



Electrical & Computer Engineering

2021-2022 Ph.D. Catalog/Handbook

ECE Office of Academic Affairs

This document is for the internal use of the Department of Electrical and Computer Engineering at Carnegie Mellon University only and may not be distributed or reproduced for external distribution in any form without express written permission of the Department Head of the Department of Electrical and Computer Engineering. This handbook is posted to the [ECE Ph.D. webpage](#) prior to the start of each academic year and is updated as needed. This handbook is effective August 1, 2021 through July 31, 2022.

Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213-3890
(412) 268-2000
www.cmu.edu

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

TABLE OF CONTENTS

WELCOME TO ELECTRICAL AND COMPUTER ENGINEERING	8
Core Values	9
Vision	9
Mission and Objectives	9
INTRODUCTION	11
Graduate Degrees and Programs Offered	11
Graduate Student Catalog/Handbook	11
CARNEGIE MELLON POLICIES, EXPECTATIONS, STATEMENT OF ASSURANCE, AND CODE	11
Carnegie Mellon Policies & Expectations	11
Carnegie Mellon Statement of Assurance	12
Carnegie Mellon Code	12
Carnegie Mellon Child Protection Requirements	13
DEPARTMENTAL INFORMATION	13
University Personnel	13
University Resources	13
Stellic Degree Audit	13
University Resource Websites	14
University Library	14
Department Resources	16
Course Instructors	16
Academic Advisors	16
Faculty Advisors	17
Graduate Studies Committee (GSC)	20
Bulletin Boards	20
Tech & Receiving	20
Computer Clusters	20
Printers	20
Keys	20
Lab & Office Space	20
Graduate Student Lounges	21
Department Office/Building Security, Repairs and Services	21
General Silicon Valley campus facilities description	21
Graduate Student Organizations	21
Press & Media Relations	22
Electrical & Computer Engineering Brand & Logos	22
PRE-MATRICULATION	22
Admissions Policies	22
TOEFL Requirements and Language Proficiency	22
Deferral	23
Final Undergraduate Transcripts	23
Responsible Conduct of Research (RCR) Education	23
ENROLLMENT AND REGISTRATION	23

Overview	23
Degree Progress and Planning	24
Student Responsibility	24
Degree Timeframe and Residency Requirement	24
Summer Registration Process & Procedures	25
Vacations & Time-Off	25
Full-time and Part-time Requirements	26
Statute of Limitations	26
Campus Location Tracking & Reporting Requirements	27
Obtaining an M.S. on the Way to the Ph.D.	27
Change of Degree Program	28
Center for the Neural Basis of Cognition (CNBC) Program	28
Joint Degree Programs	29
Courses Outside of Degree Requirements	29
Double Counting Courses	29
Retaking Courses	30
Auditing Courses	30
Pass/No Pass Courses	31
Petition Process	31
Course Transfer Request Policy and Process	31
Pittsburgh Council on Higher Education (PCHE) Cross-Registration Program	33
Registering for Courses	33
Academic Calendar	33
Course Load	33
Adding Courses	33
Course Locations	34
Dropping Courses	34
Withdrawing from Courses	34
Waitlists	34
Technology Enhanced Courses	35
Courses with Time Conflicts	35
Prerequisites	35
Ph.D. Program Course List	36
Final Exams	36
Enrollment Verifications	36
Leave of Absence	36
Returning from a Leave of Absence	37
Degree Certification Process & Commencement	37
ACADEMIC STANDARDS	37
Grades	37
University Policy on Grades	38
CIT Grading Policy	38
Incomplete Grade	38
Withdrawal Grade/Withdrawing from Courses	38
Academic Performance	38
Quality Point Average	38
Probation	38

Satisfactory Progress & Program Dismissal	38
Academic Integrity	39
Penalties for Violating Academic Integrity	39
PH.D. DEGREE REQUIREMENTS	40
Overview	40
Coursework	41
Required course total	41
Professional Development coursework	42
Course Restrictions	42
Petitioning to Count a Course Not on the Pre-approved List	42
Breadth Area Requirement	43
Qualifying Exam Requirement	43
Timeline	43
Mechanics	44
Outcomes	45
Research	45
Teaching Internship Requirements	46
Prospectus	46
Prospectus Description	47
Prospectus Format	47
Prospectus Committee	47
Prospectus Procedure	48
Milestone Review	48
All But Dissertation Status	48
Ph.D. Dissertation	49
Departmental Progress Reviews	50
Internships Course Option	51
POST-MATRICULATION GUIDELINES	51
Return of University Property	51
Career Services Employment Outcomes	51
“Grandfather” Clause	51
TUITION, FEES, FINANCES, AND FINANCIAL SUPPORT	51
Purchasing & Reimbursements	51
Graduate Student Reimbursement Policy	52
Business Expenses	52
Travel Expenses	53
Conditions	53
Academic Year Tuition & Stipend	53
Summer Semester Tuition & Stipend	54
Losing, Reducing, or Changing Funding	55
Self-Supporting Students	55
Fees	55
Taxes	56
Conference & Travel Funding	56
Additional Sources for Financial Support	56
University Financial Aid	56

Emergency Loans	56
Fellowships	56
GuSH Funding	57
Teaching Assistantships	57
Payroll	57
Outside Employment	57
CAREER SERVICES	57
Career Consultants	58
Job Search Guidelines	58
Job Classification and Salary Disclosure	58
UNIVERSITY POLICIES	58
Academic Integrity	58
Assistance for Individuals with Disabilities	59
Evaluation & Certification of English Fluency for Instructors	59
Leave of Absence & Withdrawal Policies	59
Tuition Refund Policy	59
Returning to Carnegie Mellon	60
Retention of Student Records	60
Safeguarding Educational Equity – Sexual Harassment and Sexual Assault Policy	61
Suspension/Required Withdrawal Policy	61
Withdrawal of a Degree	61
University Grievances	62
Student Maternity Accommodation Protocol	62
Verification of Employment	62
APPENDIX A: ADDITIONAL UNIVERSITY RESOURCES	63
Key Offices for Graduate Student Support	Error! Bookmark not defined.
Office of the Assistant Vice Provost for Graduate Education	Error! Bookmark not defined.
Office of the Dean of Student Affairs	Error! Bookmark not defined.
Silicon Valley Student Services	Error! Bookmark not defined.
Carnegie Mellon Ethics Hotline	Error! Bookmark not defined.
Graduate Student Assembly	Error! Bookmark not defined.
Intercultural Communication Center (ICC)	Error! Bookmark not defined.
Office of International Education (OIE)	Error! Bookmark not defined.
Employment with ECE Department	62
Key Offices for Academic & Research Support	Error! Bookmark not defined.
Computing and Information Resources	Error! Bookmark not defined.
Research at CMU	Error! Bookmark not defined.
Office of Research Integrity & Compliance	Error! Bookmark not defined.
Key Offices for Health, Wellness & Safety	Error! Bookmark not defined.
Counseling & Psychological Services	Error! Bookmark not defined.
Health Services	Error! Bookmark not defined.
University Police	Error! Bookmark not defined.
Shuttle and Escort Services	Error! Bookmark not defined.
The WORD	Error! Bookmark not defined.
APPENDIX B: ADDITIONAL INFORMATION FOR CALIFORNIA PROGRAMS	75

APPENDIX C: LIST OF PROGRAM COURSES	80
APPENDIX D: ADDITIONAL INFORMATION ON FEDERAL AND STATE AID / FINANCIAL AID POLICIES	115

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 2021 *US News and World Report* ranked our graduate programs in electrical engineering and computer engineering 8th 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 and your CIT graduate student handbook are specific to your academic experience in the department, there are several other resources and offices graduate students are encouraged to consult during their tenure at Carnegie Mellon University. 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 don't hesitate to contact us if you have any questions or comments.

Sincerely,

A handwritten signature in blue ink, appearing to read 'L. Pileggi'.

Larry Pileggi
Tanoto Professor and Department Head
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

Our vision is our guiding light; it informs and propels us in the right direction. The strategies of following that path change over time; the vision does not.

To be a creative driving force within the university and worldwide of highest scholarly and entrepreneurial quality.

Mission and Objectives

The Carnegie Mellon University mission is:

To create a transformative educational experience for students focused on deep disciplinary knowledge; problem-solving; leadership, communication and interpersonal skills; and personal health and well-being.

To cultivate a transformative university community committed to (a) attracting and retaining diverse, world-class talent; (b) creating a collaborative environment open to the free exchange of ideas, where research, creativity, innovation and entrepreneurship can flourish; and (c) ensuring individuals can achieve their full potential.

To impact society in a transformative way - regionally, nationally and globally - by engaging with partners outside the traditional borders of the university campus.

The ECE Department mission is our “what, who, how”; it explains what we do, who we do it for, and how we do it so we engage the “hearts, heads, and hands” of our faculty, students, and staff in achieving our objectives.

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 ECE Ph.D. Program are provided a research-intensive study of the fundamentals of electrical or computer engineering. Students will create and disseminate knowledge of electrical and computer systems during the course of obtaining the Ph.D. degree. Upon enrollment in the department, students, with the help of a faculty advisor, define an education and research program that is consistent with their background and is best suited to their own academic goals.

INTRODUCTION

Graduate Degrees and Programs Offered

Master of Science in Electrical and Computer Engineering

- Pittsburgh
- Silicon Valley
- Africa

Master of Science in Software Engineering

- Silicon Valley

Doctor of Philosophy in Electrical and Computer Engineering

- Pittsburgh
- Silicon Valley
- Portugal

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

Graduate Student Catalog/Handbook

This catalog/handbook is intended to set guidelines and expectations for new and current doctoral students in Electrical and Computer Engineering at Carnegie Mellon University. This catalog/handbook is not exhaustive and is subject to revision at any time by the ECE department. It covers Ph.D. 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 Graduate Affairs Office.

CARNEGIE MELLON POLICIES, EXPECTATIONS, STATEMENT OF ASSURANCE, AND CODE

Carnegie Mellon Policies & Expectations

It is the responsibility of each member of the Carnegie Mellon community to be familiar with university policies and guidelines. In addition to this departmental graduate student catalog the following resources are available to assist you in understanding community expectations:

- [The Word/Student Catalog](#)
- [Academic Integrity Website](#)
- [University Policies Website](#)
- [Graduate Education Website](#)
- [College of Engineering Website](#)

- Please see [Appendix A](#) for additional information about The Word and University resources.

Carnegie Mellon 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 university ombudsman, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, telephone 412-268-1018. Obtain general information about Carnegie Mellon University by calling 412-268-2000.

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. You can obtain a copy by contacting the Carnegie Mellon Police Department at 412-268-2323. The annual security and fire safety report also is available online at www.cmu.edu/police/annualreports.

Information regarding the application of Title IX, including to admission and employment decisions, the sexual misconduct grievance procedures and process, including how to file a report or a complaint of sex discrimination, how to file a report of sexual harassment, and how the university responds to such reports is available at www.cmu.edu/title-ix. The Title IX coordinator may be reached at 5000 Forbes Ave., 140 Cyert Hall, Pittsburgh, PA 15213; 412-268-7125; or tix@cmu.edu.

Carnegie Mellon Code

Students at Carnegie Mellon, because they are members of an academic community dedicated to the achievement of excellence, are expected to meet the highest standards of personal, ethical and moral conduct possible. These standards require personal integrity, a commitment to honesty without compromise, as well as truth without equivocation and a willingness to place the good of the community above the good of the self. Obligations once undertaken must be met, commitments kept.

As members of the Carnegie Mellon community, individuals are expected to uphold the standards of the community in addition to holding others accountable for said standards. It is rare that the life of a student in an academic community can be so private that it will not affect the community as a whole or that the above standards do not apply.

The discovery, advancement and communication of knowledge are not possible without a commitment to these standards. Creativity cannot exist without acknowledgment of the creativity of others. New knowledge cannot be developed without credit for prior knowledge. Without the ability to trust that these principles will be observed, an academic community cannot exist. The commitment of its faculty, staff and students to these standards contributes to the high respect in which the Carnegie Mellon degree is held. Students must not destroy that respect

by their failure to meet these standards. Students who cannot meet them should voluntarily withdraw from the University.

The [Carnegie Mellon Code](#) can also be found online.

Carnegie Mellon Child Protection Requirements

Carnegie Mellon is committed to providing a safe and secure environment for all minors involved in any programs or activities conducted on university premises, as well as any off-campus programs or activities sponsored by the university. Details are available through Leonard Gelfand Center [Child Protection Operations](#).

If you have questions regarding Act 153 or encounter a situation when you would need to have the clearances, please contact Meighan at meighan.harding@ece.cmu.edu.

DEPARTMENTAL INFORMATION

University Personnel

Throughout your time in the M.S. program, you will encounter a variety of faculty and staff who will help you on your way to completing your degree. You may view a list of faculty (<https://www.ece.cmu.edu/directory/faculty.html>) and a list of staff (<https://www.ece.cmu.edu/directory/staff.html>) affiliated with ECE online. Below is a list of faculty and staff whom you are likely to encounter during your time in the M.S. program.

