, linear prediction, short-time Fourier analysis, adaptive filtering, plus selected topics in array processing and homomorphic signal processing, with applications in speech and music processing. 4 hrs. lec.

Image and Video Processing (18-793) – 12 Units
This course covers signal processing techniques specialized for handling 2D (images) and 3D (videos) signals. It builds upon 1D signal processing techniques developed in 18-290 and 18-491 and specializes them for the case of images and videos. In this class, you will learn fundamental tools and techniques for processing images and videos, and will learn to apply them to a range of practical applications. This course provides the fundamentals for studying images and videos. We will develop signal models specific to images and videos, develop associated optimization techniques for solving restoration problems like denoising, inpainting, study specialized compression algorithms. Specific focus will be on transform-domain, PDE and sparsity-based models and associated optimization techniques. These formal techniques will be enriched via applications in mobile devices, medical image processing, and compressive sensing.

Pattern Recognition Theory (18-794) – 12 Units
Decision theory, parameter estimation, density estimation, non-parametric techniques, supervised learning, linear discriminant functions, clustering, unsupervised learning, artificial neural networks, feature extraction, support vector machines, and pattern recognition applications (e.g., face recognition, fingerprint recognition, automatic target recognition, etc.). 4 hrs. lec. Prerequisites: 36-217, or equivalent introductory probability theory and random variables course and an introductory linear algebra course and senior or graduate standing.

Bioimage Informatics (18-795) – 12 Units
Bioimage Informatics (formerly Bioimaging) 12 units This course gives an overview of tools and tasks in various biological and biomedical imaging modalities, such as fluorescence microscopy, electron microscopy, magnetic resonance imaging, ultrasound and others. The major focus will be on automating and solving the fundamental tasks required for interpreting these images, including (but not restricted to) deconvolution, registration, segmentation, pattern recognition, and modeling, as well as tools needed to solve those tasks (such as Fourier and wavelet methods). The discussion of these topics will draw on approaches from many fields, including statistics, signal processing, and machine learning. As part of the course, students will be expected to complete an independent project. Prerequisites: 18-396 Signals and Systems

Machine Learning for Signal Processing (18-797) – 12 Units
Signal Processing is the science that deals with extraction of information from signals of various kinds. This has two distinct aspects -- characterization and categorization. Traditionally, signal characterization has been performed with mathematically-driven transforms, while categorization and classification are achieved using statistical tools. Machine learning aims to design algorithms that learn about the state of the world directly from data. A increasingly popular trend has been to develop and apply machine learning techniques to both aspects of signal processing, often blurring the distinction between the two. This course discusses the use of machine learning techniques to process signals. We cover a variety of topics, from data driven approaches for characterization of signals such as audio including speech, images and video, and machine learning methods for a variety of speech and image processing problems. Prerequisites: Linear Algebra, Basic Probability Theory, Signal Processing and Machine Learning. 18-797 is a cross listing of 11-755 offered by LTI.

Fundamentals of Semiconductors and Nanostructures (18-817) – 12 Units
This course is designed to provide students with a foundation of the physics required to understand nanometer-scale structures and to expose them to different aspects of on-going research in nanoscience and nanotechnology. Illustrative examples will be drawn from the area of semiconductor nanostructures, including their applications in novel and next-generation electronic, photonic, and sensing devices. The course begins with a review of basic concepts in quantum physics (wave-particle duality, Schrödinger's equation, particle-in-a-box, approximation methods in quantum mechanics, etc.) and then continues with a discussion of bulk three-dimensional solids (band structure, density of states, the single-electron effective-mass approximation). Size effects due to nanometer-scale spatial localization are then discussed within a quantum-confinement model in one-, two-, and three- dimensions for electrons. An analogous discussion for photons is also presented. The basic electronic, optical, and mechanical properties of the low-dimensional nanostructures are then discussed. A select number of applications in electronics, photonics, biology, chemistry, and bio-engineering will be discussed to illustrate the range of utility of nanostructures. Upon completion of the course, students will have an appreciation and an understanding of some of the fundamental concepts in nanoscience and nanotechnology. The course is suitable for first-year graduate students in engineering and science (but advanced undergraduates with appropriate backgrounds may also take it with permission from the instructor). Prerequisites: 09-511, 09-701, 09-702, 18-303, 18-310, 18-402, 27-770, 33-225, 33-234 or familiarity with the material or basic concepts covered in these courses and senior or graduate standing.

Mobile and Pervasive Computing (18-843) – 12 Units
This is a course exploring research issues in the newly emerging field of mobile computing. Many traditional areas of computer science and computer engineering are impacted by the constraints and demands of mobility. Examples include network protocols, power management, user interfaces, file access, ergonomics, and security. This will be an "advanced" course in the truest sense --- most, if not all, the topics discussed will be ones where there is little consensus in the research community on the best approaches. The course will also offer significant "hand-on"

experience in this area. Each student will have to present and lead the discussion on a number of papers. Students will work in groups of three under the guidance of a mentor on a hands-on project. Each student will also be required to write one of two documents: (a) a research proposal (similar in spirit to an NSF proposal) on an idea in mobile computing or (b) a short business plan for a commercial opportunity in mobile computing. Grading will be based on the quality of the presentations, the project, and the proposal or business plan. Prerequisites: 15-410 and senior or graduate standing.

