Northwestern | McCORMICK SCHOOL OF ENGINEERING

Graduate Study Manual

Computer Engineering Program
2024 - 2025

Department of Electrical and Computer Engineering
Department of Computer Science

Effective Fall 2024 – Summer 2025

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Welcome

As the Director of Graduate Studies and the Director of the program, it gives us great pleasure to welcome you to Computer Engineering at Northwestern University.

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) in the McCormick School of Engineering and Applied Science and offers programs leading to the MS and PhD degrees in Computer Engineering (CE). Computer Engineering covers a diverse set of areas including, but not limited to, the design and analysis of integrated circuits, computer architecture, computer systems, operating systems, compilers, embedded systems, internet of things, mobile and wearable computing, cyber-physical systems, real-time systems, high-performance and parallel computing, distributed computing, and software systems.

Our award-winning faculty continues to expand the frontiers of knowledge in many areas of engineering, science, and technology that are essential for the modern world. The broad interdisciplinary interests of our faculty lead to strong collaborative research with other engineering and science departments both within Northwestern University and at other institutions in the U.S. and abroad, the Feinberg School of Medicine, national laboratories including Argonne, Fermi, Sandia and Oak Ridge, as well as industry. The program aims to 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.

We look forward to meeting each of you and working with you to achieve this goal. We wish you very successful and pleasant years at the Computer Engineering program at Northwestern University.

Sincerely,

Prof. Jie Gu
Director of Graduate Studies, Computer Engineering
Department of Electrical and Computer Engineering
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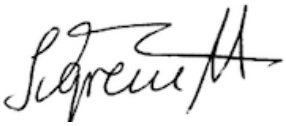

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1 Overview

This handbook 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.

1.1 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 PhD 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.

1.1.1 Home Departments

As the Computer Engineering program is a joint program between CS and ECE, it caters to both ECE and CS students alike. ECE graduate students in Computer Engineering are members of the Computer Engineering division. These students have ECE as their home department, and, upon successful completion of the corresponding graduate program, they receive Computer Engineering degrees (MS and/or PhD), conferred by the ECE department.

CS graduate students that follow the Computer Engineering track have CS as their home department, and, upon successful completion of the corresponding graduate program, they receive Computer Science degrees (MS and/or PhD), conferred by the CS department.

The degree requirements detailed in this handbook apply to both types of students, i.e., ECE graduate students that are members of the Computer Engineering division, and CS graduate students that follow the Computer Engineering track.

All students should follow the guidelines of their home department, and interact with the staff of their home department as they navigate through the various processes pertaining to their graduate degree. Throughout this document, "CE program" and "CE students" encompass both student categories (i.e., ECE graduate students in the Computer Engineering division, and CS students following the Computer Engineering track). Whenever a distinction is necessary, it will be made explicit in the document.

1.1.2 Core Computer Engineering Faculty

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

1.1.3 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 is comprised of Profs. Nabil Alshurafa, Yan Chen, and Alan Sahakian. This list is updated at irregular intervals; please consult with the Director of Graduate Studies (DGS) in Computer Engineering for the up-to-date list of Affiliated Computer Engineering Faculty.

1.1.4 Computer Engineering MS/PhD Program Mission Statement

The MS and PhD 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.

1.1.5 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) *Students should be able to…*	Milestone/ Requirement/ Capacity	Assessment Strategies and Criteria* *How do we know this objective has been achieved?* *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: Advisor, faculty committee, and class instructors evaluate course performance. Discussed at CE-wide annual student performance evaluation. Criteria: Satisfies Core CE coursework; Satisfies Track CE coursework; Meets coursework milestones within specified time limits; Meets minimum GPA requirements.
Contribute original research to scholarly community.	MS Thesis; PhD Prospectus; Dissertation; Publication of research papers / Research	Assessment Strategy: 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. Criteria: 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: 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. Criteria: 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: Successful completion of RCR training. Discussed at CE-wide annual student performance evaluation. Criteria: 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 / Communication (scientific writing)	Assessment Strategy: 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. Criteria: 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: 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. Criteria: 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: Teaching assistant collaborates with professor and fellow TAs during course development and teaching. Instructor, peer TAs and students (through CTECs) evaluate TA's performance. Discussed at CE-wide annual student performance evaluation. Criteria: 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: 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. Criteria: Infrastructure quality; Infrastructure completeness; Efficacy or task prioritization; Demonstrated effectiveness 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.