- Dean of the College of Engineering: [Bill Sanders](#)
- Associate Dean of Graduate and Faculty Affairs: [Professor Shelley Anna](#)
- Department Head: [Professor Larry Pileggi](#)
- Executive Assistant to the Department Head: [Kimmy Nguyen](#)
- Director, CMU Africa: [Professor Vijayakumar Bhagavatula](#)
- Associate Department Head for Research: [Professor Shawn Blanton](#)
- Associate Department Head for Academic Affairs: [Professor James A. Bain](#)
- Associate Department Head for Students: [Professor Dave O'Halloran](#)
- Director of Finance and Sponsored Research: [Charlotte Ambrass](#)
- Academic Services Manager: [Megan Oliver](#)
- Director of Graduate Affairs: [Tara Moe](#)
- Student Organizations Advisor in Silicon Valley: [Brittany Bristoll](#)
- Ph.D./M.S. Academic Program Advisor in Silicon Valley: [Brittany Bristoll](#)

A general list of contacts (<https://www.ece.cmu.edu/about/contact.html>) can also be found on the ECE website.

University Resources

Stellic Degree Audit

Each student has access to [Stellic Degree Audit Application](#) which includes degree planning tools can show how courses taken or registered for meet the degree requirements. Students should

also meet with their academic advisor to review how their courses have been applied to the degree requirements.

University Resource Websites

Several pertinent university policies are included in this handbook, primarily found in the [University Policies section](#). The complete university policies are available online at the following link: <http://www.cmu.edu/policies>.

Additional assistance is available in understanding community expectations, with the following resources being particularly relevant to ECE students:

- The Office of the Assistant Vice Provost for Graduate Education. Website: www.cmu.edu/graduate. Email: grad-ed@cmu.edu
- The Office of the Dean of Student Affairs. Website: www.cmu.edu/student-affairs/index.html
- Student Services in Silicon Valley. Website: <http://sv.cmu.edu/student-services/index.html>.
- Assistance for Individuals with Disabilities. Contact Larry Powell, Equal Opportunity Services, 412-268-2013, lpowell@andrew.cmu.edu
- Eberly Center for Teaching Excellence. Website: www.cmu.edu/teaching
- Graduate Student Assembly. Website: <http://www.cmu.edu/stugov/gsa/index.html>
- Intercultural Communication Center. Website: www.cmu.edu/icc
- Office of International Education. Website: <https://www.cmu.edu/oie/>
- Counseling & Psychological Service (CaPS). Website: <https://www.cmu.edu/counseling/>
- University Health Services. Website: www.cmu.edu/HealthServices
- University Police. Website: www.cmu.edu/police
- The Word (student online handbook). Website: <http://www.cmu.edu/student-affairs/theword>
- Academic Integrity Website: <https://www.cmu.edu/student-affairs/ocsi/academic-integrity/index.html>
- University Policies Website: www.cmu.edu/policies/

Please refer to [Appendix A](#) for additional information about each of the above-cited resources.

University Library

Pittsburgh campus

Students in Pittsburgh have access to several on-campus libraries. More information about the libraries can be found on the CMU Library website: <https://www.library.cmu.edu>

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. 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

E-book developments can be found on our website at <http://guides.library.cmu.edu/svc>.

Since we have students, staff, and faculty in Pittsburgh, Qatar, Africa, and Silicon Valley, we're making a concerted effort to collect whatever e-Books we can so that all of our community can use them. You'll find them in CAMEO - our online catalog.

University Quick Links can also be found on the website at <http://guides.library.cmu.edu/svc>.

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

Department Resources

Course Instructors

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

Anupam Datta, Professor

Ph.D., Computer Science, Stanford University

Hakan Erdogmus, Teaching Professor

Ph.D., Telecommunications, Université du Québec

Manish Pandey, Adjunct Instructor/Professor

Ph.D., Computer Science, Carnegie Mellon University

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

Patrick Tague, Associate Research Professor

Ph.D., Electrical Engineering, University of Washington

Leonardo da Silva Souza, Assistant Teaching Professor

Ph.D., Computer Science, Pontifícia Universidade Católica do Rio de Janeiro

Pei Zhang, Associate Research Professor

Ph.D., Computer Engineering, Princeton University

Academic Advisors

Your academic advisor is a resource for having any university paperwork signed, asking questions regarding registration or the curriculum, and guiding you to other important resources. Nathan Snizaski and Brittany Reyes serve as the academic advisors for Ph.D. students.

Academic advising is done through the Graduate Affairs Office. In Pittsburgh this is in Hamerschlag Hall 1113; in Silicon Valley this is in B23 123. The Ph.D. Academic Program Advisor administratively advises all ECE Ph.D. students throughout the entire duration of the Ph.D. program. While this advisor does not provide content-specific expertise in ECE, he/she helps students navigate through the program by tracking milestones, meeting one on one and in groups with students for questions related to registration or the curriculum, guiding students to other important resources, completing enrollment and university-related paperwork, and answering questions for students who may not know where else to turn. Nathan Snizaski and Brittany Bristoll are the Academic Advisors for Ph.D. students.

Nathan can be reached by email: nathanedward@cmu.edu, by phone: (412) 268-3200, or in person in 1113 Hamerschlag Hall. To guarantee availability, you are encouraged to schedule an appointment with him by accessing his [calendar](#) in the signature block of his e-mail. Nathan advises Pittsburgh based Ph.D. and Portugal based students.

Brittany can be reached by email: bjreyes@andrew.cmu.edu, or by phone: (650) 603-0934. To guarantee availability, you are encouraged to schedule an appointment with her by accessing her [calendar](#) in the signature block of her e-mail. Brittany advises all Silicon Valley based Ph.D. students.

Faculty Advisors

Students also receive a faculty advisor. Faculty advisors help guide Ph.D. students through the program by ensuring that all students receive the necessary support and mentoring to succeed.

Faculty Credentials

For all faculty please visit the ECE [faculty directory](#).

Faculty based in Silicon Valley and teaching in Silicon Valley:

Anupam Datta, Professor

Ph.D., Computer Science, Stanford University

Hakan Erdogmus, Teaching Professor

Ph.D., Telecommunications, Université du Québec

Manish Pandey, Adjunct Instructor/Professor

Ph.D., Computer Science, Carnegie Mellon University

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

Patrick Tague, Associate Research Professor

Ph.D., Electrical Engineering, University of Washington

Leonardo da Silva Souza, Assistant Teaching Professor

Ph.D., Computer Science, Pontifícia Universidade Católica do Rio de Janeiro

Pei Zhang, Associate Research Professor

Ph.D., Computer Engineering, Princeton University

Faculty based in Pittsburgh and broadcasting courses to Silicon Valley:

Lujo Bauer, Associate Professor

Ph.D., Computer Science, Princeton University

Franz Franchetti, Professor

Ph.D., Computational Mathematics, Vienna University of Technology

Saugata Ghose, Special Faculty Systems Scientist

Ph.D., Computer Systems, Cornell University

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

Diana Marculescu, Professor

Ph.D., Computer Engineering, University of Southern California

Bill Nace, Teaching Professor

Ph.D., Electrical and Computer Engineering, Carnegie Mellon University

Aswin Sankarayananan, 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

Matching

Within the first few weeks of entering ECE, most students are matched with faculty advisors using a “mutual match” process. During orientation, faculty from ECE’s four areas give an overview of available research projects in order to help students find an advisor who aligns with his or her research interests. ECE’s four research areas are:

- Circuits/CAD/VLSI
- Computer Systems
- Device Sciences and Nanofabrication
- Signals, Communications, and Controls

After the area overview, students are required to meet with all the faculty listed on their admission letter and are also welcome to meet with any other faculty member with an ECE affiliation. In addition to attending the orientation presentations, students can learn about an individual faculty member’s research interests by viewing the faculty’s member Curriculum Vitae and website (if available) and from meeting individually with different faculty members during the matching period.

Matching is done through a mutual matching process: students rank their top three [3] faculty preferences and faculty discusses their student preferences. A committee then matches each student with a faculty member, taking into consideration each of their preferences and other factors. Final matches will be communicated to students by the end of the first full month of enrollment.

Some programs have different matching processes. These variations are listed below.

Program	Matching Process
CMU Portugal Dual Degree Program	CMU Portugal dual degree students typically enter the program pre-matched based on recommendations from the Program Directors. One advisor will be from CMU and one advisor will be from the student's home institution in Portugal.
Silicon Valley	Silicon Valley students are generally directly matched with the faculty advisor listed on the admission letter. Silicon Valley students will still be expected to formalize this relationship by filling out the matching process survey.

Expectations

Faculty advisors are expected to help guide Ph.D. students through the program by ensuring that all students receive the necessary support and mentoring to succeed. Each relationship between a student and his or her faculty advisor is unique and tends to evolve over the course of the student's time in the Ph.D. program. It is the responsibility of both the student and his or her advisor to identify goals, plans, and criteria for success in the Ph.D. program.

Occasionally, students request to switch advisors. While this request must be approved by the Graduate Affairs Office, it is generally viewed as routine and is almost always granted. It is recommended that students pursue such switches early in the Ph.D. program so that their academic progress can continue as it is expected. To switch an advisor, a student must complete the [Change of Advisor form](#).

Faculty advisors must have an ECE affiliation and be able to financially support the student for the duration of their studies.

Co-advisors

It is possible for students to have more than one advisor at the same time. Usually, co-advising is done when a student is pursuing a topic that is interdisciplinary in nature or that would benefit from the expertise of two faculty members. Both advisors must have an ECE affiliation to co-advise an ECE student.

Advisor Departure

In case of advisor departure from CMU, Ph.D. students have the following options:

- Remain with advisor as a CMU student; physically located at CMU

- Remain with advisor as an enrolled CMU student, but work with advisor at his/her new institution
- Remain with advisor and transfer to advisor's new institution
- Find a new advisor at CMU and remain a CMU student

When an advisor leaves the ECE Department, the department will hold an information session for that faculty member's students to discuss this transition and their options.

Graduate Studies Committee (GSC)

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

The GSC Chair for the 2021-2022 academic year is Professor L.R. Carley. The dates for the GSC meetings will be posted on the [GSC Petitions Procedures website](#) (requires Andrew ID log in) before the start of each semester.

Bulletin Boards

Silicon Valley campus

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

Tech & Receiving

Silicon Valley campus

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

Computer Clusters

There are not computer clusters available in Silicon Valley.

Printers

[Printers](#) are provided for student academic use.

Silicon Valley campus

- Printers are for use in Building 23 (B23) Room 123 and the hallway in B23 outside of 109/110. Instructions for adding printers and policies are posted next to each printer.

Keys

Silicon Valley campus – you must use your CMU ID to enter building 23 every time.

Lab & Office Space

Lab and office space for both campuses will be assigned to students once they have been formally matched with a faculty advisor. Lab and office assignments may be modified at the discretion of

the students' faculty advisor or the department. Students may not re-locate without prior permission from the department.

Silicon Valley campus

- There are two labs on the Silicon Valley campus that are attached to Building 23. The Carnegie Mellon Innovations Lab (CMIL) is the larger general-use lab. Bench space is shared. Lab access is a privilege, not a right. It requires training, respect for access controls, and adherence to/signature on the written lab policies. CMIL contains the following equipment for personal and course projects: Ultimaker 2+ 3D printer, Oscilloscopes (40 MHz and 200 MHz,) regulated DC power supplies, 5MHz Function Generator, Agilent digital multimeter, ESD safe electronics work area, soldering irons, Weller rework station, Various hand tools.

Graduate Student Lounges

Silicon Valley campus

- There are several spaces for students in Silicon Valley to use. The main student lounges can be found in B23, downstairs Room 129 and upstairs Room 227.

Department Office/Building Security, Repairs and Services

Silicon Valley campus

- 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 campus 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: 5 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 lab space.

Graduate Student Organizations

- **EGO (ECE Graduate Student Organization)** organizes academic and social events throughout the academic year.
- **WinECE (Women in Electrical and Computer Engineering)** provides academic and social events to women in ECE throughout the year.
- **HKN (Eta Kappa Nu)** is the honor society for Electrical and Computer Engineering students. HKN members engage in community service, professional engagement, and social activities. Ph.D. students are invited by the board of HKN to join based on academic performance.

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

Press & Media Relations

ECE's Assistant Director of Communications is the point-of-contact between news media and the ECE, including faculty, students, and staff.

If any student, staff or faculty member of ECE is contacted by a media representative, they are required to immediately inform either the Communication Manager and/or the Director of Operations. Members of the ECE community are not required to answer any questions from the media without first seeking information from ECE's Communication Manager and/or the Director of Operations.

Persons interested in publicizing a program, project, event, or other activity affiliated within ECE should contact the Communications Manager [Krista Burns](#) who can provide guidance on internal and external communications.

Electrical & Computer Engineering Brand & Logos

The [Information Technology Services \(ITS\) website](#) contains information regarding the department's branding and identity standards.

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>

TOEFL 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 TOEFL 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. The TOEFL is not required if the applicant has graduated from a U.S. university, or if the applicant is a CMU student or alum.

The Admissions Committee prefers the TOEFL to the IELTS. While you are encouraged to take the TOEFL, if you are unable to do so, we look for a minimum overall score of 7 on the IELTS, with minimum sub-scores of Reading-6.5, Listening-6.5, Speaking-6, and Writing-6.

Nonnative English speakers may utilize the Intercultural Communication Center (ICC) for language support: <https://www.cmu.edu/icc/>. The Silicon Valley campus also has a 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 offered admission 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.

Final Undergraduate Transcripts

Applicants admitted to any ECE program 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 Ph.D. degree from being certified.

Responsible Conduct of Research (RCR) Education

The [Office of Research Integrity and Compliance website](#) 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 at citiprogram.org. Select "Carnegie Mellon University" as your participating institution when you create your account.

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 Graduate Affairs Office. 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 their process by reviewing degree requirements on the website, connecting with their academic advisor, and conferring with their faculty advisor. 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, there is a Course Planning module that allows students 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/fail deadline, and the audit deadline. Academic deadline information can be found within [The HUB's Academic Calendar](#).