Internet Services (18-845) – 12 Units

This course investigates the issues involved in providing scalable and highly available network services over the best-effort Internet. Examples of such services include Web servers, application servers, search engines, proxy caches, online auction systems, and remote visualization. Topics include network programming, server design, clustering, caching, proxies, remote execution, resource naming, discovery, and monitoring, and wide-area metacomputing. The course consists of lectures on existing technology, student presentations of research papers, and a project where students design and implement a significant network service.

Wireless Systems Design Experience (18-846) – 12 Units

This project-oriented course is the culmination of the MS ECE Wireless Systems Concentration. It provides third-semester students with a design experience that brings together concepts from the Wireless Systems core to solve a real-world problem.

The class organizes the students as a design team to build an outdoor system for distributed sensing of physical quantities, wireless connectivity to a data repository, and analysis and presentation of the data. The specific problem domains (e.g., pavement-mounted traffic sensors, sensors for overland water flow, soil moisture, or stream height) are selected to present specific challenges in wireless connectivity, low-power operation, distributed synchronization, federation of dissimilar sensor types, real-time computation, and information presentation. The instructors and project sponsors (customers) will guide the students in developing an understanding of the problem domain (environment and requirements) and selecting suitable technologies for addressing the challenges specific to it, creating and documenting a system architecture with verifiable interfaces, decomposing the architecture into sub-problems that sub-groups of students can address, integrating the results into a single system, and verifying system performance against the documented requirements. Consistent with the Wireless Systems concentration methodologies, student work will be organized around fixed-length sprints followed by an evaluation of progress with the customer and instructors.

Upon completion of this course, the student will be able to: generate systems specifications from a perceived need; partition functionality between hardware and software; produce interface specifications for a system composed of wirelessly-connected subsystems; use power and RF modeling tools; fabricate, integrate, and debug a hardware/software system; and evaluate the system in the context of an end user application.

Engineering and Economics of Electric Energy Systems (18-875) – 12 Units

The course has two parts. The first part introduces basic components and networks used in the electric power industry. This is followed by systematic modeling of these components, as well as of the entire system. Methods for modeling and analyzing both system equilibria and dynamics are presented. Simulations and lab demos are given to simulate and analyze typical system blackouts. This is followed by introducing decision and control methods for preventing these problems, as well as for managing the system more reliably, securely and efficiently over broad ranges of its operating conditions. The emphasis is on IT, software and control (both distributed and coordination) for achieving pre-specified system performance. This part of the course will involve simulation demos and hands on studies in which students create their own power network, simulate it and assess for performance. The second part of the course will review the industry structure, the experience with deregulatio n, and economic issues concerning choice of generating fuel and technology, the costs of blackouts, and environmental discharges. The course will integrate engineering and economic aspects to examine the design, investment, and operations that satisfy public desires for low cost, nonpolluting, reliable, and secure power. Knowledge of basic electric circuits and/or basic economics is assumed. 3 hrs. lec., 1 hr. rec. Prerequisites: Basic electric circuits and/or basic economics and at least graduate standing.

M.S. Graduate Project (18-980) – Variable Units
Master's level research.

Introduction to Graduate Studies (18-989) – 1 Unit
The Introduction to Graduate Studies course is designed to increase awareness and understanding of academic integrity issues, Carnegie Mellon community standards and the ethical job search. This is done via various sessions/modules that are already offered via several entities throughout campus (such as the CPDC, ICC, and GCC). Topics covered include: paraphrasing and citation, participating in the US classroom, avoiding plagiarism, unconscious bias, combating sexual violence on campus, finding jobs and internships, negotiation, communication, relationship building and other topics of interest. The course culminates in students writing a reflection paper. For international students, the paper should compare western academic and cultural standards to those of their home country. For domestic students, the paper should be a reflection on CMU's community standards. Active participation in various sessions/modules in the above mentioned areas and the submission of the reflection paper will determine a pass/fail grade.

Internship for Electrical and Computer Engineering MS Students (18-994) – 3 Units
The Department of Electrical and Computer Engineering considers experiential learning opportunities important educational options for its graduate students. One such option is an internship, normally completed during the summer. The ECE Graduate Office will add the course to the student's schedule. This process should be used by any Electrical and Computer Engineering graduate student wishing to have their internship experience reflected on their official University transcript. International students should also be authorized by the Office of International Education (OIE). Completion of written assignments and requirements will determine the letter grade for the course. Prerequisites: Graduate standing in ECE

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APPENDIX D: ADDITIONAL INFORMATION ON FEDERAL AND STATE AID / FINANCIAL AID POLICIES

Carnegie Mellon University Consumer Information

Below is a summary of consumer information made available to all Carnegie Mellon University prospective and current students as required by the Higher Education Act of 1965, as amended. Required Disclosure have been categorized into five topics. Each disclosure gives a brief description of information that is required to be disclosed and explains how it can be obtained. This information may be changed from time to time as required.

If you need assistance or would like a paper copy, contact the Student Financial Aid Office, 5000 Forbes Avenue, Warner Hall, Pittsburgh, PA. If you wish to speak with a representative about the information contained here, please contact Associate Director Catherine Demchak at (412) 268-1353.

