Northwestern | McCORMICK SCHOOL OF ENGINEERING

# Computer Engineering Graduate Study Manual

## 2025-2026

Department of Electrical & Computer Engineering
McCormick School of Engineering, Northwestern University
Technological Institute
2145 Sheridan Road, Room L359
Evanston, IL 60208

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# Welcome

Dear Students,

As Director of Graduate Studies for the Computer Engineering (CE) graduate program at Northwestern University, I am delighted to welcome you to our department and community.

Computer Engineering at Northwestern is a joint program between the Department of Electrical and Computer Engineering (ECE) and the Department of Computer Science (CS) within the McCormick School of Engineering. We offer programs leading to the MS and Ph.D. degrees, designed to prepare students for impactful careers in research, industry, and academia.

The CE program spans a range of foundational and emerging topics across hardware, software, and systems. From computing architectures and embedded platforms to real-time systems and distributed computing, our curriculum and research opportunities are designed to support deep technical growth and interdisciplinary exploration.

Our faculty are internationally recognized leaders advancing the frontiers of knowledge across engineering and computing. Their collaborations span Northwestern's engineering and science departments, the Feinberg School of Medicine, national laboratories like Argonne and Sandia, and leading companies across the globe.

As a graduate student, you'll benefit from a rigorous academic environment, personalized mentorship, and opportunities to engage in world-class research that shapes the technologies of tomorrow.

We look forward to working with you and supporting your journey in the Computer Engineering program. Welcome to Northwestern!

Sincerely,

**Professor Jie Gu**
Director of Graduate Studies, Computer Engineering
Department of Electrical & Computer Engineering
Email: jgu@northwestern.edu

# Overview

This manual provides detailed information about the educational opportunities in the computer engineering program. It includes descriptions of our curricula, milestones, processes, and information about our faculty, facilities, services, and student activities. The handbook is in full compliance with the guidelines provided by The Graduate School (TGS) and often refers to sources available at their website.

## Graduate Studies in Computer Engineering

Northwestern University's Computer Engineering program is a joint program between the Department of Computer Science (CS) and the Department of Electrical and Computer Engineering (ECE), and offers programs leading to the MS and Ph.D. degrees in Computer Engineering (CE). Computer Engineering covers a diverse set of research areas which our faculty are actively pursuing. These areas include, but are not limited to, computer architecture, computer systems, operating systems, compilers, parallel systems, distributed systems, high-performance and parallel computing, distributed computing, data mining, artificial intelligence, machine learning, big data science and applications, integrated circuits/VLSI, mixed-signal circuit design, design automation, formal methods, embedded and real-time systems, mobile and wearable computing, internet of things, cyber-physical systems, database systems, and reconfigurable systems.

The broad interdisciplinary interests of our faculty lead to strong collaborative research with other engineering and science departments within Northwestern University as well as at other institutions, including the Feinberg School of Medicine, national laboratories such as the Argonne National Laboratory, Fermi National Accelerator Laboratory, Sandia National Laboratories and Oak Ridge National Laboratory, as well as industrial companies. The wealth of research pursuits and the collaborative and interdisciplinary nature of the CE program enrich the experience of our graduate students beyond the conventional classroom.

### Core Computer Engineering Faculty

The Core Computer Engineering Faculty is comprised of Profs. Nivedita Arora, Simone Campanoni, Alok Choudhary, Peter Dinda, Branden Ghena, Jie Gu, Nikos Hardavellas, Russ Joseph, Seda Ogrenci, Stephen Xia, David Zaretsky, Hai Zhou, Jakub Szefer, and Qi Zhu.

The complete faculty list and profiles can be found on the ECE website at: https://www.mccormick.northwestern.edu/electrical-computer/people/faculty.html

## Affiliated Computer Engineering Faculty

In addition to the Core Computer Engineering faculty, the CE program maintains strong connections and interactions with other affiliated faculty that are world-renowned experts in their respective fields. The Affiliated Computer Engineering Faculty can be found on the ECE website at: https://www.mccormick.northwestern.edu/electrical-computer/people/affiliated.html

## Computer Engineering MS/Ph.D. Program Mission Statement

The MS and Ph.D. programs in Computer Engineering provide education, technical expertise, skills, mentoring and opportunities to develop graduate students into independent and productive scholars, practitioners, and thought leaders in their chosen area of specialization. The program offers a firm technical background to prepare graduate students for lifetime careers in academia and industry, guides them in the pursuit of original research and emerging fields, fosters intellectual curiosity, and prepares students for life-long learning to adapt in response to the needs of a rapidly changing world. The program also aims to develop the students' ethos as researchers and scholars, and promotes the effective oral and written communication of scientific concepts.

## Learning Objectives and Assessment Strategies

To provide clarity and transparency around program curricular goals and criteria, per TGS' Assessment Initiative guidelines, the table below enumerates the CE graduate programs' learning objectives, aligns them to program-specific milestones/requirements, and outlines assessment criteria and strategies.

| Learning objective(s)<br>*Students should be able to…* | Milestone/ Requirement/ Capacity | Assessment Strategies and Criteria*<br>*How do we know this objective has been achieved?*<br>*What criteria do we have to measure success?* |
|---|---|---|
| Demonstrate technical expertise and skills in Computer Engineering. | Courses / Literacies (mathematical, scientific, engineering, programming, design, digital) | Assessment Strategy:<br>Advisor, faculty committee, and class instructors evaluate course performance. Discussed at CE-wide annual student performance evaluation.<br>Criteria:<br>Satisfies Core CE coursework; Satisfies Track CE coursework; Meets coursework milestones within specified time limits; Meets minimum GPA requirements. |

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| Contribute original research to scholarly community. | MS Thesis; PhD Prospectus; Dissertation; Publication of research papers / Research | Assessment Strategy:<br>Advisor and faculty committee assess research papers, MS Thesis or PhD Prospectus and Dissertation, demonstrating levels of achievement. Advisor and faculty committee (together with peers from the scientific community through program committee service) assess research papers. Discussed at CE-wide annual student performance evaluation.<br>Criteria:<br>Offers original work; Presents novel ideas; Advances the field; Defines and uses appropriate methodology; Adheres to scientific method; Delineates sources. |
| Design and execute accurate experiments; Quantitatively evaluate research artifacts and | Methodology and experimental sections in MS | Assessment Strategy:<br>Advisor and faculty committee assess successful design, analysis and evaluation of research experiments and artifacts in |
| experimental results. | Thesis, MS Project Report, PhD Prospectus, Dissertation, and published research papers / Research | MS Thesis or Project, or PhD Prospectus and Dissertation, and (together with peers from the scientific community through program committee service) in research papers. Discussed at CE-wide annual student performance evaluation.<br>Criteria:<br>Defines and uses appropriate methodology; Utilizes appropriate measurement tools; Configures and uses appropriate experimental environment; Sound & complete evaluation and analysis of artifacts and experimental results. |
| Enact ethical research methodologies and practices. | Responsible Conduct of Research Training (RCR) / Research | Assessment Strategy:<br>Successful completion of RCR training. Discussed at CE-wide annual student performance evaluation.<br>Criteria:<br>Fosters ethical problem-solving skills; Increases the ability to recognize ethical issues in design and conduct of research; Identify and understand ethics regulations, policies, and resources. |
| Articulate scientific research, scientific results and their impact to the field and to society in writing. | MS Thesis; MS Project Report; PhD Prospectus; Dissertation; Publication of research papers / | Assessment Strategy:<br>Advisor and faculty committee (together with peers from the scientific community through program committee service) assess writing skills prioritizing specific criteria that demonstrate levels of achievement. Discussed at CE-wide annual student performance evaluation.<br>Criteria: |

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| | Communication (scientific writing) | Document organization; Construction of argument flow; Clarity of explanation; Clarity of visual aids; Conciseness; Completeness; Successful publication of research paper. |
| Articulate scientific research, scientific results and their impact to the field and to society in oral presentation and speaking. | MS Thesis oral defense; PhD Prospectus oral exam; PhD Thesis oral defense; Presentations in seminars and conferences / Communication (presentation, public speaking) | Assessment Strategy:<br>Advisor, faculty committee, and peers assess speaking and oral presentation skills, using specific criteria that demonstrate levels of achievement. Discussed at CE-wide annual student performance evaluation.<br>Criteria:<br>Presentation organization; Construction of argument flow; Clarity of oral arguments and explanations; Clarity of visual aids; Information pruning; Audience engagement; Ability to answer questions; Ability to provide rationale for research or aspects of the research; Ability to articulate broader impact. |
| Develop effective teaching strategies and methods; Develop course materials; Evaluate student learning; Lead recitation sessions. | Teaching Assistantship (TA) / Teaching | Assessment Strategy:<br>Teaching assistant collaborates with professor and fellow TAs during course development and teaching. Instructor, peer TAs and students (through CTECs) evaluate TA's performance.<br>Discussed at CE-wide annual student performance evaluation. Criteria:<br>Quality and usefulness of developed course materials; Ability to clearly explain concepts; Ability to incorporate examples to foster learning; Student engagement during recitations and office hours; Ability to answer student questions clearly (online, in class, office hours); Ability to evaluate written and lab work fairly; CTEC evaluations |
| Effectively manage infrastructure building and development tasks; Effectively manage research project and publication timelines; Effectively manage lab sub-groups and collaborate with peers. | Organization and Management/ Leadership and Collaboration | Assessment Strategy:<br>Research projects typically require substantial infrastructure building and development, and effective management of complex timelines to achieve publication. Research projects often require multi-person teams, typically led by a graduate student. Student leads may also participate in other sub-groups as collaborators. The quality and completeness of the infrastructure, the efficacy in managing research and publication timelines, task prioritization, and leadership and collaboration ability are assessed informally by the advisor and faculty committee. Discussed at CE-wide annual student performance evaluation.<br>Criteria:<br>Infrastructure quality; Infrastructure completeness; Efficacy or task prioritization; Demonstrated effectiveness |

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| | | of time management; Effectively coordinates development and experimental efforts; Team meets internal deadlines. |
| Create and communicate professional development plan. | Annual Meeting/ Career Development | Student develops and shares career plan annually with advisor, Director of Graduate Studies in CE and faculty committee at annual evaluation meeting; Student seeks appropriate resources in response to professional development plan, such as identifying career paths of program alumni. |

# Personnel

Graduate students are expected to discuss all academic issues with their advisors first, in an open and constructive manner. Help with administrative aspects is provided by the ECE Graduate Affairs Coordinator (Tech Institute Room L359, ecegrad@northwestern.edu). The Graduate Affairs Coordinator can advise students on the best course of action, and promptly take the measures needed toward the successful completion of the student's graduate degree.

In addition, graduate students in the Computer Engineering program may discuss questions regarding academic matters, degree requirements or disputes with advisors or committee members. Ph.D. students can speak with the Director of Graduate Studies (DGS) in Computer Engineering, Prof. Jie Gu (jgu@northwestern.edu). MS students can speak with the Director of the MS Program, Prof. David Zaretsky (david.zaretsky@northwestern.edu).

Finally, sometimes (albeit, infrequently) complex situations arise in academic life that may require the consultation and direct involvement of The Graduate School (TGS; https://www.tgs.northwestern.edu/). Additional information on TGS appears in the next section of the handbook.

# Program Resources

The program, the ECE department, the McCormick School of Engineering and Applied Science, and the University offer a wealth of resources to assist graduate students in their academic life.

## Graduate Student Tracking System (GSTS)

The Graduate Student Tracking System (GSTS; https://gsts.northwestern.edu/) is the online portal used to record and manage the student's progress through the graduate program. GSTS lists the major program milestones and their respective deadlines (students should always consult this handbook for additional milestones and deadlines), completed coursework and unofficial transcripts, course plans, advisor, committee

members, annual evaluation reviews, etc. GSTS can also be used by the student to formally invite faculty members to serve in the student's committee, provide concise descriptions of the student's research, complete the annual self-evaluation, submit milestone forms, request admission to Ph.D. candidacy, degree completion, etc. It is strongly recommended that GSTS is used in all cases that it is applicable, e.g., for all formal communications with the student's advisor, committee members, program administration, and program-related form submissions and petitions.