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

Degree Timeframe and Residency Requirement

Completion of the Ph.D. degree usually takes about four to six years of study (depending on if the student enters with a B.S. degree or an M.S. degree). At least one calendar year of [full-time graduate study in residence](#) is required by CIT (see 'Ph.D. degree' section). This requirement may be waived for part-time students via a petition to the Department Head and the Associate Dean for Graduate and Faculty Affairs.

The total time allowed to complete the Ph.D. degree requirements is six years following the successful completion of the Ph.D. Qualifying Examination milestone. A minimum of 144 units is required beyond the bachelor's degree. In calculating these 144 units, a student's master's degree from another institution can be factored towards the 144 units. Please see the [Full-time and Part-time Requirements section](#) for additional information.

Students are encouraged to register as soon as possible for each semester to avoid waitlists and ensure that tuition and stipend support continues smoothly.

Students must be physically present and attend class 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 he or she is not here by the tenth day of class as defined by the [academic calendar](#).

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 prior to the end date on their I-20. Please see details and relevant forms on OIE's website under [Maintaining Legal Status](#).

Summer Registration Process & Procedures

Students are expected to continue their research over the summer or pursue an internship that is relevant to their Ph.D. research. Any deviation from this expectation must be approved by the student's faculty advisor prior to the beginning of the summer semester.

Students who are performing full-time research with their faculty advisor should register themselves for 18990-R Reading and Research for 36 units during the Summer 1/All semester.

International students who are completing an internship in the United States must complete the paperwork for Curricular Practical Training (CPT). For more information about internships and CPT, see the [Internship Course](#) section outlined in this handbook. Academic and OIE advisors will provide students with information about CPT during the spring semester.

Vacations & Time-Off

Students with graduate assistantships are expected to continue with their research during academic breaks (including summer months) with the exception of official University holidays. Paid time off for personal business or vacations generally is not included as part of a graduate's financial support.

A supported graduate student who wants to take a short break (up to two weeks) must get approval for that break from his/her advisor in writing and, if required by the terms of the student's support package, must make up the work. Supported graduate students wishing to take longer periods of personal time off must do so without financial support and must receive written approval from their faculty advisor at least three weeks prior to the requested time off. International students should pay particular attention to the rules governing their visa in relation to time off. The student's faculty advisor will notify the Department's Business Office of any such arrangements so that an appropriate adjustment in the student's support package can be processed.

University holidays include:

- New Year's Day
- Martin Luther King Day
- Memorial Day
- Independence Day
- Labor Day
- Thanksgiving Day
- Day After Thanksgiving
- Day Before Christmas
- Christmas Day
- Day Before New Year's Day

Full-time and Part-time Requirements

Full-time Requirements

Full-time students must be enrolled for a minimum of 36 units each semester – fall, spring, and summer.

Moreover, international students must be enrolled in a full course load (minimum 36 units) each semester to maintain their immigration status. Enrollment less than full time may be applicable at certain periods of the Ph.D. program (e.g., self-supporting in the final semester). See your academic advisor for more information.

Part-time Requirements

Occasionally, employment constraints may result in a student being enrolled part-time (less than 36 units per semester) in the Ph.D. program while they continue to work full-time elsewhere. Students planning to enroll in the Ph.D. part-time should discuss their part-time status with their faculty advisor and academic advisor and create a plan that will ensure their timely and comprehensive fulfillment of the Ph.D. program. Part-time students should note that the Ph.D. program is rigorous and that students should think carefully about embarking upon a part-time program while continuing to work full-time.

Part-time students are subject to [CIT's residency requirement](#) (see 'Part-Time graduate programs' section) and requires that student spend at least one academic year (fall and spring) on campus over the course of the Ph.D. program. Any deviation from this requirement must be petitioned for by the student and his advisor prior to his or her enrollment in the Ph.D. program. The petition must be approved by the Department Head and the Associate Dean for Graduate and Faculty Affairs.

Part-time students should be enrolled for less than 36 units each fall and spring semester. Most part-time students take 12 or 24 units per semester.

Statute of Limitations

ECE adheres to [CIT's policy on Ph.D. completion timelines](#). The CIT policy is as follows: "Passing the Ph.D. qualifying examination admits a student to candidacy for the Ph.D. degree for a period of no longer than six calendar years. If, at the end of this six-year period, the Ph.D. has not been awarded, the student must reapply for admission to the graduate program and will be judged competitively with other students applying at the same time." Former ECE students who did not fulfill graduation requirements and would like to return to complete a degree should refer to the [statute of limitations](#) in CIT's graduate student policies for more information.

Under extraordinary circumstances, such as leave of absence, military or public service, family or parental leave, or temporary disability, a school or college may, upon the relevant department's recommendation and with the written approval of the dean, defer the lapse of All But Dissertation status for a period commensurate with the duration of that interruption. Students, who are pursuing the Ph.D. degree as part-time students for all semesters of their program, as approved by their program, may also appeal to their program or department for extension of the time to degree limit. Requests for extensions to the statute of limitations must be submitted to

the Graduate Studies Committee at least one semester prior to the statute of limitations expiration.

Students wishing to obtain an extension due to special circumstances must to submit a formal petition at least one semester prior to his or her defense timeline expiring. The time clock will stop for students who have not taken the qualifying exam prior to the leave of absence.

Campus Location Tracking & Reporting Requirements

Students who are not based in Pittsburgh will be required to report their expected location for the future semester by responding to an online poll disseminated by the Graduate Affairs Office. This information is critical in ensuring that students are billed properly and, if they are traveling to the United States from abroad, receive their visa in a timely fashion. Additionally, some programs regulate on how long a student can be in Pittsburgh over the course of the program.

Any deviations from the location requirements outlined by the program must be approved by the student's faculty advisor. Additional information regarding funding may also be requested by the Business Office in order to facilitate the students' deviation from traditional location requirements.

Information on location requirements can be found in the table below:

Program	Location Details
CMU Portugal Dual Degree Program	CMU Portugal dual degree students receive funding for a total of two years on the Pittsburgh Campus. Students and their advisors should work together to determine where the student will be physically located each semester. Three years will be spent in Portugal.
Silicon Valley	Students and their faculty advisors should work together to determine where the student will be physically located each semester.

Once students have reported their location to the Graduate Affairs Office, any change in plans should be communicated immediately and directly to the Graduate Affairs Office. It is the responsibility of the student and his or her advisor to communicate location information to the Graduate Affairs Office. Late or inaccurate reporting of future locations may limit a student's ability to travel to the United States and may result in inaccurate financial charges to the student's account.

Obtaining an M.S. on the Way to the Ph.D.

Many Ph.D. students wish to obtain an M.S. on the way to the Ph.D. in order to demonstrate their academic progress in the program and to have a milestone to show on their curriculum vitae/resume. Ph.D. students have two M.S. options: a course M.S. or a project M.S.

Course M.S.

The **course M.S.** requires 96 units of coursework, 12 units of which can be research. Of the 96 units, 60 units are restricted (including 12 units of research) and 36 are less-restricted.

Project M.S.

The **project M.S.** is only open to ECE Ph.D. students. This option also requires 96 units of coursework, 36 units of which can be research in exchange for writing a 40 page or less research paper. This paper will need to be approved by both the student's faculty advisor and a second reader who must be an ECE faculty member. Twelve of the 36 units will be allocated to the restricted 60 units, and 24 of the 36 units will be allocated to the less-restricted units.

Both types of M.S. degrees require the completion of a **Request for an M.S. Degree form**. This form must be completed at least two weeks before the final grades deadline if a student is requesting an MS at the end of a given semester.

Change of Degree Program

Sometimes students begin the Ph.D. program and realize that they do not want to continue as a Ph.D. student. When this occurs, students may have the option of switching to the M.S. program. Switches to the M.S. program should be discussed with the student's advisor prior to filling out **the switch to M.S. form** to formalize the switch.

Please note that this switch must be done prior to or within the first 10 days of classes in the semester in which a student would like to switch to the M.S. program via the switch to M.S. form. After the 10th day of class, the switch will not be permitted until the following semester and the student will be expected to continue with Ph.D. research until the end of the semester.

Students who switch to the M.S. program will become financially self-supporting, meaning that they will no longer receive tuition or stipend support from the department. Prior to switching to the M.S. program, international students should consult with OIE.

Center for the Neural Basis of Cognition (CNBC) Program

ECE Ph.D. students interested in the neural basis of cognition can apply to the **Center for the Neural Basis of Cognition (CNBC)** Graduate Training Program, which allows students to combine neuroscience and engineering in an interdisciplinary training program.

The CNBC program offers a certificate graduate training program in collaboration with ECE and several other affiliated doctoral programs at Carnegie Mellon University and the University of Pittsburgh. The program trains interdisciplinary scientists interested in understanding how cognitive processes arise from neural mechanisms in the brain. Students combine intensive training in their chosen specialty with broad exposure to other disciplines that touch on neural computation and problems of higher brain function.

Students who have been accepted to the ECE Ph.D. program can apply to participate in the CNBC graduate training program. The program requires four core courses in the areas of cellular and molecular neuroscience, systems neuroscience, cognitive neuroscience, and computational

neuroscience. The CNBC program also includes several colloquium/seminar series, student-run journal clubs, research ethics training, and a variety of optional elective courses. Students in the CNBC program receive travel support and possible computer equipment support.

The following describes how the CNBC course requirements can be integrated with the ECE Ph.D. course requirements:

For incoming Ph.D. students with a B.S. degree

Students entering the ECE Ph.D. program with a B.S. degree will be able to complete the CNBC course requirements entirely within the framework of the ECE course requirements. In other words, these students will be able to complete the CNBC course requirements without taking units above and beyond the 96 units required for an ECE Ph.D.

For incoming Ph.D. students with a M.S. degree

Students entering the ECE Ph.D. program with a M.S. degree may petition the GSC for one CNBC course to be counted towards fulfillment of an ECE breadth area and course requirements. One other CNBC course will be allowed to count as an ECE-related course with no GSC petition required. The student will then need to take four more courses: two more to satisfy the CNBC requirements, and two more to satisfy the ECE breadth requirement and the 48 units required for an ECE Ph.D.

All students who are planning to complete the CNBC graduate training program along with an ECE Ph.D. are required to meet with their faculty advisor to discuss their course plans. The course plan must then be discussed with the Graduate Affairs Office.

Joint Degree Programs

Joint degrees are when two departments come together to create one program and award one degree. The College of Engineering has a [joint degree program with the Department of Engineering and Public Policy](#) (under 'Joint Degrees with EPP').

Courses Outside of Degree Requirements

Courses that do not satisfy degree requirements include StuCo courses (98), Physical Education course (69), audited courses, and pass/fail courses. Similar to courses taken for degree requirements, students must register for these other courses, and the units will count towards their course load for the semester. Students should confer with their faculty advisor for approval prior to registration.

Double Counting Courses

ECE follows the [CIT Policy on double counting courses](#). Students are required to notify the Graduate Affairs Office prior to declaring a degree outside of ECE as this may have repercussions for your units and coursework to date.

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

Retaking Courses

If students do not pass a course, they should take a different course that will fulfill the requirement. Retaking a course is not recommended. Students who wish to retake a prerequisite course in which they did not receive the minimum grade required should first confer with their faculty advisor for approval. Should a student choose to retake a course, only the course with the higher final grade will be counted towards the ECE Ph.D., provided the student receives a “B-” or better.

All grades are recorded on the transcript and factored into the cumulative QPA. Depending on previous education (entering Ph.D. program with or without M.S. degree) approved courses will be factored into the 48 or 96 units that fulfill degree requirements are factored into the required 3.0 graduation QPA.

Auditing Courses

Auditing a course is being present in a classroom without receiving academic credit or a letter grade. An audited course will appear on a student’s transcript. Students are permitted to audit courses in consultation with their faculty advisor. Please note that audited courses cannot count towards the Ph.D. Course or Breadth Area requirements. Students who are present in a classroom and who are not receiving academic credit or a letter grade must complete audit the class to continue to attend regularly.

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](#).
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. You can find the deadline for submitting this form on the [Academic Calendar](#). After the deadline, students will not be 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. Any student may audit a course. For billing, an audited course is considered the same as the traditional courses under the 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 are permitted to take courses pass/no pass in consultation with their faculty advisor. Students interested in taking a course pass/no pass should register for the course, then complete the [Pass/No Pass Approval form](#). The form should be signed by the academic advisor. Courses taken pass/no pass cannot count towards the course or breadth requirements for the ECE Ph.D.

Once a Pass/Fail 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. 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; work with a grade at or lower than 'D+' 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 QPA.

The units of pass/no pass courses count toward the maximum course load units, but do not count toward the degree requirements. You can find the deadline for submitting this form on the [Academic Calendar](#). After the deadline, students will not be able to request the option to pass/fail a course.

Any student may take a course pass/fail. For billing, the pass/fail course is considered the same as the traditional courses under the tuition charges. If a part-time student takes a course pass/fail, he/she will be charged part-time tuition based on the per-unit tuition rate for the course.

Petition Process

Petitions are approved by the GSC. Petitions to the GSC may include program transfers, breadth area substitutions, Ph.D. milestone extensions, increase in units, course substitutions and any other changes that are outside of the policies stated in the student handbook. Students are advised to discuss their petitions with their academic advisors.

The petitions process is as follows:

1. Student completes the appropriate [petition form](#) and submits it to their academic advisor in the Graduate Affairs Office no later than 5pm ET on the Friday before the GSC meeting.
2. The academic advisor presents the petition to the GSC.
3. Students are notified of the outcome of their petition via an email from the M.S. 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. When this occurs, students will be notified via email.
5. The academic advisor saves a finalized version of the petition in the student's academic file.