Information about the Institution:

Accreditation Information

Carnegie Mellon University is accredited by the Middle States Commission on Higher Education (MSCHE), 3624 Market Street, 2nd Floor West, Philadelphia, PA 19104 (www.msche.org). The Commission may be contacted by telephone at 267-284-5000 or via email at info@msche.org or espanolinfo@msche.org (Spanish/Español). The university's current "Statement of Accreditation Status" can be found at, https://www.msche.org/institution/.

State Approvals

Carnegie Mellon University is licensed to operate in the states listed below. Individuals may contact the relevant agency for more information or information about how to file a complaint.

California

Bureau for Private Postsecondary Education
1747 North Market Blvd, Suite 225,
Sacramento, CA 95834
Telephone: (916) 574-8900
Email: bppe@dca.ca.gov
Website: www.bppe.ca.gov

New York

New York State Education Department
Office of Higher Education
Room 977 Education Building Annex
Albany, NY 12234
Telephone: 518-486-3633
Email: hedepcom@nysed.gov
Website: www.highered.nysed.gov

Pennsylvania

Pennsylvania Department of Education
Office of Postsecondary and Higher Education
333 Market Street, 12th Floor
Harrisburg, PA 17126-0333
Telephone: 717-783-8228
Email: ra-collunivseminfo@pa.gov
Website: www.education.state.pa.us

Washington, D.C.

Office of the State Superintendent of Education
Government of the District of Columbia
810 First Street NE 9th Floor
Washington, DC 20002
Telephone: 202-727-6436
Email: osse@dc.gov
Website: osse.dc.gov

Inquiries regarding the university's accreditation status or authorization to operate in any of the above states may be directed to: Associate Vice President / Director of Enrollment Services, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh PA 15213, telephone: 412-268-5399, email: krieg@andrew.cmu.edu.

Distance Education, State Authorization and Reciprocity Agreement (SARA)

The State Authorization Reciprocity Agreement (SARA) is an agreement among member states, districts, and territories in the United States, which establishes national standards for interstate offering of postsecondary distance education courses and programs. It is intended to standardize the process of offering online courses and programs by postsecondary institutions located in states other than the state in which the enrolled student(s) are residing. SARA is overseen by a national council (NC-SARA) and administered by four regional education compacts.

Carnegie Mellon University has been approved by the Commonwealth of Pennsylvania to participate in NC-SARA and was accepted as a SARA institution on May 2, 2017; additionally, Carnegie Mellon secured approval through NC-SARA on May 18, 2017. Carnegie Mellon University is listed as an approved, participating institution on the NC-SARA website (http://www.nc-sara.org/). At this time, 49 of the 50 United States are SARA members. California is not a member of SARA; however, Carnegie Mellon is able to offer online education to California residents.

Except where prohibited by applicable law, students who reside outside of the United States generally are not restricted from enrolling in our online programs. Some online programs do require in-person attendance at one of Carnegie Mellon's teaching locations (e.g., Carnegie Mellon's Pittsburgh, Pennsylvania campus) for short portions of the program. Students interested in enrolling in a specific online program are encouraged to contact the person designated by the online program for questions about the program's requirements or enrollment.

Copyright Infringement Policies

Carnegie Mellon University takes copyright violation seriously. Besides raising awareness about copyright law, it takes appropriate action in support of enforcement as required by policy and law. United States copyright law (http://www.copyright.gov/) "protects the original works of authorship fixed in any tangible medium of expression, from which they can be perceived, reproduced, or otherwise communicated, either directly or with the aid of a machine or device".

The University's Fair Use Policy (http://www.cmu.edu/policies/administrative-and-governance/fair-use.html) states that all members of the University must comply with US copyright law and it explains the fair use standards for using and duplicating copyrighted material. In addition, the policy prohibits the duplication of software for multiple uses, meeting the Digital Millennium Copyright Act (DMCA) (http://www.copyright.gov/legislation/dmca.pdf) requirements. The DMCA criminalizes the development or use of software that enables users to access material that is copyright protected. Furthermore, the Computing Policy (http://www.cmu.edu/policies/information-technology/computing.html) prohibits the distribution of copyright protected material via the University network or computer systems, unless the copyright owner grants permission.

The Higher Education Opportunity Act of 2008 (Public Law 110-315) Section 488, requires institutions of higher education to annually inform students that "unauthorized distribution of copyrighted material, including unauthorized peer-to-peer file sharing, may subject the students to civil and criminal liabilities". Carnegie Mellon does this by publication of a news article on Computing Services' website or via mass mail communication each semester. The law goes on to require institutions "to provide a summary of penalties for violation of Federal copyright laws, including disciplinary actions that are taken against students who engage in unauthorized distribution of copyrighted materials using the institution's information system." Copyright protected materials can include, but are not necessarily limited to:

Music

Movies or other videos

Literary works

Software

Digital images or libraries

Cost of Attending the University

Actual tuition and fee charges can be found on the Student Financial Services' website at https://www.cmu.edu/sfs/tuition/index.html.

For estimated books and supplies, room and board, and personal/miscellaneous expenses view the cost of attendance for the Graduate program at https://www.cmu.edu/sfs/tuition/graduate/index.html.

Descriptions of Academic Programs

Information on the university's graduate academic programs and degree offerings is available from the various schools/colleges and admitting offices. Links to those programs can be found at https://www.cmu.edu/academics/index.html.