## Course Planning Resources

Graduate students should regularly check the ECE and CS courses webpages when planning the courses to be taken in the subsequent quarters, discuss their course plan with their academic advisor, and populate the data in GSTS. The schedule and descriptions for ECE courses can be found online at https://www.mccormick.northwestern.edu/electrical-computer/courses/, and the schedule and descriptions for CS courses at https://www.mccormick.northwestern.edu/computer-science/courses/. Course names with prefixes COMP_ENG, COMP_SCI and ELEC_ENG denote CE, CS and EE courses, respectively.

Students can register for courses using CAESAR (https://www.caesar.northwestern.edu/). Courses approved for credit by The Graduate School are courses with a Career Course of "The Graduate School", as designated in CAESAR.

## The Graduate School (TGS)

Every graduate student is assigned a counselor at TGS. The counselor monitors overall academic progress from the standpoint of TGS-based milestones, along with a satisfactory GPA, etc. Please be advised that most of the forms that concern completion of milestones are subject to a final approval by TGS in addition to being approved by the student's academic advisor and the CE program. TGS is located at 633 Clark Street in Evanston, and its webpage (https://www.tgs.northwestern.edu/) contains a wealth of information pertaining to various aspects of students' life.

## Northwestern University Graduate Faculty

The faculty of The Graduate School is drawn from the faculties of colleges or schools of the University which have placed the administration of part (or all of the graduate work) under the control of The Graduate School. Information on membership to the Northwestern University Graduate Faculty can be found at https://www.tgs.northwestern.edu/about/for-faculty/.

### Other Resources

Other useful information (e.g., forms, job postings, announcements of visits by companies and recruiters, seminars, etc.) is posted at https://www.mccormick.northwestern.edu/electrical-computer/resources/.

## Services

In addition to the world-class educational opportunities to work with top faculty while accessing a wealth of facilities, research labs, and libraries for intellectual growth, Northwestern University offers a variety of services which can assist different aspects of student life.

### Wildcard

The Wildcard is your photo identification card and can be used in almost every place that needs an identity verification on campus (library, recreational facilities, Norris University Center, campus, intercampus bus transit, etc.). It is issued by the Wildcard office in Norris University Center, underground level, Evanston campus, and at the University Services (support services) office in Abbott Hall, Room 100, Chicago campus. Lost or stolen ID cards are replaced for a $15 fee. Broken or damaged cards will be replaced at no charge (providing the damaged card is returned). For more information, visit https://www.northwestern.edu/wildcard/.

### Transportation

There are three basic types of services available:

- Shuttle: there are several shuttle buses that operate in each of the Chicago and Evanston campuses (and between the two) upon presentation of a valid Wildcard. Detailed information is available at https://www.northwestern.edu/uservices/transportation/shuttles/.
- Route 201: the Route 201 CTA bus (https://www.transitchicago.com/bus/201/) offers free service to Ryan field and to the Old Orchard mall in Skokie upon presentation of a valid Wildcard.
- U-Pass: this is a collaboration between Northwestern and Chicago Transit Authority (CTA) based on Ventra (https://www.tgs.northwestern.edu/services-support/transportation/upass-faq.html) a contactless payment fare card and system that serves as a U-Pass. The card is issued at the beginning of every academic year, and can be used 365 days a year on all CTA buses and trains.

## Health Services

Northwestern University provides a basic outpatient care and other primary-care services, and there are facilities in both Evanston and Chicago campuses. The Evanston location is at 633 Emerson Street (Searle Building). Per TGS regulations, every graduate student is legally required to have health insurance coverage. While it is provided for Ph.D. students and a partial coverage is available for MS students, one may opt out of this coverage, as long as there is a proof of sufficient alternate coverage for the entire duration of graduate studies. In case of life-threatening or severe emergencies call 911 to summon paramedics, or go to the nearest hospital emergency room. If in need of urgent after-hours medical care, call 847-491-8100. More information can be found at the Health Services website at https://www.northwestern.edu/healthservice-evanston/.

## Counseling and Psychological Services (CAPS)

CAPS provides a set of core mental health services on campus, including clinical services, educational workshops, and consultation with faculty and staff as needed. Services are free for all students and available on both the Evanston (633 Emerson St) and Chicago campuses (710 N. Lake Shore Drive, Abbott Hall, 5th Floor, Suite 500; 847-491-2151; https://www.northwestern.edu/counseling/).

## Personal Safety

Students should always be aware of their surroundings and avoid areas that have indication of being a potentially non-safe environment (e.g., poorly lit walkways and alleys at night). The University Police is on duty 24/7 and they are located at 1200 Davis St. in Evanston. In the case of emergency, always dial 911. Note that there are blue-light poles distributed across the University, which can also be used to contact the University police. The non-emergency contact number is 847-491-3456.

## Office of International Student and Scholar Services (OISS)

The OISS is available to all the international students and its primary two roles are: (a) to provide guidance and advise for maintaining proper immigration status consistent with the laws of the United States; (b) to ensure compliance with those laws and help the students with various forms, such as OPT (Optional Practical Training) and CPT (Curriculum Practical Training). The OISS is located at 630 Dartmouth Place. More information is available at https://www.northwestern.edu/international/. OISS staff can be contacted via phone at 847-491-5613 or via email to intoff@northwestern.edu. Your OISS advisor is assigned by your last/family/surname, please visit the staff page to find yours: https://www.northwestern.edu/international/about/our-staff/index.html.

## AccessibleNU

Northwestern University and the Computer Engineering program are committed to providing an accessible, supportive and challenging environment for all undergraduate, graduate, professional school, and professional studies students with disabilities who attend the University. AccessibleNU works with our faculty to provide students with disabilities a learning and community environment that affords them full participation, equal access, and reasonable accommodation.

Any student requesting accommodations related to a disability or other condition is required to register with AccessibleNU (accessiblenu@northwestern.edu; 847-467-5530) and provide professors with an accommodation notification from AccessibleNU, preferably within the first two weeks of class. More information on AccessibleNU can be found at https://www.northwestern.edu/accessiblenu/.

## Postal Services

Mailboxes maintained by the staff are provided for all graduate students for university-related postal- mail and packages only (not for personal use) and are located in the ECE Main Office. Each student is expected to show their WildCard upon pickup, and may only pick up their own mail, not that of another student. It should be made a matter of a habit to check for such mail at least once a month. Our mailing address is:

Department of Electrical and Computer Engineering
McCormick School of Engineering
2145 Sheridan Road, Rm L359
Evanston, IL 60208, USA

## The Graduate School (TGS) Resources

The Graduate School (TGS) offers a wide range of resources to support graduate students' academic, professional, and personal success. These include professional development programs, health and wellness services, academic support, legal assistance, international student services, and family resources such as parental leave and childcare grants. TGS also provides guidance on housing, transportation, and opportunities to engage in the vibrant campus and community life in Evanston and Chicago. Visit www.tgs.northwestern.edu for details on these and other resources.

## ECE Departmental Resources

Graduate students are expected to discuss all academic issues with their advisers first, in an open and constructive manner. Further help with academic issues is provided by the ECE Graduate Student Affairs Coordinator (Tech, Rm L359; ecegrad@northwestern.edu). The staff in the Graduate Office is experienced and can advise you on the course of action and promptly take the measures needed towards successful completion of your degree.

Mailboxes maintained by the staff are provided for all graduate students for university-related postal mail and packages only (not for personal use) and are located in the ECE Main Office (L359). Each student is expected to show their Wildcard upon pickup, and may only pick up their own mail, not that of another student. It should be made a matter of a habit to check for such mail at least once a month.

The information about our courses is available at: https://www.mccormick.northwestern.edu/electrical-computer/courses/

Graduate students should make it a habit of checking the above webpage when planning the courses to be taken in the subsequent quarters, and then proceed with a discussion with the respective academic advisers, and populating the data in the Graduate Student Tracking System (GSTS).

Other useful information (e.g., forms, job posting, announcements of visits by companies and recruiters, etc.) can be found at: https://www.mccormick.northwestern.edu/electrical-computer/

ECE organizes various social events throughout the Academic Year for which announcements via email are made regularly.

## Nondiscrimination Statement

Northwestern University does not discriminate or permit discrimination by any member of its community against any individual on the basis of race, color, religion, national origin, sex, pregnancy, sexual orientation, gender identity, gender expression, parental status, marital status, age, disability, citizenship status, veteran status, genetic information, reproductive health decision making, or any other classification protected by law in matters of admissions, employment, housing, or services or in the educational programs or activities it operates.

Harassment, whether verbal, physical, or visual, that is based on any of these characteristics is a form of discrimination. Further prohibited by law is discrimination against any employee and/or job applicant who chooses to inquire about, discuss, or disclose their own compensation or the compensation of another employee or applicant.

Northwestern University complies with federal and state laws that prohibit discrimination based on the protected categories listed above, including Title IX of the Education Amendments of 1972. Title IX requires educational institutions, such as Northwestern, to prohibit discrimination based on sex (including sexual harassment) in the University's educational programs and activities, including in matters of employment and admissions. In addition, Northwestern provides reasonable accommodations to qualified applicants, students, and employees with disabilities and to individuals who are pregnant.

Any alleged violations of this policy or questions with respect to nondiscrimination or reasonable accommodations should be directed to Northwestern's The Office of Civil

Rights and Title IX Compliance, 1800 Sherman Avenue, Suite 4-500, Evanston, Illinois 60208, 847-467-6165, TitleIXCoordinator@northwestern.edu.

Questions specific to sex discrimination (including sexual misconduct and sexual harassment) should be directed to Northwestern's Title IX Coordinator in the The Office of Civil Rights and Title IX Compliance, 1800 Sherman Avenue, Suite 4-500, Evanston, Illinois 60208, 847-467-6165, TitleIXCoordinator@northwestern.edu.

A person may also file a complaint with the Department of Education's Office for Civil Rights regarding an alleged violation of Title IX by calling 800-421-3481 or visiting https://www2.ed.gov/about/offices/list/ocr/complaintintro.html. Inquiries about the application of Title IX to Northwestern may be referred to Northwestern's Title IX Coordinator, the United States Department of Education's Assistant Secretary for Civil Rights, or both.

## General Admission Requirements

The primary objective of the admission process in the ECE Department is to determine an applicant's qualifications and judge the applicant's prospects for success in their desired program of study. To maintain a proper balance between department resources and the size of the graduate student population, we must limit offers of admission to the most qualified applicants. Thus, our admission process is highly selective and competitive in nature.

The deadline for **Ph.D.** applications is **December 15** of the respective year for the applicants who wish to be admitted to the program starting in the Fall Quarter of the subsequent academic year. The deadline for **MS** applications is typically the **last week of February** of the year during which an applicant plans to start in the Fall Quarter.[1]

Requests for admission and financial aid for doctoral students are reviewed in the weeks following the application deadline. It is the policy of the department that students begin their programs in Fall Quarter. Under special circumstances, students are allowed to begin in the Winter or Spring Quarter. A typical applicant is expected to have a B.S. in electrical engineering, computer engineering, or a related discipline from a recognized institution. Highly qualified candidates with other academic backgrounds may also be considered. The specific undergraduate preparation required for graduate study depends on the program and the area of specialization. An applicant with insufficient undergraduate preparation in any particular area but well qualified in every other respect may be required to take certain undergraduate courses as soon as possible after enrolling at Northwestern.

[1] NOTE: MS applicants are only admitted for a Fall Quarter start date. This is to avoid any problems with the course sequence.

A student would be informed of such a requirement at the time of admission, along with grade expectations.

The Graduate School (TGS) website https://www.tgs.northwestern.edu/admission/index.html provides a means to navigate through the application process for graduate study at Northwestern University.

# Financial Aid

## Ph.D. Students

The policy of the McCormick School is to admit only those students for whom financial support can be provided in the form of Northwestern Fellowships (e.g., Cabell, Murphy), research assistantships, and teaching assistantships. Students who have financial support from outside institutions or government grants will also be considered for admission. However, if such internal (McCormick, CS or ECE Department) or external (company, institutional, governmental) financial support is not provided, then the CE program will not recommend admission of the student to The Graduate School.