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 M.S. degree. As a guideline, three-credit courses from other universities equate to 9-unit CMU courses; a four-credit course equates to a 12-unit CMU course.

The course being transferred in must:

- Fulfill an ECE degree course requirement and is 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](#) (under 'Transfer Credit and Special Students'). A grade of 'B' or better must be earned for the course to be transferred. The transfer credits will appear on the student's transcript and will not be factored into the 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 Carnegie Mellon. After matriculating to Carnegie Mellon, ECE students should consult with their academic advisor before taking a course at another university.

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.

If a course has previously counted towards a degree, you may still request that the course count towards the Breadth Area requirement.

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

1. Meet with academic advisor and faculty advisor to discuss the course transfer
2. Complete and collect the following mandatory documents:
 - a. [Petition for Graduate Studies Committee approval](#)
 - b. Official transcript from previous institution
 - c. Detailed course description/syllabus (should include grading scale, assignments required, mandatory books, and time required in class) of the course you wish to transfer
 - d. Letter from the previous institution's registrar or academic advisor stating the course intended for transfer was not used towards a degree
 - e. E-mail endorsement from the instructor of the CMU course you believe your transfer course is most equivalent to
 - f. [CIT Graduate Transfer Credit Request form](#)
3. Submit the completed packet to the academic advisor
4. The academic advisor will present the transfer request to the CIT Dean's office and notify the student of the result.
5. Once the petition is approved, the Graduate Affairs Office will work with the student to complete the transfer request.

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.

Pittsburgh Council on Higher Education (PCHE) Cross-Registration Program

Full-time Carnegie Mellon students may take subjects for credit through the Pittsburgh Council on Higher Education (PCHE). The purpose is to provide opportunities for enriched educational programs by permitting *full-time* paying undergraduate and graduate students to cross-register for **one** course at any of the ten PCHE institutions. Please refer to [The HUB website](#) for additional details.

Registering for Courses

Academic Calendar

ECE adheres to the official CMU [Academic Calendar](#). The [Heinz College](#) and the [Tepper School](#) follow their own calendars with dates that may differ from the University's calendar for the add, drop and pass/fail/audit deadlines. ECE students must adhere to the deadlines of the courses they are taking if the courses are in Heinz or Tepper.

Course Load

Prior to registering each semester, it is strongly recommended that students consult with their faculty advisor in order to ensure that their course load is balanced and relevant to the student's Ph.D. research.

Some programs have specific registration requirements. These requirements are outlined in the table below.

Program	Registration Details
CMU Portugal Dual Degree Program	CMU Portugal dual degree students should register for at least 37 units in their first semester in Pittsburgh and 36 units during each semester before or afterward, regardless if they are in located in Portugal or Pittsburgh.
Silicon Valley	Silicon Valley students should register for at least 37 units in their first semester and 36 units each semester thereafter whether they are in Silicon Valley or Pittsburgh.

Adding Courses

Students have the option of adding courses to their schedule starting at their assigned registration time until the add/drop deadline through SIO. If a student wishes to be added to a course after the add/drop deadline, the [Course Add Request Form](#) must be completed and signed by the course instructor. Then, the student must 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 cross-listed with a course from another department, ECE students must register for the ECE course number.

Courses in the Tepper School of Business may be taken and can be registered for through a site outside the SIO. Tepper will publish a list of available MBA courses, and in order to register for Tepper courses, students should visit the [Tepper registration site](#).

Course Locations

Courses will take place at various buildings and room locations across CMU campuses as assigned by the University Registrar's office each academic semester. Each course location is tied to a section and has a final assignment that is linked to the final grade. It could be in the form of a final exam, final project, or research as stated in the syllabus on the first day of classes. Students should register for sections of their courses according to their physical campus location. Please refer to the schedule of classes available on your campus.

Dropping Courses

Students have the option of dropping courses from their schedule starting at their assigned registration time until the [add/drop deadline](#) through SIO. 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 allow a waitlisted student to be enrolled and will limit the disruption to any team-based projects.

Withdrawing from Courses

Students should remove themselves from a course before the [drop deadline](#) each semester. If a student chooses to withdraw from a course after the drop deadline, the student must officially withdraw from the course and should consult with their academic advisor and faculty advisor to discuss the withdrawal. Withdrawals take place after the drop deadline but before the last day of the semester. Students must complete and submit the [Course Withdrawal Request form](#) 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](#). Withdrawals receive a "W" grade for the course on a transcript; this "W" grade is not factored into the QPA but the course does count towards the maximum units.

Waitlists

It is typical to be waitlisted from the time of registration up until the tenth day of class. This is common practice across the university to ensure that students within the department have the opportunity to take the courses they need in order to graduate. To determine the likelihood that you will be registered from a waitlist for an ECE course, students should send an email to Academic Services Manager, Megan Oliver at mvoliver@andrew.cmu.edu. You should only attend courses for which you are waitlisted if you have permission from the instructor. Students may only be waitlisted for a maximum of 5 courses.

As a courtesy, students should remove themselves from the waitlist and/or drop a course 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 their waitlists will result in being dropped from the waitlist.

It is strongly recommended that students have a back-up plan in case they are not removed from a waitlist by the tenth day of class.

Technology Enhanced Courses

The ECE department offers courses that are taught exclusively online, and some have a live recitation component. ECE refers to them as “Technology Enhanced” courses and can be identified by the section code that includes “T”. Other departments with online courses may list their technology enhanced courses in a different format, so be sure to check with the instructor if it is unclear whether a course is online. International students on a US residential campus (Pittsburgh, Silicon Valley) may take a maximum of one online course per semester that does not have a required in-person component, per F1 regulations.

Courses with Time Conflicts

Students are not permitted to register for two courses that conflict in time. Registration may be possible with consent from an instructor, allowing the conflict or attendance at an alternate time. Students should forward permissions from instructors to their academic advisor in order to register for conflicting courses.

Prerequisites

While SIO may allow you to register for courses without the published prerequisite, it is the student’s responsibility to have adequate background knowledge to be successful in the subsequent course. This background knowledge may come in the form of an introductory course taken at Carnegie Mellon, your undergraduate institution, or other work/research experience. We recommend that you consult with the instructor as it is at the discretion of the instructor to decide if a prerequisite course or knowledge can be waived.

For ECE courses that require 18-600/15-213/15-513/18-213 as a prerequisite, students will not be permitted to enroll in the subsequent course without credit for 18-600/15-513. 18-600 and 15-513 are the only courses available to graduate students that satisfy the prerequisite requirement. Students attending Pittsburgh campus can plan to take 15-513 in the summer prior to their matriculation in the fall semester. Tuition will apply at a **per unit rate**.

Graduate courses that require 18-600/15-213/15-513/18-213 anywhere in their prerequisite tree include:

- 18-640 – Foundations of Computer Architecture
- 18-648 – Embedded Real-Time Systems
- 18-649 – Distributed Embedded Systems
- 18-656 – Data Intensive Workflow Development for Software Engineers
- 18-725 – Advanced Digital Integrated Circuit Design
- 18-740 – Computer Architecture
- 18-742 – Parallel Computer Architecture
- 18-745 – Rapid Prototyping of Computer Systems
- 18-746 – Advanced Storage Systems
- 18-748 – Wireless Sensor Networks
- 18-756 – Packet Switching and Computer Networks

- 18-759 – Wireless Networks
- 18-842 – Distributed Systems
- 18-845 – Internet Services
- 18-848 – Special Topics in Embedded Systems

Ph.D. Program Course List

See Appendix C.

Final Exams

All ECE students must attend final exams as scheduled by the university and individual course instructors. If a student believes that a final exam presents a scheduling conflict, he or she must discuss the issue with the course instructor. ECE administration does not have control over the university exam schedule. Please keep this in mind when arranging travel at the end of a semester; having purchased airline tickets is not a proper excuse for missing a final exam. Please refer to [Carnegie Mellon University Policies on Examinations](#) for additional information.

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.

ECE may verify some limited information in the form of a letter, which may be suitable for some purposes, such as the verification of skills students acquired through the ECE programs. Please contact your academic advisor for more information. Please note that the ECE department is only able to verify information on ECE and Computer Science courses. Information on courses offered in other departments can only be verified by the other department. To obtain a verification letter, the student or alumni should contact the Graduate Affairs Office.

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 his or her academic advisor prior to taking a leave of absence in order to ensure his or her understanding of the leave of absence policy and its ramifications.

Leaves of absences are capped at two calendar years' time maximum throughout the Ph.D. program, accrued either as a 2-year leave or amount to 2 years accrued through various leaves. In extreme cases, a student may request additional leave time via a petition to the GSC. If they do not return within two academic years, they will be administratively withdrawn from the graduate program. Students are not eligible to complete departmental milestones while on a leave of absence and must return from a leave of absence in order to complete any program requirements, including the Course requirement, Breadth Area requirement, Teaching Internships (TI), Qualifying Exam, Prospectus, and thesis or dissertation defense.

Students who intend to return to the Ph.D. program beyond or after the two-year leave cap must re-apply to the graduate program. Questions can be addressed to the Ph.D. Academic Program Advisor.

Once a student decides to take a leave of absence, he or she should complete the [Leave of Absence form](#) and bring it to their academic advisor for additional processing. Please note that the student's advisor must sign the leave of absence form. The student and his or her faculty advisor are expected to have a conversation about the requirements for the student's return. ECE faculty are not required to hold spaces in their research group for students who are on leaves of absences. As a result, a student may need to be prepared to find a new faculty advisor and new funding in order to return from a leave.

Returning from a Leave of Absence

To return from a leave of absence, the student must have financial support and an ECE faculty advisor's approval. A student intending to return from leave must submit the [Petition to Return from Leave of Absence form](#) to their academic advisor at least 30 days prior to the start of the semester in which he/she plans 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 in mid-semester, with the exception of summers.

Per [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."

More information about the University's [Leave of Absence and Withdrawal](#) policies can be found in the [University Policies](#) section of this handbook.

Degree Certification Process & Commencement

Ph.D. degrees will be certified after students successfully defend their dissertation and submit all required paperwork, including publication permissions and contact information. 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. Students will be notified of their degree certification via email once the certification has been completed by the Graduate Affairs Office.

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.

Students who are certified in the summer or fall semesters will be invited to attend the following spring commencement ceremony. Spring graduates will be invited to the spring commencement ceremony. Students are not eligible to participate in the Doctoral Hooding Ceremony or the ECE Diploma Ceremony unless their degree has been certified by the Graduate Affairs Office.

The title of the degree students receive is Doctor of Philosophy in Electrical and Computer Engineering.

ACADEMIC STANDARDS

Grades

Below are the policies surrounding grades for students in the Department of Electrical and Computer Engineering.

University Policy on Grades

The [university policy on grading](#) offers details concerning university grading principles for students taking courses and covers the specifics of assigning and changing grades, grading options, drop/withdrawals and course repeats. It also defines the undergraduate and graduate grading standards.

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 is 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.

Students must receive a "B-" grade or better in both the graduate and undergraduate courses for the course to count towards the Ph.D. requirements.

Incomplete Grade

Incomplete grades will be assigned at the discretion of the course instructor, per the [university grading policy](#).

Withdrawal Grade/Withdrawing from Courses

Students can withdraw from a course after the add/drop deadline until the last day of classes. This will result in a 'W' on the transcript, which is not factored into the QPA. To withdraw, the [Course Withdrawal request form](#) 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. Students should confer with their faculty advisors before withdrawing from a course.

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 units for the Ph.D. program. 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.

Probation

In the event that a student's semester or cumulative QPA falls below a 3.0, that student is on academic probation and will receive a letter from the department alerting them. While on probation, students must meet with their academic advisor and comply with their recommendations. Once a student's semester and cumulative QPA increase above 3.0, the student is automatically removed from probation.

Satisfactory Progress & Program Dismissal

Students are expected to make satisfactory academic progress each semester of the Ph.D. program. "Satisfactory" progress may be defined differently for each student. Students should

work together with their faculty advisor to determine what satisfactory progress entails and to improve performance when a student receives feedback that progress has been unsatisfactory.

Occasionally, students fail to meet their advisor's expectations for satisfactory progress for one or more semesters, despite attempts to remediate substandard progress. When this situation occurs, faculty may issue a dismissal letter to students. Such letters must be issued no later than the end of the first week of the semester in which a dismissal is taking place. For example, dismissal letters for the Fall 2019 semester must be sent to students by the Department by the end of the first week of classes in the Fall 2019 semester. This timing affords impacted students adequate time to make other arrangements to continue in the Ph.D. program.

Dismissal letters are drafted by the student's faculty advisor, and then sent to the Department Head and Graduate Affairs Office for review and approval. Once the letter has been approved, the letter will be distributed to the student via email. The letter will outline the causes for dismissal and possible options for the student. Students who receive dismissal letters should schedule an appointment to meet with the Graduate Affairs Office to discuss their options. International students should also schedule an appointment with OIE to discuss the potential visa ramifications of a program dismissal.

Faculty may rescind a dismissal letter in writing and must notify the Department Head and Graduate Affairs Office of any such action. Dismissal from a program will result in the loss of the student's affiliation with CMU and their student status.

Academic Integrity

Students at Carnegie Mellon are engaged in preparation for professional activity of the highest standards. Each profession constrains its members with both ethical responsibilities and disciplinary limits. To assure the validity of the learning experience a university establishes clear standards for student work.