Faculty

Information on the university's faculty and instructional personnel is available from individual schools/colleges. This information can be found on the university's academics website at https://www.cmu.edu/academics/index.html.

Facilities & Services for Disabled Students

The Office of Disability Resources provides responsive and reasonable accommodations to students who self-identify as having a disability, including physical, sensory, cognitive and emotional disabilities. If you would like to learn more about the services and accommodations provided by the Office of Disability Resources, visit their website at https://www.cmu.edu/disability-resources/students/. To discuss your accommodation needs, please email us at access@andrew.cmu.edu or call us at 412-268-6121 to set up an appointment.

Student Privacy & FERPA

One of the most significant changes a parent or guardian experiences in sending a student to college is the difference in privacy standards for educational records. Carnegie Mellon values the student's right to privacy. The university adheres to a federal law called the Family Educational Rights and Privacy Act (also called FERPA or the Buckley Amendment) that sets privacy standards for student educational records and requires institutions to publish a compliance statement, including a statement of related institutional policies. For more detailed information, view the university's brochure at https://www.cmu.edu/hub/privacy/ferpa-brochure.pdf.

Return to Title IV Funds Policy and Procedural Statement

Policy Reason

The U. S. Department of Education requires that the university determine the amount of Federal Title IV aid earned by a student who withdrawals of fails to complete the period of enrollment. The university must determine the earned and unearned portions of Title IV aid as of the date the student ceased attendance based on the amount of time the student spent in attendance. Up through the 60% point in the period of enrollment, a pro rata schedule is used to determine the amount of Title IV funds the student has earned at the time of withdrawal. After the 60% point in the period of enrollment, a student has earned 100% of the Title IV funds he or she was scheduled to receive. For a student who withdraws after the 60% point-in-time, there are no unearned funds. Federal regulations can be found at:

Federal Student Aid Handbook, Volume 5

Chapter 1 Withdrawals and the Return of Title IV Funds 34 CFR 668.22

Policy and Procedural Statement

At Carnegie Mellon Title IV funds are awarded to a student under the assumption that the student will attend school for the entire period for which the assistance is awarded. When a student withdraws, the student may no longer be eligible for the full amount of Title IV funds that the student was originally scheduled to receive.

If a recipient of Title IV grant or loan funds withdraws from a school after beginning attendance, the amount of Title IV grant or loan assistance earned by the student must be determined. If the amount disbursed to the student is greater than the amount the student earned, the unearned funds must be returned. If the amount disbursed to the student is less than the amount the student earned, and for which the student is otherwise eligible, he or she is eligible to receive a Post-withdrawal disbursement of the earned aid that was not received.

Carnegie Mellon determines the Withdrawal Date and Date of Determination to complete the return calculation. A student's withdrawal date and date of determination varies depending on the type of withdrawal. When a student provides official notification to Carnegie Mellon through the Student Leave of Absence and Withdrawal Process, the withdrawal is defined as official withdrawal. When the student does not complete the Student Leave of Absence and Withdrawal Process and no official notification is provided by the student it is considered an unofficial withdrawal.

Leave of Absence/Withdrawal Process

A student may leave Carnegie Mellon by either taking a leave of absence (leaving the university temporarily with the firm and stated intention of returning) or by withdrawing from the university (leaving the university with no intention of returning). Students choosing to take a leave of absence should first contact their academic advisor to discuss their plans while on leave and to work out any conditions that may be necessary for a smooth return to Carnegie Mellon. A student deciding to leave the university should take the following steps:

- Complete a Leave of Absence or Withdrawal Form.
- The form must include all necessary signatures or the process will not be completed.
- Return the completed form to the University Registrar's Office, 5000 Forbes Ave., Warner Hall A12, Pittsburgh, PA 15213.

Determination of Withdrawal Date

Official Withdrawals (Notification Provided by the Student)

Those withdrawals defined as official are processed in accordance with federal regulations. The Office of the Registrar provides information that identifies which students have processed a Student Leave of Absence and Withdrawal Form for each semester. This information includes the Date of Withdrawal, the Date of Determination, Withdrawal/Leave Status (LA, LS, & W2) and the semester of attendance. This information is maintained in the student’s academic file and in the university’s Student Information System.

For students who notify the university of their intent to withdraw or take a leave of absence, the official date of withdrawal or leave of absence is the earliest of:

- Date the student began the withdrawal or leave of absence process;

- Date the student notified his or her home department;
- Date the student notified the associate dean of his or her college; or
- Date the student notified the dean of students.

Unofficial Withdrawal (No Official Notification Provided by the Student)

For a student who withdraws without providing notification to Carnegie Mellon, the institution determines the withdrawal date using defined criteria. This category of withdrawals includes students that drop out and students that do not earn a passing grade.

To identify the unofficial withdrawals the Registrar develops a preliminary list of students that did not complete the semester by reviewing the final student grade reports. The list includes all students with: a) semester units carried, b) 0 semester units passed, c) 0 quality points earned, and d) 0.0 QPA. The Registrar contacts the academic divisions about each student to determine if the student actually completed the semester and earned the grades (0.0) or failed to complete the semester and did not notify the University of their status.