All students receiving financial aid in the form of fellowships, research assistantships, or teaching assistantships must register as full-time students. The normal full-time program of graduate study is 3- 4 units per academic quarter. The maximum permitted is 4 units.

## MS Students

The ECE Department encourages MS students, especially from industry, to apply. However, the Department does not provide financial support to MS students. Such students can be supported by a company, government, or an external fellowship, or be self-supported. **MS students are not eligible for teaching assistantships or research assistantships**.

## Student Responsibilities and Academic Misconduct

It is the responsibility of each graduate student to ensure that all the requirements of The Graduate School (TGS) and the ECE Department are met, given the program he or she selects; that necessary examinations are properly scheduled; and that deadlines dependent on current Northwestern University calendars are observed. The current procedures and degree requirements of the ECE Graduate Programs are detailed in this Manual.

Students should always consult with the ECE Graduate Student Affairs Coordinator (Tech, L359, ecegrad@northwestern.edu) first to execute procedures, confirm requirements, and obtain paperwork for exams and various other procedures. In addition, students are strongly urged to consult regularly with their faculty advisers.

Official notices about degree program progress, financial aid and other important notices are sent to each student's official email and mailboxes.

*Students are responsible for checking their official Northwestern email account (@u.northwestern.edu) on a regular basis, no less than once a week.*

*Students are responsible for checking their official department mailbox on a regular basis, no less than once per month.*

All students at Northwestern University are responsible for knowing the University's policies on academic integrity. The principles and possible consequences of academic misconduct are documented at: https://www.northwestern.edu/provost/policies/academic-integrity/principles.html

Students found guilty of academic misconduct, such as cheating on coursework or plagiarizing research, by definition are failing to make satisfactory academic progress, and are hence subject to be placed on academic probation.

https://www.tgs.northwestern.edu/academic-policies-procedures/policies/satisfactory-academic-progress.html

Students must be particularly vigilant in programming courses. Unless the instructor for the course has explicitly documented otherwise in the course syllabus:

- Code you submit must be your own.
- Copying and adapting someone else's code is not allowed.
- Studying someone else's solution for a specific assigned problem is not allowed.
- This includes code from a friend, an online article, or online code repository.
- Letting another student study your solution is not allowed.

If an instructor concludes that cheating has occurred, he or she will submit the evidence to your dean for adjudication. Penalties for cheating will depend on the specifics of the case. They can range from loss of points on the assignment in question, a reduction in letter grade for the course, or even failure in extreme circumstances.

## Part-time Graduate Studies

U.S. citizens and permanent residents may pursue their graduate studies in CE on a part-time basis, subject to approval by the CE program. Part-time graduate studies are not available to international applicants because the U.S. government does not give student visas for part-time enrollment. Please discuss the details of the part-time graduate

program with the CE academic advisors, the Director of Graduate Studies in CE, and the Graduate Affairs Coordinator of your home department.

## Graduate Internships & Post-Graduation Employment

With the permission of their advisor, a graduate student wishing to combine research work with industrial experience may elect to participate in the Crown Family Graduate Internship Program. This experience permits the student to gain a broader understanding of some problems that eventually could serve as the background for a thesis or project. For more information on the Crown Family Graduate Internship Program, see Internships During Graduate Study.

International students who seek employment in the US upon graduating, who are on an F-1 visa, are in good academic standing, and have a valid I-20 should be aware that the visa status required for legal employment in the US after graduation is called OPT, and it **MUST BE APPLIED FOR 3-4 MONTHS BEFORE GRADUATION**. Without submitting this application in advance, you will not be able to transition smoothly from the F-1 student status to the OPT visa status, and any such interruption may delay or prohibit your employment with a US employer. The Office of International Student and Scholar Services (OISS) assists students with collection and submission of the required documents. In addition to consulting with your adviser, you should also schedule a meeting at least one month in advance of the OPT submission deadline to ensure you have enough time to collect the needed documentation.

## Disclaimer

Northwestern University reserves the right to change without notice any statement in this publication concerning, but not limited to, rules, policies, tuition, fees, curricula, and courses.

# MS Program

This section discusses the details of the academic aspects of obtaining an MS degree with the ECE department. Unless otherwise specified, all the items pertain to both EE and CE majors.

## Advising and Course Requirements

### Advising

Each MS student is assigned an academic advisor upon admission, Director of MS Studies, Prof. David Zaretsky. However, the student's preferences and interests may change, especially if they elect to follow the project or thesis degree plan, which typically entails the completion of one or more 590 research units. This may require the student's transition to a new research advisor, who will likely also advise on courses to take. Such a transition involves the following steps:

1. The student first obtains the formal agreement of a Core or Affiliated Computer Engineering faculty to serve as the student's MS Thesis or Project advisor;
2. The student notifies the current assigned advisor and the ECE Graduate Affairs Coordinator;
3. The ECE Graduate Affairs Coordinator records the advisor change in the Graduate Student Tracking System (GSTS).

Each MS student should consult with their advisor before registering online for courses on CAESAR. Failure to do so could result in poor course selection that would delay completion of the student's MS degree, or even result in academic probation due to poor grades. All courses should be listed and updated quarterly in GSTS..

### Course Requirements

To obtain an MS Degree in CE, the student must successfully complete a total of **12 course units**, with the following requirements met (common for all MS options). The choice of courses must represent a coherent program of study that prepares the student for advanced work in a specific field. The ECE Specializations provide recommended courses to take that focus on specific industry fields, but students may choose to customize their study plan with guidance from their graduate advisor.

| General Requirements |
| --- |
| • The student must complete a total of 12 course units made up of 6 Core and 6 Electives.<br>• Only 300-level or higher courses are counted towards the degree (excluding 399 and undergraduate courses).<br>• At least 9 courses must be eligible for TGS credit (See Course Planning Resources).<br>• At least 3 units at the 400-level or above (excluding 499 Independent Projects and 590 Research)<br>• Except for 590 Research, all courses must be taken for a quality letter grade (i.e., ABC, not P/N).<br>• Any course taken for P/N credit is not included in calculating the grade-point average (GPA).<br>• All coursework must be completed with a composite grade-point average of B (GPA 3.0) or higher.<br>• Courses may not be repeated for credit, except 499, 590, and Special Topics courses with different sections (e.g. ECE 395/495, CS 396/496, CS 397/497, etc.)<br>• Courses completed for undergraduate credit cannot be repeated or counted for graduate credit.<br>• The course study plan must be approved by the student's advisor prior to registration. |
| **Core Courses (6 units)** |
| • 6 Units of ECE courses (ELEC_ENG or COMP_ENG).<br>• At least 3 units of CE courses must be completed.<br>• 499 Projects and 590 Research are not included.<br>• Up to 3 units of CS courses may be petitioned to count with approval by the Director of Master's Program. |
| **Elective Courses (6 units)** |
| • 6 Units of elective courses.<br>• At least 3 units of ECE or CS courses must be completed (ELEC_ENG, COMP_ENG or COMP_SCI).<br>• At most 3 units of courses outside of ECE and CS, with approval by the Director of Master's Program.<br>• At most 3 units of 499 Projects.<br>• At most 2 units of 590 Research for an MS Project Plan, or 3 units of 590 Research for an MS Thesis Plan. |

## ECE Specializations

The master's program offers great flexibility in shaping your education based on your academic and career objectives. You can choose to focus your studies on a particular specialization from twelve (12) tracks listed below, or you can create a custom program to gain exposure in any number of areas of interest.

- Artificial Intelligence & Machine Learning
- Computer Vision & Image Processing
- Cybersecurity
- Embedded Systems
- High-Performance Computing
- Internet of Things & Edge Computing
- Network & Communication Systems
- Photonics & Optoelectronics

- Quantum Computing, Sensing & Communications
- Robotics & Autonomous Systems
- Semiconductors
- Sustainable Energy & Low-Power Design

Each specialization provides a list of recommended core and elective courses from which to build your education and career path. However, it is important to note that you do not need to follow these recommended courses specifically, so long as you complete the program requirements as outlined above.

## Graduate Minor Programs

Students enrolled in the full-time master's programs have the option of earning a certificate in a minor to complement their Master's in Computer Engineering and enhance their credentials and marketability. Generally, each minor program requires 3 units, which are applied towards your 6 elective requirements for the master's program. Since these units are outside of the ECE Department, they require approval of the Director of the Master's Program. You can learn more about the Minor programs on the McCormick Graduate Study website.

- **Minor in Engineering Management:** One particularly popular combination is a major in any engineering field with a three-course minor in engineering management, or EM Minor, offered through the Master of Engineering Management (MEM) Program within the Department of Industrial Engineering and Management Sciences.
- **Minor in Entrepreneurship:** The Farley Center for Entrepreneurship and Innovation offers the graduate minor in entrepreneurship, designed to provide the requisite skill sets to students who plan to create or participate in a start-up endeavor during their careers. It can also provide knowledge to assist researchers when traditional funding sources no longer exist, and commercialization is the next logical step. Applications are accepted annually for students planning to commence coursework in the fall quarter.
- **Minor in Cybersecurity:** The Master of Science in Information Technology program offers a three- unit cybersecurity minor to all students enrolled in professional Master's programs at McCormick. Applications are accepted each year starting September 1.
- **Minor in Scientific Computing:** The minor in scientific computing offers a substantive programming and algorithmic knowledge base to science students. It certifies that a student has the programming and algorithmic skills to develop codes to solve modern engineering problems.

## Transfer of Credit

To transfer a course, a student must submit a petition to the Director of Master's Program in Computer Engineering along with supporting evidence. The supporting evidence should include documentation of the course content (e.g., syllabus, slide decks, assignments, projects) and an official transcript that shows the grade received for the course. The student should identify which Northwestern University course they petition for a waiver. The coordinator of the corresponding course at Northwestern University will review the petition and make a recommendation. The transfer of credit is ultimately subject to the approval of the student's advisor (MS Thesis Research advisor, MS Project advisor, or academic advisor, for MS degree options A, B, C, respectively) and the Director of Master's Program in CE. The following requirements also apply:

- At most three (3) of the required 12 units may be waived, based on graduate-level courses taken previously elsewhere.
- Only coursework that has not been applied to a completed degree will be considered for transfer credit for an MS degree.
- For a course to be transferred, it must substantially match a course at Northwestern University that counts toward the 12-unit requirement.

The student must consult with their advisor before registering for courses. Failure to do so could result in poor course selection that would delay completion of the student's MS degree, or even result in academic probation due to poor grades or missed coursework completion deadlines.

## ECE course credit waivers

An MS student may petition to have **at most three** course credits waived, based on the student's graduate level courses taken previously elsewhere. Only coursework that has **not** been applied to a completed degree will be considered for transfer credit for a MS degree. A petition for such a waiver must include complete documentation (e.g., syllabus, assignments, projects, etc.) of the content of a graduate level course from the student's previous institution that most closely matches the ECE Department course credit to be waived. The student must also provide an official transcript, sent directly to the department, that shows the grade received for each course used for transfer credit.

The coordinator of this ECE Department course will review the petition and make a recommendation. All such waivers are ultimately subject to the approval of the advisor, the ECE Research Group, and the ECE Director of Master's Program.

### Enrollment Options to Maintain Resident Student Status

There are several non-classroom courses that may, at times, be used to maintain residency and student status. Below is a brief guide to these courses. Before enrolling in any non-classroom course, especially a special registration course listed below, be sure to consult with your academic advisor and the ECE graduate student services staff.

**Special Registration Courses:** These courses are used to maintain student status in cases where registering for research or classroom courses is not appropriate.

- **TGS 512 - Continuous Registration**: This course does not apply to the 12 units that must be completed for any ECE MS degree. It may, however, be a way to save money if a student has already completed the required letter-graded units and needs to maintain student status while completing a project or thesis. Tuition for TGS 512 is $100 and students do not need to pay the activity fee. Students may enroll in TGS 512 only if they have completed all their quality letter-graded (ABC) courses. The only credits that may be taken after TGS 512 are 590 Research. When enrolled in TGS 512, the student cannot enroll in additional classes.
- **TGS 588 - Resident Master's Study**: Available to master's degree students who are primarily doing research related to a master's thesis or project. It provides full-time status but allows no accumulation of credit or residency toward the master's degree. This registration requires The Graduate School's permission.