In any presentation, creative, artistic, or research, it is the ethical responsibility of each student to identify the conceptual sources of the work submitted. Failure to do so is dishonest and is the basis for a charge of cheating or plagiarism, which is subject to disciplinary action.

ECE adheres to Carnegie Mellon's [policy on academic integrity](#) and all students are expected to review the policies prior to their arrival at CMU. ECE also adheres to [CIT's policy](#) on graduate student academic integrity violations.

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.

Instructors are responsible for defining academic integrity for students in their courses, including student performance expectations and attendance requirements. Students are responsible for understanding and abiding by the instructor's academic integrity policies. Policies may vary from instructor to instructor and students should seek further guidance from a faculty member if they have specific questions about a course's academic integrity policy.

Penalties for Violating Academic Integrity

Instructors are responsible for defining academic integrity for students in their courses, including student performance expectations and attendance requirements. Students are responsible for understanding and abiding by the instructor's academic integrity policies. Policies may vary from instructor to instructor, and students should seek further guidance from a faculty member if they have specific questions about a course's academic integrity policy.

Instructors who suspect that an academic integrity violation has occurred should consult with the Office of the Dean of Student Affairs, who will assist the faculty member in handling a possible academic integrity violation and determine possible sanctions, if appropriate. 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 to avoid penalty. If the student attempts to drop the course, he/she will be reenrolled.

If a student is found to have violated the academic integrity policy for a second time, the student will be dropped from the Department of Electrical and Computer Engineering effective at the end of the semester in which the infraction has occurred. Students have the right to [appeal an academic integrity decision](#).

PH.D. DEGREE REQUIREMENTS

Overview

ECE Ph.D. students must satisfy multiple milestones before the doctoral degree is certified. These milestones addressed in this section include:

- [Coursework](#)
- [Breadth Area Requirements](#)
- [Qualifying Exam](#)
- [Research](#)
- [Teaching Internships](#)
- [Prospectus](#)
- [Thesis](#)
- [Dissertation defense](#)

Below is an example of a student's plan of study over the duration of the ECE Ph.D. program. Please note that this plan is an example and may vary based on whether the student has an MS degree prior to enrolling, on conversations between the student and his or her advisor, and which ECE Ph.D. program the student is enrolled in.

	Semester									
Milestones	F1	S1	F2	S2	F3	S3	F4	S4	F5	S5
Research	X	X	X	X	X	X	X	X	X	X
Courses & Breadth	2 classes	2 classes	2 classes	2 classes						
Qualifying Exam				X students incoming F15	X students enrolled prior to F15					
Teaching Internship			X			X				
Prospectus								X		
Thesis and Defense										X

Coursework

Students must receive a "B-" grade or better in both the graduate and undergraduate courses in order for the course to count towards the Ph.D. requirements.

Prior to registering each semester, students should consult with their faculty advisor to ensure that their semester course load is balanced and relevant to their Ph.D. research.

Required course total

- Students in the Ph.D. program without a M.S. degree, and students in the Ph.D. program who have an ECE M.S. degree from Carnegie Mellon, must take a total of eight [8] ECE or related courses (totaling 96 units) at Carnegie Mellon. At least six of these eight courses must be approved graduate-level courses. In addition, students must also successfully complete a 1-unit Introduction to Graduate Studies course during their first semester in the Ph.D. program.
- Students in the Ph.D. program who have earned a M.S. degree elsewhere (outside of CMU's ECE Department) must take a total of four [4] ECE or related courses (totaling 48 units) at Carnegie Mellon. At least three of these four courses must be approved graduate-level courses. In addition, students must also successfully complete a 1-unit Introduction to Graduate Studies course during their first semester in the Ph.D. program.
- Students who received an M.S. in ECE from Carnegie Mellon may use their M.S. courses to count toward Ph.D. requirements.
 - Students who have received an M.S. from Carnegie Mellon in ECE are strongly encouraged to schedule an appointment with the Ph.D. Academic Program Advisor to discuss their M.S. courses and which will count towards the Ph.D. degree requirement. In addition, students must also successfully complete a 1-unit Introduction to Graduate Studies course during their first semester in the Ph.D. program.

A comprehensive list of graduate courses that have been approved for the ECE Ph.D. can be found on the [Ph.D. Breadth Area website](#). In addition to this list, any 12-unit ECE course at the 18-600 level or higher is approved to count towards the ECE Ph.D. degree, except for any project, seminar and independent study courses. Courses in the Computer Science Department (CSD) that are 15-700 or higher and are non-project, non-seminar or non-independent study courses are also approved.

Undergraduate courses that are pre-approved to count towards the ECE Ph.D. include ECE undergraduate courses 300 or above (18-3XX) and CSD courses 300 or above (15-3XX).

Professional Development coursework

Up to twelve (12) units total of professional development coursework in ECE may be counted towards the ECE Ph.D. Course requirement, in any combination of the following course list:

- 18-601 (12 units)
- 18-603 (12 units)
- 18-605 (12 units)
- 18-606 (12 units)
- 18-700 (12 units)
- 18-703 (12 units)
- 15-894 (12 units)
- 18-701 (6 units)
- 18-702 (6 units)
- 18-996 (3 units)
- 18-997 (3 units)
- 18-998 (3 units)

Course Restrictions

Students are responsible for checking the syllabi for classes to ensure their courses are not deemed as a restricted course by the following criteria:

- Courses where more than 50% of the course grade is based on a group project or more than 20% is based on attendance are restricted.
- Mini courses worth 12 units are restricted.
- No more than 12 units of professional development coursework can be applied toward the Course requirement.

Petitioning to Count a Course Not on the Pre-approved List

Students wishing to count a graduate course at Carnegie Mellon not listed in the approved graduate course list, or an undergraduate course offered by another department at Carnegie Mellon, must formally petition the Graduate Studies Committee. Please see the section in this handbook on [petitions](#) and schedule an appointment with your academic advisor for more information.

Breadth Area Requirement

The ECE Department has defined 7 technical areas (plus an 'Other' area) as Breadth Areas for the Ph.D. degree. These areas are:

- Algorithms/Complexity/Programming Languages
- Applied Physics (Solid State/Magnetics/Fields)
- Artificial Intelligence, Robotics and Control
- Circuits
- Computer Hardware Engineering
- Signal Processing and Communications
- Software Systems and Computer Networking
- Other (by petition)

Each Ph.D. candidate must take at least one [1] graduate class from at least three of these areas to fulfill the breadth requirement. Students must receive a "B-" grade or better in these courses.

By petition to ECE's Graduate Studies Committee, students may be able to count one course that they have taken during a previous degree toward the breadth course requirement. If the petition is accepted, only two more breadth areas must be satisfied. However, students will still be held to the same course requirements.

Qualifying Exam Requirement

Students who are working towards a Ph.D. degree are required to take the Ph.D. Qualifying Examination. The Ph.D. Qualifying Examination tests the student's ability to think, speak, and write. Students must read and understand three technical papers that define the examination topical area. Students then write a review paper as well as orally present this review to a faculty examining committee. This committee includes three faculty from the ECE department whose research focus is in the area the student wants to be tested on. The student must answer detailed questions from the faculty committee. These questions can be about the review paper and presentation, the reference papers, and obvious undergraduate-level technical background for the material in the review and reference papers.

Timeline

Students matriculating in the Fall 2015 semester or afterwards must take the Ph.D. Qualifying Exam for the first time no later than the fourth semester after being admitted to the Ph.D. program, and must pass the exam no later than the fifth semester after being admitted to the Ph.D. program. Summer semesters are not included in this qualifying exam timetable.

Students matriculating prior to Fall 2015 must take the Ph.D. Qualifying Exam for the first time no later than the fifth semester after being admitted to the Ph.D. program, and must pass the exam no later than the sixth semester after being admitted to the Ph.D. program. Summer semesters are not included in this qualifying exam timetable. Students are encouraged to take the Ph.D. qualifying exam as soon as possible.

Each student should determine with her or his advisor when to take the qualifying exam the first time.

The time clock determining when a student must take the qualifying exam is stopped for one semester if the student is engaged in a full-time industrial internship during an academic year semester (fall or spring). This policy applies for up to one semester of internship experience. Students engaged in internships for more than one academic semester must petition to ECE's Graduate Studies Committee to request a deferment of the qualifying exam timeline beyond one semester. Please note that there is no guarantee that such petitions will be approved.

Fall exams generally occur in the month of November. Spring exams generally occur in the month of April.

Mechanics

Declaration, Abstract, and Technical Papers (due in September or February)

With faculty advisor input, the student will complete a qualifying exam declaration, write a presentation abstract, and submit three technical papers. The declaration will allow students to rank order between seven [7] and ten [10] ECE faculty that the student and his or her advisor feel would be the best fit for the examination committee. The three technical papers provide context to the faculty examining committee regarding the student's area of focus.

Students can choose no more than two papers that may have authors who are currently faculty at Carnegie Mellon. Students can choose no more than one paper that the student has co-authored. The total length of all three papers may not exceed 50 pages.

The Graduate Studies Committee reviews the declaration packets and recommends a three-person faculty examination committee. While every attempt is made to choose faculty from the student's declaration submission, these preferences cannot always be accommodated due to faculty availability and committee balancing. This committee is subject to approval by the student's faculty advisor.

Review paper (due in October or March)

The qualifying examination tests your written communication skills through a short review paper. This paper defines the focus of your qualifying examination topic. You should explain your technical area; your work and the relationship between your work and the content of the student's three technical papers. This paper must not exceed four pages and must be in a 2-column format.

Exam (occurs in November or April)

Prior to the start of the qualifying exam, the Graduate Affairs Office will communicate each student's exam date, time, committee, and location via email.

The Qualifying Examination tests a student's oral communication skills by having the student present a short, conference-style talk during the first 30 minutes of a Qualifying Exam. The examining faculty will typically ask the student's questions to help clarify the presentation immediately following your presentation.

Once the clarification question and answers are completed, the examining committee will ask the student questions about the student's research area, technical papers, review paper, and electrical and computer engineering fundamentals that relate to your research area.

Outcomes

At the conclusion of the qualifying exam, the faculty examiners will consult with each other and grade the qualifying exam. All qualifying exams will be discussed at the faculty qualifying exam review meeting, which occurs on the Friday of the second week of qualifying exams. Final outcomes will be determined by the faculty at this meeting, not by the three-person faculty examination committee.

All students will be notified of their qualifying exam outcome and provided with feedback after the faculty has convened.

Students failing the qualifying exam the first time can take it a second time, no later than the sixth semester after being admitted to the Ph.D. program if the student started prior to Fall 2015 or the fifth semester if the student started in the Fall 2015 semester or afterwards. One faculty member from the first exam committee will serve on the second committee. A student who fails the exam twice must leave the Ph.D. program at the end of the semester in which the second failure occurs.

Students who pass the qualifying exam will officially be recognized as candidates for the Ph.D. degree.

Research

All full-time Ph.D. students are required to complete research every semester they are enrolled in the program. The completion of research is represented by the student's enrollment in *18990 Reading and Research* each semester. Expectations for research and productivity vary greatly throughout the department and should be discussed regularly with the student's faculty advisor.

Each fall and spring semester, students should register for *18990 Reading and Research* in the section that represents their physical location.

18990 Reading & Research sections:

- Section A: For students studying in Pittsburgh
- Section PP: For all CMU Portugal students studying in Portugal. (CMU Portugal students in Pittsburgh will register for section A.)
- Section SV: For all Silicon Valley students studying in Silicon Valley. (SV students in Pittsburgh will register for section A.)

Resources and Regulations Governing Research at Carnegie Mellon that may be of interest to Ph.D. students include the following:

- [Office of Sponsored programs](#)
- [Office of Research Integrity & Compliance](#)

Students are expected to abide by the university's position on ethical research as posted on the Office of Research Integrity and Compliance website. See the [Responsible Conduct of Research Education](#) section in this handbook for more information.

Teaching Internship Requirements

All ECE Ph.D. students are required to complete two Teaching Internships ("TI") over the course of the Ph.D. program. These Teaching Internships are unpaid and students will receive a letter grade reflecting their performance. Students must receive a "B" or better in the TI course to receive credit for completing the teaching internship.

The [TI program](#) is coordinated through the Academic Services Office. All students must complete a [teaching assistant application](#) for the TI to be formally recognized by the department. The Academic Services Office will work with the student to enroll him or her in the correct course representing their work as a TI prior to the start of the semester.

Students may complete a TI for a course outside of ECE or during the summer semester, though it must be approved by the Associate Department Head for Academic Affairs and recorded by the Associate Director of Student and Academic Affairs prior to the student starting the TI. Students should contact the Graduate Affairs office to facilitate this process.

Programs that are not based in Pittsburgh may have requirements pertaining to where each TI is completed. More information on location-specific requirements can be found below:

Program	Teaching Requirements
CMU Portugal Dual Degree Program	CMU Portugal dual degree students will complete one TI in Pittsburgh and one TI in Portugal.

Students are expected to support the course instructor and establish mutual expectations while providing excellent academic support to students. Depending on a student's area of expertise and English proficiency, he or she may be assigned to a variety of tasks that can range from grading to leading recitations.

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](#).

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 the "Evaluation & Certification of English Fluency for Instructors" section in the University Policies of this handbook.

Prospectus

All Ph.D. students are required to prepare a thesis prospectus (also known as a proposal) within four semesters following the successful completion of the Ph.D. Qualifying Examination. This time

clock begins with the semester following the Qualifying Examination. If a student leaves for a semester to return to industry, this four-semester clock is stopped. The Ph.D. prospectus clock stops when the student leaves and resumes at the start of the semester when the student returns. Students who have not met their Ph.D. prospectus requirement within the four-semester time limit must discuss a revised timeline with their advisor prior to the semester's Graduate Progress Review faculty meeting.