For students who do not notify the University of their intent to withdraw or take a leave of absence, the official date of withdrawal or leave of absence is:

- The midpoint of the semester;
- The last date the student attended an academically-related activity such as an exam, Tutorial or study group, or the last day a student turned in a class assignment.

Date of Determination that the Student Withdrew

Carnegie Mellon is not required to take attendance and the Date of Determination that a student withdrew varies depending upon the type of withdrawal: Official or Unofficial.

For withdrawals where the student provided *Official Notification* the Date of Determination is: The student's withdrawal date, or the date of notification, whichever is later.

For withdrawals where the student did not provide *Official Notification* the Date of Determination is: The date the institution becomes aware the student has ceased attendance.

For a student who withdrawals without providing notification to the institution, the institution must determine the withdrawal date no later than 30 days after the end of the enrollment period.

Calculation of Earned Title IV Assistance

The withdrawal date is used to determine the point in time that the student is considered to have withdrawn so the percentage of the period of enrollment completed by the student can be determined. The percentage of Title IV aid earned is equal to the percentage of the period of enrollment completed.

The amount of Title IV federal aid earned by the student is determined on a pro-rata basis up to the end of 60% of the semester. If the student completed 30% of a term, 30% of the aid originally scheduled to be received would have been earned. Once a student has completed more than 60% of a term, all awarded aid (100%) has been earned. The percentage of federal aid earned

and the order in which the unearned aid is returned are defined by federal regulatory requirements.

The calculation of earned Title IV funds includes the following grant and loan funds if they were disbursed or could have been disbursed to the student for the period of enrollment for which the Return calculation is being performed:

- Pell Grant
- Iraq and Afghanistan Service Grant
- TEACH Grant (not available at Carnegie Mellon)
- FSEOG Grant
- Federal Direct Loan

Institutional Charges

Institutional charges are used to determine the portion of unearned Title IV aid that the school is responsible for returning. Carnegie Mellon ensures that all charges for tuition, fees, room and board, as well as all other applicable institutional charges are included in the return calculation. Institutional charges do not affect the amount of Title IV aid that a student earns when he or she withdraws.

The institutional charges used in the calculation usually are the charges that were initially assessed the student for the period of enrollment. Initial charges are only adjusted by those changes the institution made prior to the student's withdrawal (for example, for a change in enrollment status unrelated to the withdrawal). If, after a student withdraws, the institution changes the amount of institutional charges it is assessing a student, or decides to eliminate all institutional charges, those changes affect neither the charges nor aid earned in the calculation.

Return of Unearned Funds to Title IV

If the total amount of Title IV grant and/or loan assistance that was earned as of the withdrawal date is less than the amount that was disbursed to the student, the difference between the two amounts will be returned to the Title IV program(s) and no further disbursements will be made.

If a student has received excess funds, the College must return a portion of the excess equal to the lesser of the student's institutional charges multiplied by the unearned percentage of funds, or the entire amount of the excess funds.

The funds will be returned in the order below as prescribed by federal regulations, within 45 days from the date of determination that a student withdrew.

- Unsubsidized Federal Stafford Loans
- Subsidized Federal Stafford Loans
- Federal PLUS loans
- Federal Pell Grants
- Federal Supplemental Educational Opportunity Grants (FSEOG)

Post-Withdrawal Disbursements

If the total amounts of the Title IV grant and/or loan assistance earned as of the withdrawal date is more than the amount that was disbursed to the student, the difference between the two amounts will be treated as a post-withdrawal disbursement. In the event that there are outstanding charges on the student's account, Carnegie Mellon will credit the student's account for all or part of the amount of the post-withdrawal disbursement up to the amount of the allowable charges.

Any amount of a post-withdrawal disbursement that is not credited to a student's account will be offered to the student within 30 days of the date that the institution determined that the student withdrew. Upon receipt of a timely response from the student, the College will disburse the funds within 90 days of the date of determination of the student's withdrawal date.

Return of Title IV Funds – Withdrawals for Programs Offered in Modules

The return of Title IV funds for programs offered in modules is defined in a separate policy statement at Carnegie Mellon. This document is included as an addendum to the Carnegie Mellon University Return to Title IV Funds Policy and Procedural Statement (see below).

Policies and Procedures

Federal Student Aid Handbook, Volume 5, Chapter 2 Withdrawals and the Return of Title IV Funds

CFR 668.22 (a), (f) and (l)

Dear Colleague Letter GEN-11-14 July 2011

For all programs offered in modules, a student is a withdrawal for Title IV purposes if the student ceases attendance at any point prior to completing the payment period or period of enrollment (unless the institution has written confirmation from the student that that they will attend a module that begins later in the enrollment period).

The regulations require the institution to determine whether Title IV funds must be returned based on the number of days actually completed versus the number of days the student was scheduled to attend in the payment period. The regulations prevent students from enrolling in modules or compressed courses spanning the period, completing a portion of the period, and retaining all aid for the period.

A program is considered to be offered in modules if a course or courses in the program do not span the entire length of the payment period or period of enrollment. The rule impacts all programs offering courses shorter than an entire semester, including semester-based programs with a summer term consisting of two consecutive summer sessions.

The Student Financial Aid Office has established the following procedures associated with handling withdrawals from programs offered in modules. An Associate Director of Student Financial Aid has the primary responsibility for compliance and implementation of these regulatory requirements.