### TGS Degree Requirements

All MS students must satisfy The Graduate School's requirements for obtaining the Master of Science degree, outlined at https://www.tgs.northwestern.edu/about/policies/masters-degree-requirements.html. This handbook presents **program-specific** requirements that are in addition to, or further elaborate upon, the requirements established by TGS, and **may go beyond TGS minimums**. A complete description of TGS' requirements, academic policies and procedures for graduate study at Northwestern University, can be found at https://catalogs.northwestern.edu/tgs/academic-policies-procedures/.

## MS Degree Study Plans

Each student pursuing an MS degree in Computer Engineering must declare their intention to follow one of the degree plans (A, B, or C) summarized below. Students declare their intention to follow one of the degree plans no later than **May 1st of the 3rd academic quarter** (typically the Spring Quarter of the first year of study). The student's declaration is subject to approval by their advisor. The student's declaration to pursue a Thesis or Project MS degree is contingent upon first securing an MS Thesis or Project advisor. Upon approval of the student's MS degree declaration, the student must satisfy the declared MS option's additional requirements.

Every MS option establishes certain time limits during which the MS student must complete all MS degree requirements. An MS student who does not meet the plan's completion deadline, and who does not successfully petition the CE Program for an extension of that deadline, will be placed on academic probation for a maximum of two academic quarters. At that point, the CE MS Program retains the option to dismiss the student in question.

Students who are interested in following a Thesis or Project MS degree are strongly encouraged to consult with a faculty research advisor and enroll in a 590 Research course beginning in the Winter or Spring quarter of their 1st year of study.

## Plan A: MS Thesis

In this plan, a student declares their intent to earn the MS degree by completing a formal thesis that reports substantial original research results.

### *MS Thesis Research Advisor*

To participate in this study plan, the student **must first obtain the formal agreement with a faculty researcher to serve as the student's MS Thesis Research Advisor**. Ideally, this agreement would be in writing (e.g., via email exchange between the student and the prospective faculty advisor). The primary MS Thesis Research Advisor should be a member of the Northwestern University Graduate Faculty and have an appointment in the ECE department. However, if the student is pursuing research outside of the ECE department, they should first seek permission from the director of the MS program, and they should have at least one ECE faculty member on their research committee, such as their academic advisor or the director of the MS program.

### *Declaring a Thesis MS Degree Plan*

The process to declare a Thesis MS degree plan is as follows:

- The student obtains the formal agreement of a faculty member to serve as the student's MS Thesis advisor, as explained in the paragraph above.
- The student selects the "*Thesis-based MS*" specialization in GSTS.
- The student invites the prospective advisor faculty from (a) to serve as the "*Principal Research Advisor*" through GSTS. The faculty must formally accept the invitation through GSTS.

### *MS Thesis Committee*

A successful thesis has two components: a written document and an oral defense of the research. These are judged by a committee, called the MS Thesis Committee. The student

must invite faculty to serve on their MS Thesis Committee, in consultation with their MS Thesis Research Advisor. The MS Thesis Committee must comprise at least two faculty members of the Northwestern University Graduate Faculty. At least one of the MS Thesis Committee members must be an ECE faculty member. The MS Thesis Research Advisor serves as the chair of the MS Thesis Committee.

The MS Thesis Committee must be formed no later than one week before the MS Thesis oral defense. It is strongly advised to form the MS Thesis Committee much earlier than that, to allow sufficient time for the committee members to schedule the oral defense at a mutually agreeable time, and to examine the MS Thesis written document. Late invitations to serve in an MS Thesis Committee may result in faculty declining to serve due to schedule constraints and time commitment to other responsibilities. Failure to secure an MS Thesis Committee may result in the student missing program milestones and completion deadlines and may result in the student being placed on academic probation.

### *Written and Oral Thesis Requirements*

A **written thesis** must show evidence of original research and must be approved by the MS Thesis Committee. The format of the written thesis must conform to the dissertation formatting guidelines specified by TGS (https://www.tgs.northwestern.edu/academic-policies-procedures/dissertation-publication/dissertation-formatting-requirements/ ). There is no specific length for a thesis. Historically, they tend to be roughly 30 pages in the double-spaced graduate school thesis format. This is not a required length. The MS Thesis Committee may specify additional thesis format requirements or a minimum thesis length.

An **oral defense** of the thesis research is highly encouraged. The oral defense is attended (either physically, or via phone or video conferencing) and evaluated by the MS Thesis Committee. The oral defense talk should take between 30 minutes and 1 hour, followed by a Q&A session that may last up to one hour. It is recommended that the student and the MS Thesis Committee schedule at least two hours for an MS Thesis oral defense.

One week prior to the oral defense, the student must provide a complete draft of the thesis to the committee. Upon a successful oral defense, the MS Thesis Committee may request modifications to the written thesis document. The student must complete the necessary work to implement all requested modifications and submit the final written thesis document to the MS Thesis Committee for approval.

### *Common MS Requirements*

The student must satisfactorily complete all Common MS Degree Requirements in Course Requirements.

### *Research Credits*

Under the MS Thesis study plan, a maximum of 3 units of 590 Research can be counted toward the 6-unit elective requirement for the MS degree.

### *Time Limits*

All requirements for the Thesis MS Degree, including coursework and approval of the thesis by the student's MS Thesis Committee, must be successfully completed before the end of the **7th academic** quarter (typically the Spring quarter of the 2nd year of study).

**IMPORTANT:** In the Spring term, The Graduate School requires that **all thesis defenses be completed ONE MONTH before the end of the quarter**, if the student is to graduate in the Spring term. Deadlines in other quarters are not as early. Consult the Office of the Registrar's academic calendar for thesis defense deadlines for each quarter.

## Plan B: MS Project

In this plan, a student declares their intent to earn the MS degree by completing a project and writing a project report that contains results based on existing theory and techniques or experimental verifications.

### *MS Project Advisor*

To participate in this study plan, the student **must first obtain the formal agreement with a faculty researcher to serve as the student's MS Project Advisor**. Ideally, this agreement would be in writing (e.g., via email exchange between the student and the prospective faculty advisor). The primary MS Project Advisor should be a member of the Northwestern University Graduate Faculty and either an ECE Faculty or affiliated with the ECE department. However, if the student is pursuing a project outside of the ECE department, they should first seek permission from the director of the MS program, and they should have at least one ECE faculty member on their advisory committee, such as their academic advisor or the director of the MS program.

### *Declaring a Project MS Degree Plan*

The process to declare a Project MS degree plan is as follows:

- The student obtains the formal agreement of a faculty member to serve as the student's MS Project advisor, as explained in the paragraph above.
- The student selects the "*Project-based MS*" specialization in GSTS.
- The student invites the prospective advisor faculty from (a) to serve as the "*Principal Research Advisor*" through GSTS. The faculty must formally accept the invitation through GSTS.

### *MS Project Committee*

The Project MS Degree option requires a written project report, which is judged by a committee called the MS Project Committee. The student must invite faculty to serve on their MS Project Committee, in consultation with their MS Project Advisor. The MS Project Committee must comprise of at least two faculty members that are a part of the Northwestern University Graduate Faculty. At least one of the MS Project Committee members must be an ECE faculty member. The MS Project Advisor serves as the chair of the MS Project Committee.

The MS Project Committee must be formed no later than one week before the MS Project examination date. It is strongly advised to form the MS Project Committee much earlier than that, to allow sufficient time for the committee members to schedule the oral presentation at a mutually agreeable time, and to examine the MS Project report. Late invitations to serve in an MS Project Committee may result in faculty declining to serve due to schedule constraints and time commitment to other responsibilities. Failure to secure an MS Project Committee may result in the student missing program milestones and completion deadlines, and may result in the student being placed on academic probation.

### *Project Requirements*

A Project MS Degree requires a **written technical report**, which must be approved by the MS Project Committee. The format of the written project report is specified by the MS Project Committee. Unless the MS Project Committee or the MS Project Advisor specify otherwise, it is recommended that the project report conforms to the formatting guidelines of a doctoral thesis, as specified by TGS (https://www.tgs.northwestern.edu/academic-policies-procedures/dissertation-publication/dissertation-formatting-requirements/). There is no specific length for a project report. The length must be negotiated with the MS Project Committee.

The student must submit a complete draft of the written project report to the MS Project Committee at least one week prior to the formal examination date. The MS Project Committee may request modifications to the report. The student must complete the necessary work to implement all requested modifications and submit the final written project report to the MS Project Committee for approval.

### *Common MS Requirements*

The student must satisfactorily complete all Common MS Degree Requirements in Course Requirements.

### *Research Credits*

Under the MS Project study plan, a maximum of 2 units of 590 Research can be counted toward the 6-unit elective requirement for the MS degree.

### *Time Limits*

All requirements for the Project MS Degree, including coursework and approval of the project report by the student's MS Project Committee, as well as any additional requirements established by the MS Project Advisor, must be successfully completed before the end of the **6th academic quarter** (typically the Winter quarter of the 2nd year of study).

## Plan C: MS Courses Only

In this plan, the student must satisfactorily complete a set of courses that represent a coherent program of study and prepare the student for advanced work in a specific field. All students begin their Master's Degree as course-based, unless they otherwise elect another study plan.

### *Common MS Requirements*

The student must satisfactorily complete all Common MS Degree Requirements in Course Requirements.

### *Research Credits*

Under the Course-based MS Degree plan, 590 Research credits **do not count** toward the 12-unit requirement for the MS degree, as these credits are reserved for MS Project and Thesis degrees. If a student switches from the MS Project or Thesis plan to the Courses plan, any 590 units previously taken will not apply towards their degree requirements.

### *Time Limits*

All requirements for the Course-based MS Degree must be satisfactorily completed before the end of the **5th academic quarter** (typically the Fall quarter of the 2nd year of study).

An MS student who does not meet the plan's completion deadline, and who does not successfully petition the ECE Department for an extension of that deadline, will be placed on academic probation for a maximum of two academic quarters. At that point, the Department retains the option to dismiss the student in question.

## Changing the MS Study Plan

Declaring an MS Study Plan can be implemented at any point on GSTS. However, changing the MS Study plan after one has been selected requires that the student notify by email the Graduate Affairs Coordinator, in which the student and the faculty research advisor explain the requested MS Plan change. If approved, the time limit for completing the work will reflect the new study plan with no further extensions.

## Degree Completion

To complete the MS degree, students must complete the following steps:

- Complete the allocation of courses in GSTS. The Director of MS Studies will validate the program and course requirements are fulfilled.
- Complete the Application for Degree (AFD) in GSTS
- Complete the Master's Degree Completion (MDC) form in GSTS
- Complete the Exit Interview, which will be sent by the Graduate Affairs Coordinator via email.
- Due dates for the aforementioned forms can be found on the university's Academic Calendar
- **For Coursework students:** in the section for Committee Members, students should enter the name of the Director of Master's Program, Prof. David Zaretsky, as the Chair. In either the Co-Chair or Member box, students should enter the name of the Director of Graduate Studies for Computer Engineering, Prof. Jie Gu.
- **For Project and Thesis students:** students should enter the names of their committee members, and then enter the name of the MS Director Prof. David Zaretsky. The student's file will be checked for any missing documents, grades, etc. The file will be given to the committee chair prior to the defense, and signed off upon receipt of the thesis and completion of the work.

## BS/MS Option for Northwestern University Students

The combined BS/MS degree program allows you to work on a master's degree at the same time you are completing your bachelor's degree. Northwestern University undergraduate students that wish to pursue an MS in CE must have successfully completed the list of ECE courses below, or their equivalent. All other requirements for an MS degree in CE apply.

- COMP_ENG 203: Introduction to Computer Engineering, or COMP_ENG 303: Advanced Digital Design
- COMP_ENG 205: Fundamentals of Computer System Software, or COMP_SCI 213: Introduction to Computer Systems
- COMP_SCI 211: Fundamentals of Computer Programming II

If you are uncertain that you have the requirements, please reach out to the Director of Master's Program to discuss your background.