Regarding time clocks, it is important to note the following:

- A calendar year has three semesters: spring, summer, and fall.
- While the prospectus clock may stop during an industry internship, the time clock for the overall Ph.D. program does not stop.

Prospectus Description

The prospectus is both 1.) an informal written description of the problem to be investigated and the expected accomplishments of that investigation and 2.) an oral presentation to the Prospectus Committee for its review and recommendations. Both prospectus requirements must be completed at least one semester prior to the final defense.

Prospectus Format

The Ph.D. prospectus write up should be no more than 25 double-spaced pages in length, although prospectuses that are on the order of five to ten pages are encouraged. The prospectus should include the following:

- An explanation of the basic idea of the dissertation topic;
- An explanation as to why this topic is interesting;
- A statement as to what kind of results are expected, and;
- A convincing argument as to why these results are attainable in a reasonable amount of time

Furthermore, the prospectus should not be:

- A summary or abstract of the dissertation;
- The first chapter or part of the dissertation;
- A technical report;
- A survey of the field, or;
- An annotated bibliography

Students should discuss the presentation format of their prospectus with their faculty advisor. Typically, a student is expected to provide a 45-60 minute presentation on his/her prospectus, and then participate in a question-and-answer-based discussion with his/her committee.

Prospectus Committee

The Prospectus Committee consists of at least four members, including the student's faculty advisor. At least two members of this committee must be ECE faculty and at least one member must be from outside the department. Faculty members from other departments who hold courtesy appointments in ECE are considered to be "inside" the department. Faculty members

who hold an adjunct appointment are considered to be “outside” members. All committee members must hold a doctoral degree.

All four committee members must actively participate in both the prospectus meeting and defense and at least three committee members must be physically present. It is desirable to have all committee members participate in person; however, a student is allowed to have one committee member of four participate by teleconferencing. Any deviation from this teleconferencing policy is exceptional and additional information must be provided on the Prospectus form. Because of the nature of the ICTI dual-degree program, teleconferencing requests by ICTI students will be approved by default.

It is expected that any committee members participating remotely will have full audio and visual access to the presentation via teleconferencing equipment. It is the responsibility of the student to provide teleconferencing access to committee members participating remotely. Students can email help@ece.cmu.edu for assistance in setting up teleconferencing equipment.

Prospectus Procedure

Once the date, time and place of the prospectus have been confirmed, the student should email the completed **Prospectus Declaration form** to the Graduate Affairs Office at least one week before the presentation. An electronic copy of the proposal paper should be submitted to the Ph.D. Academic Program Advisor on or after the presentation date.

Students will be notified by the Graduate Affairs Office of the approval of their committee. Once the committee has been approved, the student will meet with his or her committee to present the prospectus to them. To encourage open and frank dialogue, this presentation is attended only by the student, the committee, and any other interested ECE faculty members. Other attendees must be approved by the committee chair.

The outcome of this meeting will be either that the prospectus is accepted or not accepted. If the prospectus is not accepted, the student will be asked to revise it and meet again with the committee for approval. If the prospectus is accepted, then students should continue to move forward with his or her thesis.

Milestone Review

Upon completion of the prospectus proposal, students should make an appointment to meet with the Ph.D. Academic Program Advisor to review the fulfillment of Course and Breadth Area requirements, as well as Teaching Internship (TI) requirements. Provided that the student has satisfied the aforementioned program milestones, he/she may be informed of their eligibility for All But Dissertation (ABD) status.

All But Dissertation Status

Once a student has completed all program requirements, with the exception of the thesis and defense, the student is required to go on All But Dissertation (ABD) status. Two ABD options are available to students:

- ABD in Residence (ABD): students continue enrolling for 36 units each semester and will continue to receive stipend support.

- ABD in Absentia (ABS): students stop enrolling at CMU and no longer receive tuition or stipend support. The student will be responsible for paying the technology fee each semester he/she is ABS. When the student is ready to come back and defend, he/she will notify the Graduate Affairs Office, which will work with the student to re-enroll him or her in ECE. The student will be responsible for registering for and paying for 5 units of *18990 Reading and Research* as well as all fees. Please note that international students may face additional constraints before going ABS and should consult with the Graduate Affairs Office to obtain more information.

The full university [Policy for Doctoral Status](#) is a series of policies that set forth a definition of All But Dissertation (ABD), time limits on doctoral candidacy status, a definition of *in residence* and *in absentia* status for ABD candidates and the tuition charged for candidates in each status.

The ABD status agreement form and ABD status change form can be found on The HUB's [Forms & Guides website](#) under the 'Student Records' section.

Ph.D. Dissertation

Once the Ph.D. thesis is written, the student must submit the [Defense Declaration form](#) to the Graduate Affairs Office at least two weeks before the student's defense date. The Thesis Committee is usually the same as the Prospectus Committee. If there is any change in the committee, the student must submit a biographical description of any new committee member from outside Carnegie Mellon for approval. Additionally, students are expected to adhere to Carnegie Institute of Technology (CIT) guidelines on providing defense committees with a copy of the thesis prior to the defense. CIT recommends that students provide their committee with a copy of the thesis at least 1.5 months prior to the defense.

The oral defense is a public examination open to all members of the Carnegie Mellon community. All the members of the student's Prospectus Committee must actively participate in the defense meeting. It is desirable to have all committee members participate in person; however, a student is allowed to have one committee member participate remotely by teleconferencing. Any deviation from this teleconferencing policy must be requested via the Defense Declaration Form. Due to the nature of the ICTI dual-degree program, teleconferencing requests by ICTI students will be approved by default.

It is expected that any committee members participating remotely will have full audio and visual access to the presentation via teleconferencing equipment. It is the responsibility of the student to provide teleconferencing access to committee members participating remotely. Students can email help@ece.cmu.edu for assistance in setting up teleconferencing equipment.

In addition to these ECE requirements, CIT has its own requirements pertaining to the [thesis and defense process](#). This site includes instructions for the document standards and format. Students should pay particular attention to the format of the thesis title page and the required content of the acknowledgements section.

Per CIT requirements, all defenses should be completed at least two weeks prior to the final grade deadline of a given semester. Doing so should grant students sufficient time to make necessary revisions and complete all post-defense paperwork prior to the end of the semester. Any

deviation from this timeline is discouraged and may hinder a student's ability to graduate on time. Such deviation from the cited timeline may be subject to additional departmental approval and should be discussed with the Graduate Affairs Office well in advance of the planned defense.

Please note: Students who **do not** successfully complete the dissertation, defense, and all defense-related paperwork prior to the final grades deadline of a given semester may be required to register for the following semester, and thus the faculty advisor will be responsible for supporting the student for an additional semester with tuition and stipend.

After the defense, the Graduate Affairs Office will review additional paperwork that will need to be completed prior to a student's degree certification with the student.

Departmental Progress Reviews

All students working towards a Ph.D. degree must regularly demonstrate progress towards meeting the ECE Ph.D. requirements by completing a Graduate Progress Review Statement each fall and spring semester.

In this statement, the student must describe his or her:

- Activities as a graduate student researcher;
- Research goals and achievements;
- Activities as a member of the ECE community;
- Courses taken since enrollment as a graduate student in ECE, and;
- Plans for the following semester

These statements are typically due during the first week of November (fall semester) and April (spring semester). Students are encouraged to discuss the completed statement with their advisor.

Students who have passed the qualifying exam will also be asked to create a single-slide summary of his or her progress towards the ECE Ph.D. degree.

The Graduate Progress Review Statement and slide summary inform faculty discussions during each semester's Graduate Progress Review meeting. The outcome of this review is a grade that characterizes the student's progress towards the Ph.D.: satisfactory ("S") and unsatisfactory or not passing ("N"). Students who receive an "N" grade for the first time must meet with their advisor and define a course of action to achieve a satisfactory grade in the next semester. Students who continue to make inadequate progress towards the ECE Ph.D. may be subject to dismissal.

Ph.D. students do not receive a letter grade for their research each semester with one exception: students will receive a letter grade in their final semester as a graduate student in the ECE Department or prior to receiving an MS degree on the way to the Ph.D.

All students who have passed the qualifying exam will receive a letter from their faculty advisor each fall and spring semester summarizing their progress and offering suggestions for improvement or continued success. This letter is typically distributed by the final grade deadline of the fall and spring semesters.

Internships Course Option

ECE students may wish to participate in paid internships at off-campus organizations during the summer months.

ECE will enroll all students who are pursuing an internship for a 3-unit credit bearing internship course (18-996, 18-997, & 19-998) Internship for Electrical and Computer Engineering Graduate Students), which can each be taken once each throughout the student's ECE Ph.D. degree program of study. This internship will appear on a student's transcript. Ph.D. students typically are not charged summer tuition, including the Internship course. However, in the event that a student takes another summer class, summer tuition may be assessed for the summer internship course as well. Please contact your academic advisor and reference CIT's current [cost of attendance website](#). The work for the internship must be appropriate to the goals of the academic program and units can be applied toward the Ph.D. Course Requirement.

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.

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, FEES, FINANCES, AND FINANCIAL SUPPORT

Purchasing & Reimbursements

At ECE, most purchasing actions, including airline tickets, are conducted by administrative departmental employees rather than a central purchasing authority. Buyers are encouraged to purchase goods and services from the administrative coordinators and not use their own funds. If you use your own funds and they charge tax, you will not be reimbursed for the tax applied to

the purchase. All purchases including travel which are done on CMU's behalf need to have the direct approval of the faculty member or PI of the project.

The preferred method of making travel arrangements is through one of the university's preferred travel agencies with which the administrative coordinator can provide assistance. By purchasing the tickets through these agencies, the cost of the tickets is charged directly to the university instead of the student or employee paying the cost personally and needing to be reimbursed. The administrative coordinators also will complete a reimbursement for any items or travel accrued.

Please keep in mind that you must provide transaction-supporting documentation in accordance with Carnegie Mellon requirements and government policies on reimbursements. Expense reports must be submitted within 90 days after completing the travel or incurring the expense, otherwise, the reimbursement will be treated as taxable income to the individual. Please see the administrative coordinator to arrange for travel and purchasing, as well as reimbursements.

All purchases of goods, services, and equipment using University funds by charging directly to an account string, including restricted accounts and research grants and contracts, should be made at the direction of a CMU faculty or staff member. Only certain department staff members are able to confirm an order with an outside vendor. Please plan ahead. Rush orders for pick-up or delivery and orders of over \$1,000 are difficult to accommodate.

Basic office supplies are purchased by the Administrative Coordinators for general use by ECE students, faculty, and staff. Teaching Assistants should speak to an Academic Services Assistant for research- and teaching-related supplies.

Questions should be directed to the [ECE Finance Office](#), located in HH 1116. Please visit [CMU's Procurement Services website](#) for more information.

Graduate Student Reimbursement Policy

Business Expenses

As an educational institution, CMU is exempt from Pennsylvania state sales tax. Whenever possible, business purchases should be made by your faculty advisor's Administrative Coordinator or by another faculty or staff member with a tax-exempt purchasing card.

If it is necessary to make a purchase using personal funds, legitimate business expenses can be reimbursed by the department. Your faculty advisor's Administrative Coordinator will help you claim reimbursement provided you have the following:

- Receipt indicating item purchased and proof of payment
- Business purpose for purchasing item
- Account to be charged for reimbursement
- Faculty or staff approval

Please consult with the appropriate Administrative Coordinator prior to incurring the expense for additional instruction. Software purchases in particular should only be made after consulting with a departmental staff member, as the purchase will often require approval from the University Contracts office due to the popularity of Click-Through Agreements ("CTA"). If

personal funds are used to make a business purchase requiring a CTA without prior approval from Contracts, it is possible that the expense in question will not be reimbursable.

Travel Expenses

If agreed on in advance with your advisor or with another departmental staff member, legitimate travel expenses can be reimbursed by the department. Your advisor's Administrative Coordinator will help you claim reimbursement once you provide the following:

- Hotel receipts must show a zero balance with proof of payment and your name
- Receipts for meals must be collected, unless you claim per diem meals; both daily meals and per diem meals cannot be claimed for the same travel expense report. Current per diem rates can be verified on [the GSA website](#).
- Personal car mileage for business purposes; standard mileage reimbursement rates for gas/fuel but not tolls
- Business purpose for travel
- A program or agenda, when available
- Account to be charged for reimbursement
- Approval by an ECE faculty or staff member

Conditions

Tax will be reimbursed for expenses incurred due to normal business related travel (hotel, airfare, meals) but **not** for miscellaneous expenses, such as the purchase of a replacement mouse for a department laptop, poster board for a presentation, etc., purchased while traveling or preparing for travel. These items should have been purchased through a department approved buyer thus not incurring tax expense.

Academic Year Tuition & Stipend

Research assistantships are provided by research projects which are funded by government agencies, private industries, and consortia. Students who are research assistants will be expected to conduct appropriate research under the direction and guidance of their faculty advisor(s). Tuition and stipend support is renewable based on a student's acceptable performance in course work and research and the faculty advisor's funding availability.

In most situations, as long as the student is in good academic standing (with regard to grade average, progress in the program, and length of time in the program), full tuition remission will be given.