The institution will identify students enrolled for the summer session that are eligible for Title IV Aid.

- Pell eligible students are identified
- Students with summer loans are identified
- The period of enrollment and enrollment status will be identified for each student

All Leave/ Withdrawal Forms processed by the University Registrar's Office will be reviewed for the summer sessions to record the Withdrawal Date and Date of Determination to identify any student receiving federal funding.

The Student Financial Aid Office will identify any students that drop courses in the summer sessions.

- During Summer I this is standard procedure
- During Summer II this is reviewed after 10th day reporting
- Any additional dropped courses will be reviewed through the 60% enrollment period

Students who are identified as official withdrawals or that officially drop all courses in a session will be reviewed to determine the amount of federal financial aid earned. If a Return of Title IV aid is required, existing institutional procedures will be followed.

At the end of the enrollment period the institution will determine if any students are identified as 'unofficial withdrawals.' If a Return of Title IV aid is required, existing institutional procedures will be followed.

If a student does not begin courses in all sessions, a Return of Title IV aid may not be required, but other regulatory provisions concerning recalculation may apply.

If a student completes both courses in module one, but officially drops courses in module two while attending module one the student is not a withdrawal.

Since the enrollment is less than half time, the student is no longer eligible for the loan and the funds must be returned.

The following information obtained from the Federal Student Aid Handbook, Chapter 2, Withdrawals and the Return of Title IV Funds, will be used to determine whether a student enrolled in a series of modules is a withdrawal.

<u>How to determine whether a student in a program offered in modules has withdrawn</u>

Schools can determine whether a student enrolled in a series of modules is a withdrawal by asking the following questions.

1. *After beginning attendance in the payment period or period of enrollment, did the student cease to attend or fail to begin attendance in a course he or she was scheduled to attend?*

If the answer is no, this is not a withdrawal.

If the answer is yes, go to question 2.

2. *When the student ceased to attend or failed to begin attendance in a course he or she was scheduled to attend, was the student still attending any other courses?*

If the answer is yes, this is not a withdrawal; however other regulatory provisions concerning recalculation may apply.

If the answer is no, go to question 3.

3. *Did the student confirm attendance in a course in a module beginning later in the period (for non-term and nonstandard term programs, this must be no later than 45 calendar days after the end of the module the student ceased attending)?*

If the answer is yes, this is not a withdrawal, unless the student does not return.

If the answer is no, this is a withdrawal and the Return of Title IV Funds requirements apply.

Contact

Questions regarding this policy or its intent should be directed to the Student Financial Aid Office at 412-268-1353.

Satisfactory Academic Progress Policy and Procedural Statement

To be eligible for federal, state, and institutional financial aid, all students are required to maintain Satisfactory Academic Progress toward the completion of a degree. Each university determines its own policy in accordance with federal regulations set forth by the U. S. Department of Education regarding satisfactory progress standards to ensure student success. To maintain Satisfactory Academic Progress at Carnegie Mellon University, students must meet the following minimum standards for both of the qualitative (QPA) and quantitative (completion rate) measures:

Student Type	QPA (Qualitative)	Completion Rate (Quantitative)*
First Year Undergraduate	1.75	80%
Undergraduate Upper-class	2.00	80%
Heinz Graduate	3.00	80%
Other Graduate (excluding Tepper)	2.00	80%

**To calculate the completion rate, the cumulative number of completed units is divided by the cumulative number of units attempted. Advance Placement credits are excluded from both figures.*

In addition to the above mentioned Financial Aid Satisfactory Academic Progress standards, federal regulations require a student to complete their degree within a specified amount of time. The maximum timeframe cannot exceed 150 percent of the time published as needed for completion of the program.

Scope:

This policy applies to Federal aid including Federal Pell Grants, Federal Supplemental Educational Opportunity Grants, Federal Work-Study, Federal Direct Loans, and Federal Direct PLUS Loan programs; state grant aid; and Carnegie Mellon institutional aid including grants, loans, and scholarships.

Federal regulations can be found at:

Federal Student Aid Handbook, Volume 1

Chapter 1 School Determined Requirements

34 CFR 668.16(e)

34 CFR 668.32(f)

34 CFR 668.34

Evaluation:

Carnegie Mellon evaluates all students for Financial Aid Satisfactory Academic Progress annually, at the end of the spring semester. Students that are included in the review are undergraduates, graduates, both full-time and part-time.

Courses that do not count toward a student's degree cannot be used to determine enrollment status for financial aid purposes. Carnegie Mellon will count transfer credit hours that are accepted toward a student's educational program as both attempted hours and completed hours. Advanced Placement Non-Degree and Non-Credit courses are not counted as units passed or attempted. When a course is repeated, all grades will be recorded on the official academic transcript and will be calculated in the student's QPA. For financial aid eligibility, only one repeat per course is permitted in the determination of enrollment status for courses previously passed.

If the student withdraws and is not assigned a W grade, then it will not be counted in the number of units attempted or completed. If the W grade is assigned, the units will be counted in the number of units attempted and will be counted as zero in the number of units completed.

If the student has incomplete units, the units will be counted as attempted and will be counted as zero in the number of units completed.

The Financial Aid Satisfactory Academic Progress evaluation is a cumulative review of all semesters, regardless of whether or not the student received financial aid during the academic year.