More information on the BS/MS program in the ECE department can be found here: https://www.mccormick.northwestern.edu/electrical-computer/academics/undergraduate/combined-bs-ms.html

## Transfer to a different MS program

Whether it is Computer Engineering or Electrical Engineering, students admitted to an MS program in ECE are expected to complete the program of study to which they applied and were admitted. During the applications process, our admissions committee carefully reviews all the materials submitted, and students are admitted with a belief that they would succeed in the program they were admitted to. Only in very rare cases are MS students allowed to transfer to a different program.

Our MS programs have limited capacity, and we only accept a small percentage of applicants. We cannot accept all those who wish to transfer to them from other programs at Northwestern. Only in very rare cases are transfers from an MS in another Northwestern department allowed.

All requests to transfer programs must be approved by both the Director of Master's Program for the student's current degree program and the Director of Master's Program for the desired program. The current advisor will also be consulted during the evaluation of the request. **Transfer is not guaranteed**. If approved, **transfers may require one or more additional quarters of study**, since curriculum progress towards the original program is one of the prerequisites of a transfer request.

Transfer requests are accepted for review after the student has demonstrated success as evidenced by **at least one quarter of graded work** in the current degree program and, at the earliest, transfer requests may be placed in the 2nd (typically Winter) quarter - to be effective starting in the 3rd (typically Spring) quarter of their first year.

A student should request a program transfer no later than the date by which the students declare their degree plan**: May 1 of the academic year of their admission, at the latest**. In exceptional cases, requests for transfers will be considered after this date, however, they will be subject to extra review by the student's advisor, the Graduate Committee, and the Director of Master's Program.

Students who do not take any courses in the program to which they were admitted will not be considered for transfer until after they complete at least one quarter of graded work in the original program.

As a prerequisite, **a faculty member with primary affiliation in the desired program must express written consent to advise the student.** For Master's students who have selected the Thesis or Project option, this letter must explicitly state the advisor's willingness to advise the student on a multi-quarter research project. Furthermore, students must provide a valid justification for wanting to transfer their program of study that must also be validated by the new advisor.

Requests for program transfer should be signed by the students' academic advisor and submitted to the ECE Graduate Affairs Coordinator and will be forwarded to the appropriate Graduate Chair(s) for evaluation. They will evaluate the transfer request by taking various factors into account. These factors include, but are not limited to:

- Success in the original program of study to which the student was admitted.
- The expected ability of the student to successfully complete graduate work in the desired program of study. Relevant evidence includes transcripts and work experience.
- The justification provided by the student for requesting a transfer. This justification must be based on something more substantial than a simple desire to change the title of the degree.
- The strength of the support expressed by a faculty member who has agreed to advise the student in the desired program.

## Part-time Graduate Program

Graduate students who are US citizens or permanent residents may pursue their MS studies in the ECE Department on a part-time basis. The United States government does not give student visas to those enrolled part time.

Students should discuss any details with their academic advisor and email the ECE Graduate Affairs Coordinator for further information.

## Pursuing a Ph.D. After Being Admitted to the MS Program

MS students must apply to any Northwestern Ph.D. program as a new student application through CollegeNet. There is no guarantee for admission into the Ph.D. program for students who are currently in the terminal MS program.

# Ph.D. Program

This section describes the process and requirements for ECE doctorate (Ph.D.) students that wish to obtain a Ph.D. degree in Computer Engineering, and for CS doctorate students that wish to obtain a Ph.D. degree in Computer Science through the Computer Engineering track. See Doctoral Programs of Study of this manual for details.

## TGS Requirements

All Ph.D. students must satisfy The Graduate School's requirements for obtaining the Ph.D. degree, as outlined at https://www.tgs.northwestern.edu/about/policies/phd-degree-requirements.html, and maintain Satisfactory Academic Progress throughout their Ph.D. studies, as defined by The Graduate School at https://www.tgs.northwestern.edu/academic-policies-procedures/policies/satisfactory-academic-progress.html.

This handbook presents program-specific requirements that are in addition to, or further elaborate upon, the requirements established by TGS, and may go beyond TGS minimums. A complete description of TGS' requirements, academic policies and procedures for graduate study at Northwestern University can be found at https://catalogs.northwestern.edu/tgs/academic-policies-procedures/ .

## Milestones

Ph.D. students in CE must meet a set of milestones to remain in good academic standing. Any student who does not complete milestones in the timeline allotted will be considered in poor standing and therefore will be ineligible for fellowships, traineeships, teaching or research assistantships, and scholarships. Students who do not meet published requirements of satisfactory academic progress may be excluded from The Graduate School (TGS). Students who have taken time off for family or other approved leave will have appropriate accommodations made to adjust their milestones.

For additional information, students may use the following resources:

- https://www.tgs.northwestern.edu/about/policies/phd-degree-requirements.html
- https://www.tgs.northwestern.edu/academic-policies-procedures/policies/satisfactory-academic-progress.html

### Selection of a Ph.D. Advisor

Upon matriculation, Ph.D. students in CE are assigned an interim faculty advisor to assist with planning the first academic year of study. The interim faculty advisor must be a Core Computer Engineering Faculty or an Affiliated Computer Engineering Faculty, and also be a member of the Northwestern University Graduate Faculty.

By the end of the 3rd quarter of study (typically the end of the Spring Quarter) the student must secure a permanent research faculty advisor that:

- Must be willing to serve as the student's permanent research faculty advisor.
- Must have an approved plan for funding.
- Must be a Core Computer Engineering Faculty or an Affiliated Computer Engineering Faculty.
- Must be a member of the Northwestern University Graduate Faculty.

The student's permanent research faculty advisor will serve as the primary contact with the CE program, and should be chosen to match the student's research interests. The interim faculty advisor is most likely a faculty member with research interests closest to those stated in the student's application, and often the faculty that advocated for the student's admission into the Ph.D. program, and therefore a strong candidate for serving as the student's permanent research faculty advisor. However, the student is not required to select the interim advisor as their permanent research faculty advisor.

The student-advisor pairing must be officially declared through GSTS. The process is as follows: the student formally invites the faculty to serve as the "Principal Research Advisor" through GSTS. The faculty then formally accepts the invitation through GSTS. Both of these steps must be completed by the end of the 3rd quarter of study.

If a Ph.D. student decides to change advisors at any point in time during their studies, the previous advisor, the new advisor, the Director of Graduate Studies (DGS) in CE, and, for CS students, the Director of Graduate Studies (DGS) in CS, must all be consulted, and the DGS(s) must approve the change. Failure to secure a permanent research faculty advisor will affect the student's academic standing with the program and will result in the student being placed on probation.

## Admission to Ph.D. Candidacy

Ph.D. students in Computer Engineering typically achieve Ph.D. Candidacy through coursework.

### *Admission to Ph.D. Candidacy through Coursework*

Ph.D. candidacy in Computer Engineering can be achieved through the demonstration of high performance in the Ph.D. program's coursework, subject to the following constraints:

- Maintain good academic standing as evaluated in the Annual Academic Standing Review.

- Complete 9 units of quality-graded coursework (i.e., courses graded on an ABC letter basis, not P/N) by the end of the 3rd year of study (i.e., by the last date of the 12th quarter.
- All of these 9 units should comply with the 15-unit course requirements of the Ph.D. program in CE.
- Obtain a GPA of 3.5 or higher on these 9 units of coursework.
- Restrictions:
    - These 9 units should include all the required CE Core Courses and CE Track Courses. Remaining course units should be fulfilled through graded coursework of other electives that comply with the 15-unit course requirements of the Ph.D. program in CE.
    - If previous graduate-level coursework completed at another institution was transferred, up to 3 of these units can be used to contribute to the GPA calculation for admission to Ph.D. candidacy, subject to the approval of the advisor and the Director of Graduate Studies in CE.
    - Students that have completed more than 9 units of graded coursework can select at their discretion 9 units toward satisfying the requirements for admission to Ph.D. candidacy.

To apply for Ph.D. candidacy, qualified students need to submit a *Ph.D. Qualifying Exam* petition form through *TGS Forms* in GSTS. The program leadership evaluates the petition and the student's file, and, if approved, forwards the necessary information to TGS.

### *Admission to Ph.D. Candidacy through Oral Qualifier Examination*

If a Ph.D. student fails to meet the criteria for admission to Ph.D. candidacy through coursework by the end of the 3rd year of study (i.e., by the last date of the 12th quarter), the student is placed on probation (https://www.tgs.northwestern.edu/academic-policies-procedures/policies/satisfactory-academic-progress.html) and is required to take an Oral Qualifier Examination in the immediately-following academic quarter to determine whether the student can be admitted to Ph.D. candidacy. The examination is proctored by a committee of at least 3 Core Computer Engineering Faculty that are members of the Northwestern University Graduate Faculty. This committee is formed by the student's advisor and approved by the Director of Graduate Studies in Computer Engineering. The student is responsible for scheduling the Oral Qualifier Examination in consultation with their advisor. A student failing the Oral Qualifier Examination will be excluded from the Ph.D. program in CE. To take the Oral Qualifier Examination, a CE student needs to submit the *Examination Request Form* (https://www.mccormick.northwestern.edu/electrical-computer/resources/students/forms-documents.html) to the Graduate Affairs

Coordinator of their home department. Instructions for scheduling an exam time and reserving a room are on this form.

## Prospectus (Dissertation Proposal)

Students must have a prospectus (dissertation proposal) approved by a faculty committee no later than the end of the **4th year of study**, which falls on the last date of the 16th academic quarter. A student failing to meet this milestone will not be considered in good academic standing and therefore will be placed on academic probation, per TGS Satisfactory Academic Progress Guidelines (see TGS Requirements).

A minimum of three individuals must serve on this committee. At least two members of this committee, including the committee chair, must be members of the Northwestern University Graduate Faculty (see https://www.tgs.northwestern.edu/about/for-faculty/). At least two members, including the committee chair, must be faculty in the ECE Department. See Doctoral Programs of Study for any additional Research Interest Group requirements for the committee. Upon formation of the prospectus committee, the student should submit the Ph.D. prospectus form through TGS Forms in GSTS and fill in the **ECE Examination Request Form** available online at https://www.mccormick.northwestern.edu/electrical-computer/resources/students/forms-documents.html Instructions for scheduling an exam time and reserving a room are on this form.

Every Ph.D. candidate is required to prepare a dissertation indicating evidence of original and significant research. Read "Dissertation Formatting Guidelines" that can be downloaded from TGS at this link: https://www.tgs.northwestern.edu/academic-policies-procedures/dissertation-publication/dissertation-formatting-requirements/.

For the Final Exam, a student follows the same procedure as for the Ph.D. Qualifier Exam and Ph.D. Prospectus, although now the student clicks the "Ph.D. Final Exam" form in GSTS.

**Four weeks prior to the Ph.D. Final Exam date, the student submits the ECE Examination Request form.** The student must make sure that they have met all the degree requirements of the ECE Department as detailed in this manual and all requirements of The Graduate School, as specified on their website at the link provided in TGS Requirements.

An announcement of the student's Final Exam is then posted in the ECE Department. The student's file is checked for any missing documents, grades, etc. that need to be completed for the Final Exam and awarding of the Ph.D. degree. This file is given to the student's adviser prior to the Final Exam and must be in the examination room for reference. Upon conclusion of the Final Exam, all the committee members must submit their approval through GSTS.

Once the Ph.D. dissertation has been approved by the committee, and all subsequent edits and revisions are completed by the student, the student must submit the dissertation

online via the ProQuest website. At this point, a TGS Student Services representative reviews the formatting and confirms via email that the dissertation is acceptable or notifies the student if changes need to be made.

## Teaching Requirement

In February 2014, the McCormick School of Engineering approved the following Ph.D. teaching requirement effective with the Ph.D. class matriculating in Fall 2014:

- All students earning a Ph.D. degree from a McCormick program must meet one of the following requirements:
    - Serve as an instructor of an undergraduate course, or
    - Serve as a full-time teaching assistant (20 hours a week) in an undergraduate course for at least one quarter, or
    - Serve as a part-time teaching assistant (6-8 hours a week) in an undergraduate course for at least three quarters, or
    - Meet a Departmental teaching requirement that has been approved by The Graduate School.
- Teaching assistant positions must involve some face-to-face contact with students (office hours, lab or problem session, lecturing) in addition to grading.