For the academic year 2021-2022, this tuition is valued at approximately \$45,300. Students are responsible for the costs of purchasing their own books and miscellaneous supplies. A listing of estimated **cost of attendance** is provided for student use, with tuition increasing approximately 3% per academic year to account for inflation. 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 Ph.D. degree:

<i>Type</i>	<i>FY19 \$</i>	<i>semesters Frequency</i>	<i>entire program</i>	<i>first semester</i>
			<i>12</i>	
Application Fee*	\$75	one time	\$75	\$75
Registration Fee	\$0	n/a	\$0	\$0
Enrollment Deposit	\$0	n/a	\$0	\$0
Ph.D. Tuition	\$22,650	per semester	\$271,800	\$22,650
Activity Fee	\$108	per semester	\$1,296	\$108
Technology Fee	\$210	per semester	\$2,520	\$210
Transportation Fee	\$108	per semester	\$1,296	\$108
Books and Supplies	\$1,106	per semester	\$13,272	\$1,106
Student Tuition Recovery (STRF)	\$0	n/a	\$0	\$0
			\$290,259	\$23,322

Unless noted otherwise, stipend payments will be disbursed twice a month (semi-monthly) following the academic year cycle (August 16th through August 15th each year). Payment occurs once in the middle of the month and once on the last working weekday of the month. Exact pay dates are available on the [CMUWorks Payroll Resources website](#) (see Graduate Student - Semi-Monthly - Pay Date).

The stipend for Silicon Valley Ph.D. students is equal to \$3,216 per month for the 2021-2022 academic year to allow for the increased cost of living in the Silicon Valley area. Silicon Valley Ph.D. students can apply for up to \$1,000 of travel reimbursement from the ECE Department for the Qualifying Exam. More details about the reimbursement procedure will be communicated upon the submission of the Qualifying Exam Declaration.

Stipend amounts are reviewed each year and augmented according to increases in the cost of living. Such increases will be communicated to students prior to the following academic year. When deciding on the stipend amount, The department takes into consideration personal expenses, such as rent/utilities, health insurance, other insurance, childcare, etc.

Summer Semester Tuition & Stipend

Students supported by the ECE department are expected to continue working over the summer in some capacity, either via research on campus or through an off-campus internship. Students will continue to be compensated at the same stipend rate paid during the academic year if they are working on campus. Stipend payments will be suspended if the student is doing an off-campus internship or has failed to register for the summer semester.

Tuition is not assessed during the summer semester if the student is registered for *18990 Reading and Research*. Registration for other courses may trigger a tuition charge for which the student will be responsible to pay unless prior arrangements have been made with the student's faculty advisor. It is the student's responsibility to understand the financial repercussions of his or her summer registration.

Losing, Reducing, or Changing Funding

If a student is supported by the department through an external grant or contract, and this funding is lost, reduced, or changed, the advisor will notify the student accordingly. All efforts will be made to facilitate the student's continuation in his/her degree program, if he or she is progressing satisfactorily in the program. Students who are not progressing satisfactorily may receive a dismissal letter. The dismissal process is outlined in the "Satisfactory Progress and Program Dismissal" of this handbook. More information about becoming self-supporting is contained in the following section.

Self-Supporting Students

With few exceptions, almost all Ph.D. students in the ECE department are funded through the department or a third party entity. Students are typically not allowed to self-support. One exception to this requirement is that, occasionally, students who are in All But Dissertation (ABD) status must become self-supporting due to a change in an advisor's funding situation and/or because of other factors.

Per CIT's [In Residence Status for ABD Candidates policy](#) (under 'All but dissertation status' section):

"Under exceptional circumstances, ABD students who are self-supported, and who can demonstrate financial hardship, may petition the College through the departments for permission to register for 5 units of thesis research per semester." The exceptional circumstances for such approval include:

- Self-supporting with demonstrated financial hardship
- At least three years of full time student status
- Good standing and progress towards a degree
- No more than two semesters of required work; ABD with In Residence status and 5 units of tuition per term will not be allowed for more than two semesters of work, where a summer is considered to be one semester."

Students should submit a fully-endorsed [self-supporting application](#) to the Graduate Affairs Office prior to the 10th day of class in the semester in which they are becoming self-supporting.

If the student has not completed the degree program after two self-supporting semesters, and no additional funding from the faculty advisor is available, the student will have the option of going ABD in absentia, taking a leave of absence, or withdrawing from the ECE Ph.D. program.

Fees

ECE will pay for each student's technology fee as long as the student is enrolled as a full-time student or is under All But Dissertation in Residence (ABD) status. If a student moves into ABS absentia status, the student will be responsible for paying for the technology fee each semester while under absentia status, including the semester in which the student returns to defend his/her dissertation. **When a student returns from ABD in absentia to defend, he or she will be responsible for paying for all fees and tuition assessed.**

Students are responsible for paying the Student Activities Fee, the PAT Transit Fee, and for health insurance. Students are encouraged to check their SIO regularly to ensure that all outstanding balances are addressed. Many students pay for their Carnegie Mellon health insurance and other charges **directly from their stipend**.

The technology fee and tuition are paid over eighteen monthly installments (August 16th -May 15th). The process decreases the student account balance incrementally over the academic year such that the tuition balance reaches zero in the middle of May.

Taxes

The deadline for local, state, and federal taxes is April 15. You can obtain tax forms in the mail, at the post office, or at the Carnegie Library. Questions about your tax status should be addressed to the IRSTeleTax at 412-261-1040, or the Pennsylvania Department of Revenue at 412-565-7540. Although subject to federal taxes, student stipends are generally not assessed local or state taxes.

Conference & Travel Funding

As a department, ECE does not provide centralized travel or conference funding. However, students are encouraged to talk to their faculty advisor(s) about travel or conference funding. The Office of the Assistant Vice Provost for Graduate Education does provide some conference funding via an application process. Conference funding is 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. Students can find more information about the application process and deadlines at www.cmu.edu/graduate.

Additional Sources for Financial Support

University Financial Aid

Graduate students should consult the graduate student financial aid information found on [the HUB's Student Financial Aid website](#). Students will find the Graduate Financial Aid Guide, information about funding options and how to apply for financial aid and other helpful links.

Additional information on federal and state aid, and financial aid policies, may be found in APPENDIX D.

Emergency Loans

The Office of the Dean of Student Affairs offers short-term emergency loans for supplies, medication, food or other unexpected circumstances. The loans are interest-free and for short periods of time (not longer than a month). Graduate students who find themselves in need of immediate funds for emergency situations should contact the [Office of the Dean of Student Affairs](#) to inquire about an Emergency Student Loan (see Appendix A).

Fellowships

Students who are interested in applying for external fellowships should see their advisor or check the online information provided by the [Office of Scholarships and Fellowships website](#). The website is an excellent resource for locating an abundance of information regarding available funding for students.

Additionally, fellowship opportunities will be announced periodically over the course of the academic year by the department. While students can apply directly to some of these fellowships, most require an internal competition to identify top students for nomination. Students are encouraged to monitor the [ECE Fellowship Opportunities website](#) for active fellowships.

GuSH Funding

[GuSH Research Funding](#) is a source of small research grant funds provided by GSA and the Provost's Office and managed by the Office of the Assistant Vice Provost for Graduate Education.

Teaching Assistantships

Once an ECE Ph.D. student has completed the two required [Teaching Internships](#) (TIs), he or she can continue to teaching assistant for courses for hourly pay instead of receiving academic credit. Students must fill out the [teaching assistant application](#) to formally be matched to a course.

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.

Payroll

Other questions concerning payment options should be addressed to the [ECE Finance Office](#) in HH 1116.

Outside Employment

ECE follows [CIT guidelines on outside employment](#) (under 'Graduate Student Consulting'). Full-time students in ECE are expected to devote their full-time to research, teaching, and coursework per the compensation students are receiving via the stipend during the academic year.

Occasionally, there are employment opportunities offered to students that will enrich their research, coursework, and teaching. In these situations, students should consult with their faculty advisor regarding the opportunity and how it may impact their academic progress. Prior to accepting a position, students must receive written permission from both the faculty advisor and Department Head. Full-time students will be expected to keep up with their full-time research commitments even while employed outside of CMU. Students may consider taking a leave of absence to pursue full-time employment; however, this should be discussed with the student's advisor(s) and the Graduate Affairs Office prior to the student deciding to take a leave.

Please note that international students have additional constraints on their eligibility to pursue employment outside of CMU. OIE provides additional information on [employment options](#) for international students on their website. International students are responsible for ensuring that their work authorization is valid and up to date.

CAREER SERVICES

The [Career and Professional Development Services Center](#) (CPDC) 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. The CPDC is also heavily involved in organizing campus-wide job fairs and bringing employers to campus.

Carnegie Mellon's Silicon Valley campus hosts programming through our Student Affairs team: Lauren Schachar, Assistant Dean of Student Affairs; Leigh Mason, Assistant Director of Career Services; and Jennifer Wolfeld, Language and Communication Specialist.

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 through the CPDC website.

Career Consultants

CMU Silicon valley has career consultants who provide guidance through one-on-one appointments. Students in Silicon Valley can meet with Assistant Dean of Student Affairs **Lauren Schachar** or **Leigh Mason**, Assistant Director of Career Services. Appointments with Lauren and Leigh can be made through **Handshake**. They will each also hold open office 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 academics as a priority. It is not acceptable for students to skip classes or assignments in order to attend job interviews. Students should conduct job searched in a manner that does not impede the academic progress through their graduate program.

It is also important for students to have an understanding of 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 to honor their agreements with recruiters. Further, students should not continue looking and interviewing for a position after they have accepted an offer.

The CPDC reserves the right to limit access for any users that do not follow CMU's **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 Disclosure

The job classification(s) the ECE MS and PhD programs prepares its graduates for can be accessed online via **CMU Box**.

UNIVERSITY POLICIES

Academic Integrity

Students at Carnegie Mellon are engaged in intellectual activity consistent with the highest standards of the academy. The relationship between students and instructors and their shared

commitment to overarching standards of respect, honor and transparency determine the integrity of our community of scholars. The actions of our students, faculty and staff are a representation of our university community and of the professional and personal communities that we lead. Therefore, a deep and abiding commitment to academic integrity is fundamental to a Carnegie Mellon education. For more information on these standards, please visit the link below: <http://www.cmu.edu/policies/student-and-student-life/academic-integrity.html>

Assistance for Individuals with Disabilities

Students with disabilities are encouraged to self-identify with [Office of Disability Resources](#) by contacting [Catherine Getchell](#), 412-268-6121, to access the services available at the University.

Evaluation & 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](#). Teaching Assistant English Fluency is managed through the International Teaching Assistant testing process administered by CMU's Intercultural Communication Center. For details please visit the links below:

- <http://www.cmu.edu/policies/faculty/evaluation-certification-english-fluency-instructors.html>
- <http://www.cmu.edu/icc/>

Leave of Absence & Withdrawal Policies

“Leave of absence” means leaving the university temporarily, with the firm and stated intention to return. “Withdrawal” means leaving the university with no intention to return. Withdrawals or leaves taken on or before the university deadline to drop classes without receiving a ‘W’ (withdrawal) grade will result in all courses or grades being removed. Withdrawals or leaves taken after the university deadline to drop classes but before the last day of classes will result in ‘W’ grades assigned to all classes. Withdrawals or leaves taken after the last day of classes will result in permanent grades assigned by the instructors for each class. After the last day of class, courses cannot be removed from a student’s transcript.

International students should consult with the Office of International Education (OIE) prior to taking a leave of absence or withdraw from their program.

Further information about Carnegie Mellon’s policy on student leave is available at the following link: <http://www.cmu.edu/policies/student-and-student-life/student-leave.html>

Students who would like to take a leave of absence or withdraw must complete the appropriate form at the following link: <http://www.cmu.edu/hub/forms.html>

Please see “Preparing an Academic Plan” section (under Administrative and Program Policies) of this handbook for ECE’s policy on leave of absence and withdrawals.

Tuition Refund Policy

If an ECE student withdraws or takes a leave of absence, the HUB will determine if a student should receive a tuition refund, as this is governed by CMU policy (not ECE). Additional

information is available at the following link:

<https://www.cmu.edu/sfs/tuition/adjustment/index.html>.

Returning to Carnegie Mellon

When a student plans to return to CMU after a leave of absence, he/she must complete the [Petition for Return from Leave of Absence form](#) at least one month prior to the start of the semester. We recommend doing so prior to the registration period for the upcoming semester (for Fall, April and for Spring, November). The student must also meet any conditions that were set by ECE or the university at the time of leave was granted. Further information about Carnegie Mellon's policy on student return is available at the following link: <https://www.cmu.edu/hub/registrar/leaves-and-withdrawals/index.html>.

Retention of Student Records

The policy of Carnegie Mellon University is to ensure the safety, accessibility, confidentiality, and good condition of the permanent record of every Carnegie Mellon student, past and present.

Carnegie Mellon University (CMU), established in 1900, holds all permanent records of our students (current and former) in the University Registrar's Office. We maintain original paper records in an offsite secure climate-controlled underground storage facility along with a microfilmed copy of each record. In addition, a copy of microfilmed records also resides in the University Registrar's Office in Pittsburgh, PA. This includes all students globally, include those students studying at our California teaching location and instructional sites. CMU has established the University Registrar's Office as the official data steward of all student records.

Historical Records 1906-1989

For every student enrolled at Carnegie Mellon University as a new or continuing student prior to the fall semester, 1989, and dating back to 1906, the University Registrar's Office of Carnegie Mellon University maintains a complete permanent record, whether the student is degree-seeking or non-degree seeking, whether enrolled for credit or not within the student's official transcript. The official transcript provides brief personal information to identify the student as unique. It contains courses, units and grades; semester and cumulative grade point averages; all degrees earned; transfer credit or advanced placement and dean's list indications.