If the minimum requirements are not achieved, the student is ineligible to receive financial aid. In such a case, the student is notified and given an option to appeal their financial aid status. More information about the appeal process can be found at www.cmu.edu/sfs/docs/federal-title-iv.pdf.

A financial aid package will not be completed unless an appeal is received, approved and processed accordingly. If by chance a financial aid package is processed and released to the student, it is conditional and subjected to financial aid removal until an appeal is received, approved and processed accordingly.

Contact:

Accountable Department: Enrollment Services, Student Financial Aid. Questions regarding this policy or its intent should be directed to the Student Financial Aid Office, phone: 412-268-1353.

Student Body Diversity

For Information about the diversity of the university student body, contact the Institutional Research and Analysis Office, https://www.cmu.edu/ira/index.html.

For information about the University's Diversity, Equity and Inclusion initiative, visit the Center for Student Diversity and Inclusion's website at https://www.cmu.edu/student-diversity/.

Written Arrangement Information

A U.S. Department of Education regulation requires disclosure of specific information to prospective and current students regarding written arrangements between Carnegie Mellon University (CMU) and any institution(s) that provides a portion of an educational program to students enrolled at CMU. CMU enters into such arrangements to enrich the educational experiences offered to its students. In accordance with the regulation, CMU provides this information at http://www.cmu.edu/hub/consumer-information/docs/written-arrangement.pdf.

Student Complaints & Consumer Information by State

As required for compliance with U.S. Federal Program Integrity Regulations, state official/agency contact information for each U.S. state/territory that could handle a student's complaint is provided at https://www.cmu.edu/hub/consumer-information/docs/complaints.pdf.

Gainful Employment Disclosures

As required by U.S. Department of Education regulations Gainful Employment Disclosures (Disclosures about CMU certificate programs that prepare students for specific occupations) can be found at https://www.cmu.edu/hub/consumer-information/.

Information about Student Financial Aid:

Meeting the cost of higher education is a significant investment. We are committed to providing a comprehensive financial aid program that makes it possible for admitted students to attend Carnegie Mellon.

Application Process & Timeline:

Graduate Students: **To apply for financial aid for the 2019-2020 academic year, follow the steps below.**

Free Application for Federal Student Aid (FAFSA)

The FAFSA is required if applying for federal financial aid programs. There are now two ways to complete the *Free Application for Federal Student Aid (FAFSA)* form: a redesigned https://studentaid.ed.gov/sa/fafsa website or a mobile app (available through Google Play, https://play.google.com/store/apps/details?id=com.fsa.mystudentaid or the Apple App Store, https://itunes.apple.com/us/app/mystudentaid/id1414539145.

We recommend using the IRS Data Retrieval Tool (DRT) (https://studentaid.ed.gov/sa/resources/irs-drt-text) to complete the FAFSA. The DRT transfer process has been improved to include stronger security and privacy protections; therefore, tax information transferred will not display on the form or Student Aid Report. Instead, the phrase "Transferred from the IRS" will appear in the fields.

Those selected for federal verification after FAFSA completion or those unable to use the IRS DRT will need to request an IRS Tax Return Transcript (https://www.irs.gov/individuals/get-transcript).

Additional information:

Apply as soon as possible after October 1.

Carnegie Mellon's federal code is 003242.

Use 2018 tax information to complete the FAFSA.

A Department of Education Federal Student Aid (FSA) ID is required. View FSA ID instructions at https://fsaid.ed.gov/npas/index.htm.

Students must complete the FAFSA's electronic signature requirement.

MPN & Entrance Counseling

All first-time Federal Direct Loan borrowers are required to complete entrance counseling. The entrance counseling session provides information about borrower rights and responsibilities. CMU will be notified when a student has completed online entrance counseling. Funds will not be disbursed until the entrance counseling session has been completed. Students who completed a federal entrance counseling session while at CMU, do not have to complete another session.

Additional information:

View entrance counseling instructions (https://www.cmu.edu/sfs/financial-aid/types/federal-loans/direct/mpn-entrance-counseling.html).

Complete entrance counseling session at https://studentloans.gov.

Grad PLUS Loan

If you plan on borrowing a Federal Direct Graduate PLUS Loan, this is a two-part process and both parts must be completed in order for your loan to be originated. If you borrowed a Grad PLUS Loan last academic year, you are only required to complete the application portion of the process. The application portion of the process cannot be completed before June 1, 2019.

Additional information:

View detailed Grad PLUS Loan instructions at https://www.cmu.edu/sfs/financial-aid/types/federal-loans/plus/instructions.html.

The two-part process may be completed at https://studentloans.gov.

Financial Aid Eligibility Notification

Once a student completes all of the steps above, a financial aid package will be determined. The Student Financial Aid Office will notify the student by email that a financial aid award letter has been posted to SIO (https://s3.andrew.cmu.edu/sio/index.html#finances-home). The letter contains information and further instructions regarding the student's eligibility and awards. If a student's circumstances change, then financial aid eligibility will be re-evaluated and the student will receive notification that a revised award letter is available in SIO.