In addition to options listed above, Ph.D. students in the ECE Department can choose to satisfy the teaching requirement by registering for two quarters of *Teacher Trainee* (TT) duties. Each TT quarter's work assignment involves a half-time teaching assistantship with some additional class involvement beyond grading homework or staffing a help desk. Typically, during the academic quarter, the TT prepares and presents one class lecture or designs one new homework assignment.

First-time TT students should register for GEN ENG 545 (Teaching Experience) to receive credit for their effort. Second-time TT students should register for GEN ENG 546, which is zero credit but does place on their transcript recognition of their contribution.

Note that a Ph.D. student cannot be both a teaching assistant and a TT in the same academic quarter. Also, registrations in GEN ENG 545 and GEN ENG 546 are only for TT students.

Also note that a student **will not be able to graduate until one of the teaching requirements listed above is fulfilled**. When a student files their thesis proposal, the student must also file a form listing what part of the teaching requirement has been fulfilled at that point and what, if any, teaching requirement has yet to be fulfilled.

# Registration and Course Requirements

## The Graduate School Requirements

Full-time registration is three units (courses) per quarter. Typically, students take three courses per academic quarter and may not take more than four courses per quarter.

The Graduate School (TGS) requires Ph.D. students to register full time in order to be eligible to receive funding. This includes summer quarters.

TGS requires a minimum of 9 graded graduate level courses (**note: ECE requires a minimum of 15 graded graduate level courses)**. The cumulative grade point average over these graded courses must be a B average (3.0 GPA) or higher.

See TGS' General Registration Policies webpage for more detail: https://www.tgs.northwestern.edu/about/policies/general-registration-policies.html

Doctoral students who are primarily doing research and are receiving funding should register for TGS 500. This provides full-time status. Students may register for TGS 500-0 Advanced Doctoral Study via CAESAR when they have completed coursework requirements or during summer quarters.

Students who have completed the program coursework and are continuing in their degree program (writing a thesis or dissertation and/or performing research required for the degree), but not receiving funding should register for TGS 512. TGS 512-0 Continuous Registration is a full-time registration intended for students who are continuing to work in a full-time capacity toward degree completion.

Any alterations in the degree progress timeline can be managed through Leave of Absence requests. Per TGS Continuous Registration Policy (see TGS General Registration Policies webpage link on in the preceding paragraph), all Ph.D. students must be registered at Northwestern University in each of the Fall, Winter and Spring terms until all degree requirements have been completed, including dissertation submission to The Graduate School.

Students receiving financial support (assistantships or fellowships) must be registered as full-time students, including summer quarters. Such students must also maintain satisfactory academic progress, as per TGS Satisfactory Academic Progress Guidelines (see TGS Requirements).

## Common ECE Course Requirements

The ECE Department requires 15 graded units of graduate coursework for the Ph.D. Coursework includes ECE 499, but not ELEC_ENG 590 Research. At least 6 units should be at the 400 or 500 levels, not counting TT credits.

The Graduate School requires full-time registration while completing coursework (typically during the first two years). This translates to 24 credits of coursework, including the 15 credits of graded coursework. ELEC_ENG 590 research units make up the remainder of the units required.

A Ph.D. student's adviser or ECE Research Interest Group may require more than the minimum number of courses. In such cases, the number of ELEC_ENG 590 research units will be reduced correspondingly.

ELEC_ENG 499 is reserved for projects that are not directly related to the research required for the Ph.D. thesis or for readings in specific subjects for which the ECE Department has no regular courses.

Electrical engineering students are limited to two units of ELEC_ENG 499.

GEN_ENG 519: The National Science Foundation (NSF) requires everyone being paid on NSF grant money to complete Responsible Conduct of Research (RCR) training. For doctoral students, this requirement is satisfied by enrolling in GEN_ENG 519. All Ph.D. students are required to complete this training in their first year.

## Maintaining Student Status and Continuous Registration

Ph.D. students must register for enough units to maintain their full-time or part-time student status and meet the continuous registration requirement as defined by TGS in The Graduate School Policy Guide (https://catalogs.northwestern.edu/tgs/academic-policies-procedures/general-registration/#continuousregistration). Units required to meet the continuous registration requirement and maintain student status beyond the coursework units required by the CE program may be fulfilled by registering for COMP_ENG 590 Research units, or additional coursework, or the appropriate TGS General Registration courses.

Ph.D. students that are receiving funding should register for TGS 500 Advanced Doctoral Study instead of COMP_ENG 590 Research after they have completed all coursework requirements and are doing primarily research. TGS 500 Advanced Doctoral Study is also available during the summer quarter to Ph.D. students that are receiving funding and are doing primarily research during that quarter.

## Responsible Conduct of Research (RCR) Training

Conducting research responsibly and ethically is critical in any discipline, particularly science and engineering. Responsible Conduct of Research (RCR) training is a framework for imparting these standards and a critical component of scholarly work and career development. The training includes **two** components: web-based CITI training and instructor-led training (GEN_ENG 519). The McCormick School of Engineering requires that all Ph.D. students, regardless of funding, complete both the web-based CITI training and the instructor-led RCR training **within their first year of Ph.D. studies**.

Ph.D. students should complete the CITI course titled "*RCR course for graduate students and post docs*", and complete the zero-credit *GEN_ENG 519-0 Responsible Conduct for Research (RCR) Training* during the first year. Failure to meet this milestone will result in the student being ineligible to receive funding from National Science Foundation (NSF) and National Institutes of Health (NIH) grants. For more information, please see the McCormick School of Engineering webpages on RCR training at https://www.mccormick.northwestern.edu/faculty-staff-resources/research-conduct/.

## Petitioning for Course Credit or Substitution

A Ph.D. student may petition to have at most six (6) ECE Department course credits waived based on graduate level courses taken previously at Northwestern or elsewhere that were not counted towards the completion of another degree. This petition must include complete documentation (e.g., syllabus, assignments/projects, etc.) of the content of the course from the student's previous institution that most closely matches the ECE Department course credit to be waived. The student must provide an official transcript, sent directly to the department, that shows the grade received for each course used for transfer credit.

Note, that for every course waived, the student must enroll in one credit of ELEC_ENG 590 Research in its place. This is because waiving the course does not lessen the registration requirement imposed by The Graduate School.

The coordinator of the equivalent ECE Department course will review the petition and make a recommendation. All such waivers are ultimately subject to the approval of the adviser and the ECE Director of Graduate Studies.

## Programs of Study

Each student must complete a Program of Study that specifies additional course requirements beyond the common requirements for all ECE doctoral students. Doctoral Programs of Study specifies the requirements for each program of study.

# Doctoral Programs of Study

In addition to the common requirements, every CE doctoral student must select a track in which they complete a Program of Study (PS) under a faculty member that specializes in that track.

## CE-Specific Course Requirements

To obtain a Ph.D. Degree in CE, the following coursework is required:

- The student must successfully complete **15 course units.**
- The required 15 units must all be at the 300-level or above, and count for TGS credit (see Course Planning Resources).
- All coursework must be completed with a composite grade-point average of B (GPA 3.0) or higher. Courses taken for P/N credit do not count toward calculating the grade-point average (GPA).
- All students receiving financial aid in the form of fellowships, research assistantships, or teaching assistantships must register as full-time students. The normal full-time program of graduate study is 3-4 units per academic quarter. The maximum course load permitted per quarter is 4 units.
- All courses should be approved by the student's advisor prior to registration. Failure to do so could result in poor course selection that would delay completion of the student's Ph.D. degree, or even result in academic probation due to poor grades or missed milestones.
- COMP_ENG 495 Life Skills Building must be taken during the first two years. We strongly suggest to take it in the first year.
- Course selection restrictions:
- COMP_SCI 301 Introduction to Robotics Laboratory, ELEC_ENG 302 Probabilistic Systems, and COMP_ENG / COMP_SCI / ELEC_ENG 399 Projects do not count toward the CE Ph.D. degree. They are intended for undergraduate students only.
- COMP_ENG / COMP_SCI / ELEC_ENG 590 Research do not count toward the 15 units requirement.
- **At least 6** of the required 15 units should be from 400-level courses or above.
- **At most 6** units of COMP_ENG / COMP_SCI / ELEC_ENG 499 Projects can be counted toward the 15 units requirement.

- **At least 6** of the required 15 units should be from the **"CE Track Courses"** category below.
- All courses that can be taken for a quality letter grade (i.e., ABC, not P/N) must be taken for a quality letter grade to count toward the CE Ph.D. degree. Courses with grades of Pass (P) taken in the Spring 2020 quarter will count toward the course requirements of the Ph.D. degree in Computer Engineering. COMP_ENG 590 Research can be taken as a P/N course.
- Transfer of credit:
- At most six (6) of the required 15 units may be waived, based on graduate-level courses taken previously, provided these courses were not used toward obtaining an undergraduate degree.
- For a course to be transferred, it must substantially match a course at Northwestern University that counts toward the 15 unit requirement.
- To transfer a course, a student must submit a petition to the CE DGS (and, for CS students, also the CS DGS) along with supporting evidence. The supporting evidence should include documentation of the course content (e.g., syllabus, slide decks, assignments, projects) and an official transcript that shows the grade received for the course. The student should identify which Northwestern University course they petition for a waiver. The coordinator of the corresponding course at Northwestern University will review the petition and make a recommendation. The transfer of credit is ultimately subject to the approval of the student's advisor and the CE DGS (and, for CS students, also the CS DGS).

### *CE Core Courses*

- COMP_ENG 361 Computer Architecture I
- COMP_ENG 495 Ph.D. Life Skills Building

### *CE Track Courses*

- These courses must fulfill at least three of the six tracks.
- A track is fulfilled when the student completes **at least two of the track's courses**. The Computer Architecture track requires only one more course to be completed in addition to COMP_ENG 361.
- A course that is listed in multiple tracks can be **counted toward only one of the tracks**.
- Additional 300-level and above courses may fulfill track requirements with the consent of the student's advisor **and** the Director of Graduate Studies in CE.

- Courses in the lists below that have double numbers (e.g., COMP_ENG 368/468) can be taken only once, either for 300-level or for 400-level credit. The same rule applies to sections of the same topic in courses with temporary numbers (i.e., COMP_ENG 395/495, ELEC_ENG 395/495, COMP_SCI 396/496, and COMP_SCI 397/497).