The University Registrar's Office has established and maintains within a microfiche copy of good, readable, and reproducible quality of the student's permanent record in a secured records unit. A secondary permanent microfilm copy of all records will be maintained in good condition in the climate-controlled, fire-proof, limited-access security at an offsite facility.

Modern Records 1989-Current

For every student enrolling at Carnegie Mellon University as a new or continuing student beginning in fall semester, 1989, the University Registrar's Office of Carnegie Mellon University will establish and maintain within an electronic data file in the University Student Services Suite (S3, our student information system) a complete permanent record, whether the student is degree-seeking or non-degree seeking, whether enrolled for credit or not. The University Registrar's Office staff will, under the direction of the University Registrar, add to the electronic record such new information as pertains to the student's demographic and academic record as

it becomes available, semester-by-semester, and as the student progresses in his/her career at Carnegie Mellon University.

Daily, the Carnegie Mellon University Computing Services Division will perform a backup of all databases that have been altered during that day. Weekly, the Computing Services Division will perform a complete backup of all records within the student data file. The Computing Services Division staff will store the daily backups in the climate-controlled, fire-proof, limited-access security facility in the Computer Operations center in Cyert Hall on the Carnegie Mellon University campus. Upon successful completion of the monthly backup, the Computing Services Division staff will securely transfer the weekly and monthly backups from the preceding month to climate-controlled, fire-proof, secured vault at an offsite facility.

Cessation of Operations

In the unlikely event that CMU (which has existed for more than 100 years) ceases to exist, it will make appropriate arrangements to comply with clauses (1) and (2) for all its students consistent with the Commonwealth of Pennsylvania statutes and law. I have an informal plan and agreement with the University of Pittsburgh's University Registrar's Office, that should either school cease, we would exchange student records.

Safeguarding Educational Equity – Sexual Harassment and Sexual Assault Policy

The University prohibits sex-based discrimination, sexual harassment, sexual assault, dating/ domestic violence and stalking. The University also prohibits retaliation against individuals who bring forward such concerns or allegations in good faith. The University's Sexual Misconduct Policy is available at <https://www.cmu.edu/policies/administrative-and-governance/sexual-misconduct/index.html>. The University's Policy Against Retaliation is available at <https://www.cmu.edu/policies/administrative-and-governance/whistleblower.html>. If you have been impacted by any of these issues, you are encouraged to make contact with any of the following resources:

- Office of Title IX Initiatives, <https://www.cmu.edu/title-ix/> 412-268-7125, tix@cmu.edu
- University Police, 412-268-2323

Additional resources and information can be found at: <https://www.cmu.edu/title-ix/resources-and-information/resources.html>.

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 of a Degree

The university reserves the right to withdraw a degree even though it has been granted should there be discovery granted that the work which it was based on the academic records in support of it had been falsified. The complete reference to this university

policy is available at: <http://www.cmu.edu/policies/student-and-student-life/withdrawal-of-a-degree.html>

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>

Student Maternity Accommodation Protocol

Female students seeking Maternity Accommodations should visit the following link from the Graduate Education's website: <http://www.cmu.edu/graduate/programs-services/maternity-accommodation-protocol.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/>.

Employment with ECE Department

Eligible international students who qualify for pre- or post-completion Optional Practical Training (OPT) work authorization should note that the ECE department (as an employer) does not offer unpaid positions for OPT work authorization. While off-campus employment or volunteer opportunities under OPT work authorization do not have to be paid positions, ECE will only offer paid positions to eligible students.

Appendix A

2021-2022

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

Key Offices for Graduate Student Support

Graduate Education Office

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

The Graduate Education Office provides central support for all Master's and Doctoral students with a focus on their academic experience at Carnegie Mellon. The Graduate Education Office serves as a hub for connecting graduate students to relevant campus experts and resources to support their academic success, understanding of university level policies and practices and to assist them in advancing their personal and professional development.

Examples of resources offered through the Graduate Education Office 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 email 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 Graduate Education Office 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 Maternity Accommodations](#) in the Office of the Dean of Students or on their [website](#). This

Office also manages the **Emergency Student Loan (ESLs)** process. Emergency Student Loans are made available through generous gifts of alumni and friends of the university. The Emergency Student Loan is an interest-free, emergency-based loan repayable to the university within 30 days. Loans are available to enrolled students for academic supplies, medication, food or other expenses not able to be met due to unforeseeable circumstances.

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/>

Diversity and inclusion have a singular place among the values of Carnegie Mellon University. The Center for Student Diversity & Inclusion actively cultivates a strong, diverse and inclusive community capable of living out these values and advancing research, creativity, learning and development that changes the world.

The Center offers resources to enhance an inclusive and transformative student experience in dimensions such as access, success, campus climate and intergroup dialogue. Additionally, the Center supports and connects historically underrepresented students and those who are first in their family to attend college in a setting where students' differences and talents are appreciated and reinforced, both at the graduate and undergraduate level. Initiatives coordinated by the Center include, but are not limited to:

- **First generation/first in family to attend college programs**
- **LGBTQ+ Initiatives**

- Race and ethnically-focused programs, including Inter-University Graduate Students of Color Series (SOC) and PhD SOC Network
- Women's empowerment programs, including Graduate Women's Gatherings (GWGs)
- Transgender and non-binary student programs

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 self-identify 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.

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 uro-vaedbenefits@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 relating to areas below:

- Academic and Student Life
- Bias Reporting
- Environmental Health and Safety
- Financial Matters
- High-Risk Incident
- Human Resource Related
- Information Systems

- Research
- Threat of Business Interruption
- Threat of Violence or Physical Harm
- Title IX

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 are reported to appropriate university personnel.

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 it-help@cmu.edu.

Student Academic Success Center

<https://www.cmu.edu/student-success/>

Student Academic Support Programs

Tartan Scholars

- The Tartan Scholars program was created to provide support for limited resourced students through an intentional first year undergraduate experience with the goals of enhancing the cohort's skill and community building through a lens of self-authorship,

growth mindset, and a sense of belonging. As part of the Student Academic Success Center, Tartan Scholars are invited to join the University and participate in summer initiatives and pre-orientation activities prior to their first year at the University.

- There are opportunities for graduate students to serve as accountability, learning, or development partners, workshop facilitators, and presenters. Contact Diane Hightower at ddhighto@andrew.cmu.edu for more details.

Learning Support

- **Supplemental Instruction:** Supplemental Instruction (SI) is an academic support model that utilizes peer-assisted study sessions. The SI program provides regularly scheduled review sessions on course materials outside the classroom. SI is a non-remedial approach to learning as the program targets high-risk courses and is available in select courses based on data related to past student performance and feasibility.
- **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.
- **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.
- **“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.
- **Study Partners:** Support for students to create and benefit from their own study groups: The Student Academic Success team assists students in forming and benefiting from peer study groups, whereby all students can reap the benefits of peer-to-peer learning, student agency, and collaboration skill development. Staff from the Student Academic Success Center will be made available to instructors and students to assist with the formation of peer-led study groups. This level of support is open to any course where the instructor requests or agrees such support is appropriate and students are interested in both leading and participating.

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 choose from sessions on

- how to give a strong presentation,
- writing academic emails,
- expectations and strategies for clear academic writing,
- how to talk about yourself 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.

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 dietitian 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 (emergency only), 412-268-6232 (non-emergency)

The University Police Department is located at 300 South Craig Street (entrance is on 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 412-268-6232. 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 student on-line handbook and is considered a supplement to the department (and sometimes college) handbook. The WORD contains campus resources and opportunities, academic policy information and resources, community standards information and resources. 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/>.

Carnegie Mellon Vision, Mission
Statement of Assurance
Carnegie Code

Academic Standards, Policies and Procedures

- Educational Goals
- Academic and Individual Freedom
- Statement on Academic Integrity Standards for Academic & Creative Life
- Assistance for Individuals with Disabilities
- Master's Student Statute of Limitations
- Conduct of Classes
- Copyright Policy
- Cross-college & University Registration
- Doctoral Student Status Policy
- Evaluation & Certification of English Fluency for Instructors
- Final Exams for Graduate Courses
- Grading Policies
- Intellectual Property Policy
- Privacy Rights of Students
- Student's Rights

Research

- Human Subjects in Research
- Office of Research Integrity & Compliance
- Office of Sponsored Programs
- Policy for Handling Alleged Misconduct of Research
- Policy on Restricted Research

Tax Status of Graduate Student Awards

Campus Resources & Opportunities

- Alumni Relations
- Assistance for Individuals with Disabilities
- Athletics, Physical Fitness & Recreation
- Carnegie Mellon ID Cards and Services
- Cohon University Center
- Copying, Printing & Mailing
- Division of Student Affairs
- Domestic Partner Registration
- Emergency Student Loan Program
- Gender Programs & Resources
- Health Services
- Dining Services
- The HUB Student Services Center
- ID Card Services
- Leonard Gelfand Center
- LGBTQ Resources
- Multicultural and Diversity Initiatives
- Opportunities for Involvement
- Parking and Transportation Services
- Shuttle and Escort Services
- Spiritual Development
- University Police
- Student Activities
- University Stores

Community Standards, Policies and Procedures

- Alcohol and Drugs Policy
- AIDS Policy
- Bicycle/Wheeled Transportation Policy
- Damage to Carnegie Mellon Property
- Deadly Weapons
- Discriminatory Harassment
- Disorderly Conduct
- Equal Opportunity/Affirmative Action Policy
- Freedom of Expression Policy
- Health Insurance Policy Immunization Policy
- Missing Student Protocol
- Non-Discrimination Policy
- On-Campus Emergencies
- Pets
- Political Activities
- Recycling Policy
- Riotous and Disorderly Behavior

Safety Hazards
Scheduling and Use of University Facilities
Sexual Harassment and Sexual Assault Policy
Smoking Policy
Student Accounts Receivable and Collection Policy and Procedures
Student Activities Fee
Student Enterprises
Workplace Threats and Violence Policy

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 or by fax (916) 263-1897.

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.

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>.

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.

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/package 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-Oriented 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. Prerequisite: 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-requisites 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 successfully 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.

Service Oriented Computing (18-655) – 12 Units

Service Oriented Computing (SOC) is a one-semester course that introduces how to build and leverage software systems as a service to facilitate reusability, scalability, availability, and interoperability, in a networked environment. SOC has been significantly changing the way how software systems and applications are analyzed, architected, designed, implemented, tested, evaluated, delivered, consumed, maintained and evolved. Its comprising techniques have enabled the emergence of the contemporary third-generation software engineering: Service Oriented Software Engineering (SOSE). In this course, key concepts and standards, core enabling technologies and innovative consulting methods, as well as major solution patterns, are captured in the whole lifecycle of SOSE. 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" area requirement. Prerequisites: Proficiency with either Java or Python programming language and in modern software development concepts.

Data Intensive Workflow Development for Software Engineers (18-656) – 12 Units

Many software systems nowadays have become increasingly data intensive and data centered applications. Manipulating comprehensive datasets and heterogeneous data sources typically requires composing and executing a series of computational or data manipulation steps, called a workflow. A data-oriented workflow is a formal way of defining, automating, repeating and adapting multi-step computational procedures driven by data events. The primary objective of the course is to help students develop skills in engineering data-oriented workflows, in the context of service-oriented software engineering, big data, cloud computing, Internet of Things, social networking, and mobile computing. Core topics include: data-oriented workflow theory, models, languages, techniques, architectures, systems, tools; workflow discovery, reuse, recommendation, orchestrations and choreographies; workflow properties and data dependencies; data provenance capture, storage, retrieval, and mining; workflow execution, allocation, and optimization on cloud; workflow as a service, as well as collaborative data analytics on the Internet. 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 Systems area 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 ($\sim 100 \times 10^{12}$ 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 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 PowerDue 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 RVs; 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 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 deregulation, 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.

Ph.D. Reading and Research (18-990) – Variable Units

Ph.D. 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 5 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 Ph.D. Students (18-996, 18-997, 18-998) – Variable 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

ECE Graduate Teaching Internship (18-992) – 12 Units

Two semesters of Teaching Internship are required for the ECE Ph.D. program. Ph.D. students or M.S. students who intend to pursue a Ph.D. are eligible for the TI. Students should obtain their advisor's permission prior to applying for the TI. Students must complete the online TA application to be considered for a position. TIs are assigned to work 10 hours per week. Registration of 12 units is required for each semester of teaching. See <http://www.ece.cmu.edu/student/teaching.html> for further information about applying for a teaching internship position.

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: 888-370-7589
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 or 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 withdraws 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 (I)

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 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.

How to determine whether a student in a program offered in modules has withdrawn

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 2021-2022 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](https://www.cmu.edu/sfs/financial-aid/missing-documents/index.html) 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 pursuing 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.

APPENDIX E: ADDITIONAL INFORMATION ON COVID-19 EXCEPTIONS AND UPDATES

COVID-19 Related Updates

Pass/No Pass Policy – For Spring 2020 the university instituted a Pass/No Pass policy to allow passing grades to be converted to P/NP and still count towards degree requirements. All passing grades from Spring 2020 will be counted towards the ECE MS degree, but will not be factored into the students QPA.

Remote Courses – Due to the COVID-19 pandemic the rule where only one online class is allowed per semester is suspended for the 2020-2021 academic year. Students may register for classes that have both remote and in-person delivery modes.



5000 Forbes Avenue

Pittsburgh, PA 15213

www.ece.cmu.edu

@CMU_ECE