Missing Documents

If we are unable to process a student's financial aid package due to missing documents, a Financial Aid Alert email will be sent to the student requesting the required documents by a specified date. Until the entire application process is completed and all required documents are submitted, our office may be unable to complete a student's financial aid package. Students may log in to SIO (https://s3.andrew.cmu.edu/sio/index.html#finances-home) to view documents that have been received by our office. View instructions for submitting missing documents at https://www.cmu.edu/sfs/financial-aid/missing-documents/index.html.

Teacher Certification

Teacher certification students at the graduate level should be aware that federal regulations classify them as a grade level 5 undergraduate student for Federal Direct Student Loan purposes. Teacher certification students are, however, considered a graduate student by Carnegie Mellon for academic purposes.

Available Financial Aid

Scholarships & Grants

Graduate Students:

Graduate students interested in scholarships and grants may contact their program of interest or department. View more information on the Graduate Education Office website, http://www.cmu.edu/graduate/prospective-students/index.html. In addition, the Fellowships & Scholarships Office (http://www.cmu.edu/fso/) provides support to graduate students interesting in pursing certain external scholarships, like Fulbright and UK Awards.

Federal Work-Study

Federal Work-Study (FWS) is a need-based self-help award. If a student has been awarded FWS, the FWS award is the total that can be earned during the academic year as a work-study student.

Federal Loans

For many students and families, educational loans are a necessary part of the process of paying for college. Student Financial Aid certifies loans for students, as well as Federal Direct Parent PLUS Loans for parents of undergraduates and Federal Direct Grad PLUS Loans for graduate students.

Federal Direct Student Loan

The Federal Direct Student Loan is the most widely-used loan for college students and is available to both undergraduate and graduate students. There are two types of Federal Direct Student Loans, subsidized and unsubsidized, and eligibility for both is determined by completing the FAFSA.

Grad PLUS Loan

Eligible graduate students may borrow a Federal Direct Grad PLUS Loan to assist with educational expenses. Students may borrow any amount up to their calculated cost of attendance minus any other aid received.

Private Loans

Private loan programs offer competitive interest rates and borrower benefits. To increase chances of approval and possibly improve the rate you receive, students are strongly recommended to apply with a creditworthy co-signer.

Student Outcomes

Retention and Graduation Rates

Institutional Research and Analysis Office offers up-to-date data on degrees conferred, enrollment reports, freshmen retention rates and race and ethnicity reports for annual degrees. Retention and Graduation rates can be found at https://www.cmu.edu/ira/retentiongradrates.html.

Intercollegiate Athletic Program Participation Rates and Financial Support Data (Equity in Athletics Disclosure Act)

Please visit the U.S. Department of Education's site, The Equity in Athletics Data Analysis (http://ope.ed.gov/athletics/#/) and select the "Get data for one schools" option. Enter "Carnegie Mellon University" in the "Name" field and select the "Continue" button at the bottom of the page.

A printed copy of the report can be requested by calling the Department of Athletics, Physical Education, and Recreation at 412-268-8054 or by sending an email to Josh Centor, Associate Vice President for Student Affairs and Director of Athletics, Physical Education & Recreation, at jcentor@andrew.cmu.edu.

Health and Safety

Drug and Alcohol Abuse Prevention Program

Under the Drug Free Workplace Act of 1988 and the Drug Free Schools and Campuses Act of 1989, the Carnegie Mellon University is required to have an alcohol and other drug policy outlining prevention, education and intervention efforts and consequences for policy violations. The policy can be found at https://www.cmu.edu/policies/administrative-and-governance/alcohol-and-drug-policy.html.

CMU Annual Security and Fire Safety Report

A printed copy of the report can be requested by contacting University Police at 412-268-6232 or campuspd@andrew.cmu.edu.

The annual security and fire safety report (Carnegie Mellon University Police Department Annual Reports) is also available online at http://www.cmu.edu/police/security-fire-reports/index.html.

Vaccination Policies

CMU Prematriculation Immunization Policy can be found at http://www.cmu.edu/policies/student-and-student-life/immunizations.html.

CMU University Health Services Health Requirements for Incoming Students can be found at https://www.cmu.edu/health-services/new-students/.

Other Information

Voter Registration

Please visit http://www.usa.gov/Citizen/Topics/Voting/Register.shtml.

Carnegie Mellon Ethics Hotline

The health, safety and well-being of the university community are top priorities at Carnegie Mellon University. CMU provides a hotline that all members of the university community should use to confidentially report suspected unethical activity relating to financial matters, academic and student life, human relations, health and campus safety or research.

Students, faculty and staff can anonymously file a report by calling 877-700-7050 or visiting www.reportit.net (user name: tartans; password: plaid). All submissions will be reported to appropriate university personnel.

The hotline is NOT an emergency service. For emergencies, call University Police at 412-268-2323.

Statement of Assurance

Carnegie Mellon University does not discriminate in admission, employment, or administration of its programs or activities on the basis of race, color, national origin, sex, handicap or disability, age, sexual orientation, gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. Furthermore, Carnegie Mellon University does not discriminate and is required not to discriminate in violation of federal, state, or local laws or executive orders.

Inquiries concerning the application of and compliance with this statement should be directed to the vice president for campus affairs, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, telephone 412-268-2056.

Obtain general information about Carnegie Mellon University by calling 412-268-2000.

5000 Forbes Avenue

Pittsburgh, PA 15213

www.ece.cmu.edu

@CMU_ECE