**Track A. Digital Design & VLSI**

| | |
|---|---|
| COMP_ENG 303 | Advanced Digital Design |
| COMP_ENG 355 | ASIC and FPGA Design |
| COMP_ENG 357 | Design Automation in VLSI |
| COMP_ENG 391 | CMOS VLSI Circuit Design |
| COMP_ENG 393/493 | Advanced Low-Power VLSI and Mixed-signal IC Design |
| COMP_ENG 459 | VLSI Algorithmics |

**Track B. Embedded and Cyber-Physical Systems**

| | |
|---|---|
| COMP_ENG 346 | Microprocessor System Design |
| COMP_ENG 347-1 | Microprocessor Systems Project I |
| COMP_ENG 347-2 | Microprocessor Systems Project II |
| COMP_ENG 364/464 | Cyber-Physical Systems Design and Application |
| COMP_ENG 366/466 | Embedded Systems |
| COMP_ENG 395/495 | Wearables and Physical Computing |
| ELEC_ENG 326 | Electronic System Design I |
| ELEC_ENG 327 | Electronic System Design II |

**Track C. Computer Architecture**

*The Computer Architecture track requires only one course from the list below to be completed*

| | |
|---|---|
| COMP_ENG 368/468 | Programming Massively Parallel Processors with CUDA |
| COMP_ENG 452 | Advanced Computer Architecture |
| COMP_ENG 453 | Parallel Architectures |
| COMP_ENG 456 | Modern Topics in Computer Architecture |

**Track D. Software Systems**

| | |
|---|---|
| COMP_SCI 321 | Programming Languages |
| COMP_SCI 322 | Compiler Construction |
| COMP_SCI 323 | Code Analysis and Transformation |

**Track D. Software Systems**

| | |
|---|---|
| COMP_SCI 339 | Introduction to Database Systems |
| COMP_SCI 340 | Introduction to Networking |
| COMP_SCI 343 | Operating Systems |
| COMP_SCI 345 | Distributed Systems |
| COMP_SCI 351-1 | Introduction to Computer Graphics |
| COMP_SCI 354 | Network Penetration & Security |
| COMP_SCI 446 | Kernel and Other Low-level Software Development |

**Track E. Parallel and Distributed Systems**

| | |
|---|---|
| COMP_ENG 329 | The Art of Multicore Concurrent Programming |
| COMP_ENG 358 | Introduction to Parallel Computing |
| COMP_ENG 368/468 | Programming Massively Parallel Processors with CUDA |
| COMP_ENG 395 | Special Topics in Computer Engineering; only the following offering: Blockchain and Cryptocurrency |
| COMP_ENG 453 | Parallel Architectures |
| COMP_SCI 340 | Introduction to Networking |
| COMP_SCI 345 | Distributed Systems |
| ELEC_ENG 333 | Introduction to Communication Networks |

**Track F. Algorithms**

| | |
|---|---|
| COMP_ENG 356 | Introduction to Formal Specification & Verification |
| COMP_ENG 459 | VLSI Algorithmics |
| COMP_ENG 510 | Seminar; only the following offering: Social Media Mining |
| COMP_SCI 336 | Design & Analysis of Algorithms |
| ELEC_ENG 332 | Introduction to Computer Vision |
| ELEC_ENG 390 | Introduction to Robotics |
| IEMS 450-1 | Mathematical Optimization I |
| IEMS 450-2 | Mathematical Optimization II |
| IEMS 457 | Integer Programming |

**Track G. Internet-of-Things**

| | |
|---|---|
| COMP_ENG 365/465 | Internet-of-things Sensors, Systems, And Applications |
| COMP_ENG 395/495 | Special Topics in Computer Engineering; only the following |

**Track G. Internet-of-Things**

| | |
|---|---|
| | offering:<br>Wearables and Physical Computing |
| COMP_SCI 397/497 | Special Projects in Computer Science; only the following offerings:<br>Wireless Protocols for the Internet of Things<br>Wireless and Mobile Health |
| COMP_SCI 409 | Swarms and Multi-Robot Systems |
| BME 353-0-01 | Bioelectronics |

## Professional Development

The Ph.D. program in Computer Engineering aims not only to provide the education, expertise and technical skills that will develop the graduate students into independent and productive scholars in their chosen field of research, but also to provide mentoring in oral and written communication of scientific concepts that will allow the graduate students to effectively reach wider audiences. To that effect, the Computer Engineering program strongly encourages all Ph.D. students to engage in professional development activities in technical writing and public speaking, subject to their advisor's approval.

### *Technical Writing*

To enhance their technical writing skills beyond writing papers geared toward readers in their own highly-specialized scientific community, students are strongly encouraged to apply to a select subset of the external and internal fellowships they are eligible for. These fellowships can increase the student's stipend, open up new opportunities for flexibility in research, and can be quite prestigious. TGS and the CS and ECE departments maintain pages on available opportunities, but students should also seek advice from their advisor and/or the CE DGS. All Ph.D. students wishing to apply to fellowship opportunities should first consult with their advisor. In addition, students are encouraged to contribute to the writing of grant proposals and/or grant reports, in collaboration with their advisors. This is especially pertinent to international Ph.D. students who may not be eligible for most fellowships.

The CE Ph.D. program expects that all Ph.D. students will engage in such activities at some point in their Ph.D. careers. Engagement in technical writing activities will be one of the criteria that students will be evaluated on at the Annual Academic Standing Review.

### *Public Speaking*

Strong communication and public speaking skills are necessary to reach the highest professional levels in both academia and industry. Ph.D. students are expected to participate in public speaking activities by frequently attending seminars organized by the CS and ECE departments, and by volunteering to present their research in departmental

seminars. Engagement in public speaking activities will be one of the criteria that students will be evaluated on at the Annual Academic Standing Review.

## Annual Academic Standing Review

Students must maintain good academic standing throughout their studies. A student maintains good academic standing in the CE Ph.D. program if the Core Computer Engineering Faculty determine that the student's progress in the Computer Engineering Ph.D. program is satisfactory. The student's progress is assessed formally through an annual conference in which all Core Computer Engineering Faculty participate as voting members. Only Core Computer Engineering Faculty can have voting rights at the Annual Academic Standing Review.

Satisfactory progress is determined by a confluence of factors, including the successful completion of graduate-level courses required by the program, meeting TGS requirements, meeting academic integrity standards, meeting milestone deadlines set by the program and TGS, successfully publishing scholarly research at venues and with frequency appropriate for the specific field of study, maintaining satisfactory progress in thesis research, and participating in professional development activities with reasonable frequency. Failure to maintain good academic standing is grounds for placing the student on probation, starting at the immediately succeeding quarter. The rules governing the probationary period, including appeal processes, exclusion from the program, and loss of funding, are detailed in Probation, Exclusion, and Appeal Process.

The date of the Annual Academic Standing Review will be announced each year. At least one week before the review, students should submit an annual progress report and self-evaluation in GSTS. At least one week before the annual review conference, the advisor is also required to submit an evaluation of the student in GSTS. A face-to-face meeting between the advisor and student is highly recommended before the faculty advisor finalizes the advisor evaluation in GSTS. If a student disagrees with the advisor's evaluation, the student should contact the Director of Graduate Studies in CE (and, for CS students, also the Director of Graduate Studies in CS) before the annual evaluation meeting.

## Ph.D. Prospectus

### *Ph.D. Prospectus Committee*

A proposal of the dissertation research topic must be presented orally and in writing by the student and must be reviewed and approved by a faculty committee, called the Ph.D. Prospectus Committee. The student must invite faculty to serve on their Ph.D. Prospectus Committee, in consultation with their permanent research advisor. The Ph.D. Prospectus Committee is formed according to the following rules:

- The Ph.D. Prospectus Committee must have **at least 3 members** with full-time faculty appointments at Northwestern University that are members of the Northwestern University Graduate Faculty.
- **At least 2** of the Ph.D. Prospectus Committee members must be Core Computer Engineering Faculty that are members of the Northwestern University Graduate Faculty.
- The Ph.D. Prospectus Committee Chair must be a member of the Northwestern University Graduate Faculty and be either a Core or Affiliated Computer Engineering Faculty.
- With the approval of the Ph.D. Prospectus Committee Chair and the Director of Graduate Studies in Computer Engineering, the Ph.D. Prospectus Committee may include one additional voting member from outside Northwestern University (external committee member). This external committee member should be an expert in the area of the student's research. The Director of Graduate Studies in Computer Engineering may request a resume or curriculum vitae from the prospective external committee member before approving the appointment.
- The Ph.D. Prospectus Committee must include the student's permanent research faculty advisor, who typically serves as the Ph.D. Prospectus Committee Chair.
- Others may be invited to attend the Ph.D. Prospectus Committee meetings as non-voting members.

The Ph.D. Prospectus Committee must be formed no later than one week before the Ph.D. Prospectus Examination. It is strongly advised to form the committee much earlier than that, to allow sufficient time for the committee members to schedule the examination at a mutually agreeable time, and to study the prospectus written document. Late invitations to serve in a Ph.D. Prospectus Committee may result in faculty declining to serve due to schedule constraints and time commitment to other responsibilities. Failure to secure a Ph.D. Prospectus Committee may result in the student missing program milestones and completion deadlines, and may result in the student being placed on academic probation.

### *Ph.D. Prospectus Examination (Ph.D. Thesis Proposal)*

A proposal of the Ph.D. dissertation research topic must be presented orally and in writing by the student. Following an evaluation of the written prospectus document and the performance of the student during the oral presentation, the Ph.D. Prospectus Committee decides on approving the Ph.D. Prospectus. The Ph.D. Prospectus must be approved by the end of the 4$^{th}$ year of study (i.e., the last date of the 16$^{th}$ quarter of study). Dissertations must be formatted according to TGS' standards: https://www.tgs.northwestern.edu/academic-policies-procedures/dissertation-publication/dissertation-formatting-

requirements/ Dissertations not conforming to these instructions will not be accepted: https://www.tgs.northwestern.edu/about/policies/Ph.D.-degree requirements.html# dissertation

The oral presentation must conform to the format specified by the Ph.D. Prospectus Committee. The prospectus document must be given to the committee **at least one week prior** to the oral presentation. All members of the Ph.D. Prospectus Committee must attend the oral presentation of the prospectus, either physically, or via phone or video conferencing.

Upon formation of the Ph.D. Prospectus Committee and agreeing on a Ph.D. Prospectus Examination date, the student should submit the *Ph.D. Prospectus* form through *TGS Forms* in GSTS. **At least two weeks** prior to the Ph.D. Prospectus Examination date, the student should submit the *Examination Request Form* (available at https://www.mccormick.northwestern.edu/electrical-computer/resources/students/forms-documents.html) to the Graduate Affairs Coordinator of their home department. Instructions for scheduling an exam time and reserving a room are on this form.

If a Ph.D. candidate changes their advisor and/or research topic after completing the Ph.D. Prospectus Examination, the student may be required to form a new Ph.D. Prospectus Committee and successfully complete another Ph.D. Prospectus Examination on the new research topic.

Students that fail the Ph.D. Prospectus Examination will be considered not in good academic standing and therefore will be placed on academic probation, as per TGS Satisfactory Academic Progress guidelines (https://www.tgs.northwestern.edu/academic-policies-procedures/policies/satisfactory-academic-progress.html).

## Ph.D. Dissertation and Oral Defense

Every Ph.D. candidate is required to prepare a dissertation indicating evidence of independent, original and significant research. The dissertation and oral defense but be completed and approved, with all requested changes and corrections, within the Ph.D. timeline set by The Graduate School Policy Guide (https://catalogs.northwestern.edu/tgs/academic-policies-procedures).

The dissertation research must be defended orally and in writing by the student. A faculty committee, called the Ph.D. Thesis Committee, reviews and approves both the written dissertation as well as the oral defense of the research work. These two examinations of the written document and the oral presentation together comprise the Ph.D. Final Exam. The date of the Ph.D. Final Exam coincides with the date of the Oral Thesis Defense, as typically the Ph.D. Thesis Committee deliberates after the Oral Thesis Defense on the dissertation document, the performance of the student at the oral presentation, as well as the soundness, completeness, novelty and significance of the research work.

The rules that govern the formation of the Ph.D. Thesis Committee are the same as the rules that govern the formation of the Ph.D. Prospectus Committee. In the vast majority of cases, the Ph.D. Prospectus Committee members continue on to serve as members of the Ph.D. Thesis Committee.

The written defense of the dissertation research is performed in accordance to the following rules:

- The format of the written dissertation must conform to the dissertation format guidelines specified by TGS: https://www.tgs.northwestern.edu/academic-policies-procedures/dissertation-publication/dissertation-formatting-requirements/
- The dissertation document must be complete, in draft form, and be provided to the members of the Ph.D. Thesis Committee **at least one week prior** to the Oral Thesis Defense.
- Within 2 weeks after the Oral Thesis Defense, the Ph.D. Thesis Committee must communicate to the student (through the committee's chair) any modifications it requests on the dissertation draft. Modifications may include, but are not limited to, additional research work.
- The student must complete any additional work required and implement the changes requested by all committee members.
- Once the Ph.D. dissertation has been approved by the committee, and all subsequent edits and revisions are completed, the student must deliver the final dissertation document in accordance with TGS policies (https://catalogs.northwestern.edu/tgs/academic-policies-procedures).
- Finally, the student must publish the final dissertation document as an ECE Technical Report. The purpose of publishing the dissertation as a technical report is to make the thesis widely available to the public. The dissertation is not considered complete without this final step. Submission requests for ECE Technical Reports should be directed to the ECE Graduate Affairs Coordinator.
- Finally, the student must deposit the final dissertation document following the TGS guidelines at: https://catalogs.northwestern.edu/tgs/academic-policies-procedures/phd-degree-requirements/. A TGS representative reviews the formatting and confirms via email that the dissertation is acceptable, or notifies the student if changes need to be made.

The Oral Thesis Defense is conducted according to the following rules:

- The Oral Thesis Defense is an open, advertised, public talk.

- Oral Thesis Defense must be attended by the entirety of the Ph.D. Thesis Committee, physically, or via phone or video conferencing. Others may be invited to attend as non-voting members.

- The chair of the Ph.D. Thesis Committee also chairs the Oral Thesis Defense.

- The Oral Thesis Defense begins with an open segment, during which the public talk is performed. Only clarification questions are permitted during the talk. After the talk, each member of the Ph.D. Thesis Committee, in an order determined by the chair, may ask in-depth questions. Once the committee is finished, further questions will be solicited from the audience.

- After public questions have been exhausted, the audience will vacate the room and the open segment of the Oral Thesis Defense is followed by a closed segment with only the Ph.D. Thesis Committee and the student. During the closed segment of the Oral Thesis Defense, the committee may ask further private questions or raise other private concerns.

- After the closed segment concludes, the student vacates the room and the private segment of the Oral Thesis Defense commences, in which only the Ph.D. Thesis Committee members participate. During the private segment the Ph.D. Thesis Committee deliberates and determines whether the student has passed or failed the Oral Thesis Defense.

Upon formation of the Ph.D. Thesis Committee and agreeing on an Oral Thesis Defense date, the student should submit the *Ph.D. Final Exam* form through *TGS Forms* in GSTS. Moreover, **at least four weeks** before the Ph.D. Final Exam date, the student should complete and submit the *Examination Request Form* (available at https://www.mccormick.northwestern.edu/electrical-computer/resources/students/forms-documents.html) to the Graduate Affairs Office of their home department. Instructions for scheduling an exam time and reserving a room are on this form. Prior to submitting the Examination Request Form, the student must make sure that they have met all the degree requirements of the Ph.D. program in Computer Engineering, as detailed in this handbook, and all pertinent TGS requirements (https://www.tgs.northwestern.edu/about/policies/phd-degree-requirements.html). The student's Ph.D. Final Exam date is then announced by the student's home department. The student's file is checked for any missing documents, grades, etc., that need to be completed for the Ph.D. Final Exam and awarding of the Ph.D. degree. This file is given to the student's advisor prior to the Ph.D. Final Exam and must be in the examination room for reference.

Upon the conclusion of the Ph.D. Final Exam, and after the dissertation is approved by all members of the Ph.D. Thesis Committee, the student's file is signed by all members of the Ph.D. Thesis Committee to denote their approval of the Ph.D. dissertation work. Then, the advisor returns the completed and signed paperwork to the Graduate Affairs Coordinator of the student's home department. The Graduate Affairs Coordinator will approve the Final

Exam form after the student and the advisor confirm via email that the dissertation is complete and has been submitted to TGS and to the ECE department for archiving as a technical report.

## Ph.D. Degree Completion Procedure

To complete the Ph.D. degree, students must file an *Application for a Degree* form via *TGS Forms* in GSTS. The deadline to submit this form depends on the quarter the degree will be conferred. For more information see https://www.tgs.northwestern.edu/about/policies/phd-degree-requirements.html.

## Additional Requirements for CS Ph.D. Students Following the CE Track

CS doctorate students in the Computer Engineering track must satisfy any additional requirements specified by the CS department for the Ph.D. degree in Computer Science. As of this writing the additional requirements are:

- CS Ph.D. students following the CE track must take COMP SCI 496, Introduction to Graduate Studies (IGS). Ideally, students would take IGS in their first quarter of graduate studies. IGS counts toward the 15 course units required by the CE Ph.D. program.

Should additional requirements arise in the future, we will update this section of the handbook accordingly.

# Special Policies and Procedures

## Internships During Graduate Study

A graduate student wishing to combine graduate study with work experience in industry or national labs may, with the permission of their advisor, elect to participate in an internship opportunity. This experience provides networking and potentially future career opportunities for the student, and permits the student to gain a broader understanding of contemporary problems that eventually could serve as the background for a thesis or project.

Ph.D. students (domestic and international) who wish to take advantage of an internship opportunity are encouraged to enroll in Career Development CRDV 510 Crown Family Graduate Internship, a non- credit, non-tuition-bearing course. A prerequisite for this course is a written approval of the Ph.D. advisor. Enrolling in CRDV 510 while participating in an internship allows the student to maintain full-time status. Additional details, requirements and procedures regarding CRDV 510 can be found at McCormick's website at https://www.mccormick.northwestern.edu/students/graduate/fellowships-internships/crown-family.html

Similarly, MS students (domestic and international) who wish to participate in an internship opportunity are encouraged to enroll in Career Development CRDV 411-1 Professional Engineering Internship.

**International students who chose to do an internship must also apply for Curricular Practical Training (CPT) authorization for any off-campus internships.** "Off-campus" is defined as any internship that takes place outside of Northwestern University. For more information on applying for CPT, please visit the Office of International Student and Scholar Services' website: https://www.northwestern.edu/international/living-working/student-employment/curricular-practical-training.html

## Post-Graduation Employment

International MS and Ph.D. students who seek to complement their education with practical training though temporary employment in the U.S. upon graduation must apply for Optional Practical Training (OPT) authorization. **OPT MUST BE APPLIED FOR AT LEAST FOUR (4) MONTHS BEFORE**

**GRADUATION.** It is strongly recommended that international students interested in employment opportunities in the U.S. schedule an appointment with the Office of International Student and Scholar Services (OISS) at least one month in advance of the OPT submission deadline to obtain assistance and ensure sufficient time for the collection and submission of the required documents. Without submitting this application in advance, students may not be able to transition smoothly to OPT visa status, and any such

interruption may delay or prohibit their employment with a U.S. employer. For more information visit https://www.northwestern.edu/international/living-working/student-employment/index.html.

## Student Status and Continuous Registration – Special Courses

Graduate students must register for enough units to maintain their full-time or part-time student status and meet the continuous registration requirement as defined by TGS in The Graduate School Policy Guide (https://catalogs.northwestern.edu/tgs/academic-policies-procedures).

There are a number of non-classroom courses that may be used to maintain continuous registration and student status at the university in cases where registering for research or classroom courses is not appropriate. Below is a brief guide to these courses. Before enrolling in these special registration courses, students must consult with their advisor, the Director of Graduate Studies in CE, and the Graduate Affairs Coordinator of their home department. Additional information, policies and procedures can be found at TGS' website at https://catalogs.northwestern.edu/tgs/academic-policies-procedures/general-registration/.

- **TGS 512-0: Continuous Registration** is appropriate for cases when a graduate student is not receiving funding and needs to maintain student status and meet the continuous registration requirement while completing an MS project or an MS or Ph.D. thesis. Students may enroll in this course only if they have completed the required units of coursework. When enrolled in TGS 512-0 Continuous Registration the student cannot enroll in additional classes. Enrolling in TGS 512-0 requires the permission of the student's advisor and the ECE Graduate Affairs Coordinator.

- **TGS 588-0: Resident Masters Study** is available to students pursuing an MS degree that receive financial support administered by the University. It is particularly useful to MS students who need to maintain full-time status, but who would have reached the required units of coursework for the MS program without full time registration in a quarter. This course allows additional enrollments and can be repeated for multiple quarters, but allows no accumulation of credit or residency toward the master's degree and it is not graded. Enrolling in TGS 588-0 Resident Masters Study requires the permission of the student's advisor, the ECE Graduate Affairs Coordinator, and TGS.

## Leaves of Absence

Any alterations in the residency timeline may be managed through Leave of Absence requests. Students who have taken time off for an approved Leave of Absence will have appropriate accommodations made to adjust their milestones and program timelines. A

complete description of TGS' requirements, policies and procedures can be found at https://catalogs.northwestern.edu/tgs/academic-policies-procedures/.

## Student Responsibilities and Academic Misconduct

It is the responsibility of each graduate student to ensure that all the requirements of The Graduate School (TGS) and the CE Program are met, that necessary examinations are properly scheduled, and that deadlines dependent on current Northwestern University, McCormick, home department and CE Program calendars are observed. The current procedures and degree requirements of the CE Graduate Program are detailed in this manual.

Students should always consult with the Graduate Affairs Coordinator of their home department first to execute procedures, confirm requirements, and obtain paperwork for exams and various other procedures (e.g., visa related issues). In addition, students are strongly urged to consult regularly with their faculty advisors.

Official notices about degree program progress, financial aid and other important notices are sent to each student's official email and mail boxes. Students are responsible for checking their official Northwestern email accounts (@u.northwetern.edu) on a regular basis, **at least once a week**, and their official department mailbox **at least once per month**.

All CE students must observe the policies on academic integrity set forth by Northwestern University, The Graduate School and the McCormick School of Engineering and Applied Science. The principles of academic integrity and possible consequences of academic misconduct are documented at:

- https://www.northwestern.edu/provost/policies/academic-integrity/principles.html (University)
- https://www.tgs.northwestern.edu/academic-policies-procedures/policies/academic-integrity.html (The Graduate School)
- https://www.mccormick.northwestern.edu/students/academic-integrity.html (McCormick)

Students found guilty of academic misconduct (e.g., cheating on coursework, plagiarizing research) by definition are failing to make satisfactory academic progress, and are subject to be placed on academic probation (https://www.tgs.northwestern.edu/academic-policies-procedures/policies/satisfactory-academic-progress.html#programprobation).

Students must be particularly vigilant in programming courses. Unless the instructor for the course has explicitly documented otherwise in the course syllabus:

- Code you submit must be your own. Copying and adapting someone else's code is not allowed.
- Studying someone else's solution (including an online article or code repository) is not allowed.
- Letting another student study your solution is not allowed.

If an instructor concludes that cheating has occurred, he or she will submit the evidence to the dean for adjudication. Penalties for cheating will depend on the specifics of the case. They can range from loss of points on the assignment in question, a reduction in letter grade for the course, obtaining a failing grade for the course, or even exclusion from the program in extreme circumstances.

## Probation, Exclusion, and Appeal Process

If a student fails to remain in good academic standing at any point in the CE program, they will be placed on probation. This may result from violations of academic integrity standards (e.g., cheating on coursework, plagiarizing research) or from failure to meet any of the CE program's or The Graduate School's (TGS) requirements for the graduate degree. Such failures include, but are not limited to, not making satisfactory progress in thesis research or not having a permanent research advisor at any point during the program.

Students who are not making satisfactory academic progress in a given quarter will be placed on probation by TGS for the following quarter. Once on probation, the CE program reserves the right to review the student's case and impose additional requirements or penalties beyond those mandated by TGS. These may include, but are not limited to, loss of funding or program-specific sanctions.

During the probationary quarter, the student must fulfill all conditions set by both the CE program and TGS. This includes addressing the cause of unsatisfactory progress, whether by improving academic performance, seeking an alternate advisor, or working with their current advisor to restore satisfactory standing. At the end of the probationary quarter, the student must demonstrate satisfactory progress through a report from a permanent advisor. If the student fails to secure an advisor who can confirm satisfactory progress, the program reserves the right to discontinue funding from departmental or advisor sources and may recommend the student's exclusion (dismissal) from The Graduate School.

In cases where a student misses a milestone deadline (e.g., qualifying exams, proposal submission), they may petition TGS for an extension by providing a compelling reason and sufficient supporting evidence. If the petition is approved, the student will receive an extended milestone due date and a list of required actions to be completed by that date. Failure to meet these revised requirements may result in exclusion from both The Graduate School and the CE graduate program.

Violations that may lead to probation include failure to meet academic integrity standards (e.g., cheating on coursework), failure to maintain satisfactory academic progress (e.g., a cumulative GPA below 3.0), failure to respond to the Director of Graduate Studies or other ECE personnel, or failure to meet milestones related to research or project work (e.g., not submitting a project plan within the approved timeframe).

Once placed on probation, the ECE department reserves the right to review the student's academic standing and apply additional consequences. These may include, but are not limited to, loss of departmental or advisor funding, stricter deadlines, or exclusion from the graduate program.

More information on TGS policies regarding probation, academic progress, and appeals can be found here: https://www.tgs.northwestern.edu/academic-policies-procedures/policies/satisfactory-academic-progress.html