1.2 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 of the student's home department (for ECE students: Catherine Healey, Tech Institute Room L359, catherine.healey@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 MS and PhD programs may discuss questions regarding academic matters, degree requirements or disputes with advisors or committee members with the Director of Graduate Studies (DGS) in Computer Engineering (Prof. Jie Gu; Tech Room L473; jgu@northwestern.edu). PhD students in CS following the Computer Engineering track may additionally discuss these matters with the Director of Graduate Studies (DGS) in Computer Science (Prof. Peter Dinda; Seeley Mudd 3507; dgs-phd@cs.northwestern.edu). MS students can speak with the Director of the MS Program (Prof. David Zaretsky; Tech Room L360; 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; http://www.tgs.northwestern.edu/). Additional information on TGS appears in the next section of the handbook.

1.3 Program Resources

The program, the ECE and CS departments, 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 PhD 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 CE, CS, and EE 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 CE and EE courses can be found online at http://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 (http://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/recruiters, seminars, etc.) is posted at https://www.mccormick.northwestern.edu/electrical-computer/resources/.

Lastly, the CS and ECE departments organize various social events and activities throughout the academic year, such as bonfires, pizza parties, brown-bag lunches, and other events and gatherings organized by the Computer Science PhD Advisory Council (CSPAC), and the Graduate Students in CS (GSCS) and ECE (GSECE), for which announcements are made regularly via email.

1.4 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 a 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 nominal fee. Broken or damaged cards will be replaced at no charge (providing the damaged card is returned).

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 http://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 PhD 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) (http://www.northwestern.edu/counseling/; 847-491-2151).

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: Computer Engineering, Northwestern University, 2145 Sheridan Road, Tech Institute L359, Evanston, IL 60208, USA.

1.5 General Admission Requirements

The primary objective of the admission process in the Computer Engineering program 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 **PhD** 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. MS applicants are *only* admitted for a Fall Quarter start date to avoid any problems with the course sequence.

Requests for admission and financial aid for PhD students are reviewed during the Winter Quarter. It is the policy of the CE program that students begin their programs in the 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 computer engineering, computer science, electrical 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. A student would be informed of such a requirement at the time of admission, along with grade expectations.

The 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.

1.6 Financial Aid

PhD 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.

Terminal MS Students

The CE program encourages terminal MS students, especially from industry, to apply. However, the program does not provide financial support to terminal 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 research assistantships**.

1.7 Part-time Graduate Studies in CE

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.

1.8 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.

2 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.

2.1 Advising and Course Requirements

2.1.1 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.

2.1.2 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. • Only 300-level or higher courses are counted towards the degree (excluding 399 and undergraduate courses). • At least 9 courses must be eligible for TGS credit (See Course Planning Resources in Section 1.3). • At least 3 units at the 400-level or above (excluding 499 Independent Projects and 590 Research) • Except for 590 Research, all courses must be taken for a quality letter grade (i.e., ABC, not P/N). • Any course taken for P/N credit is not included in calculating the grade-point average (GPA). • All coursework must be completed with a composite grade-point average of B (GPA 3.0) or higher. • 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.) • Courses completed for undergraduate credit cannot be repeated or counted for graduate credit. • 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). • At least 3 units of CE courses must be completed. • 499 Projects and 590 Research are not included. • 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.

- At least 3 units of ECE or CS courses must be completed (ELEC_ENG, COMP_ENG or COMP_SCI).
- At most 3 units of courses outside of ECE and CS, with approval by the Director of Master's Program.
- At most 3 units of 499 Projects.
- At most 2 units of 590 Research for an MS Project Plan, or 3 units of 590 Research for an MS Thesis Plan.

2.1.3 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) specializations 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 in section 2.1.2 above.

2.1.4 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.

2.1.5 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.

2.1.6 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.

2.1.7 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.

2.1.8 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/.

2.2 MS Degree Options

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.

2.2.1 Plan A (Thesis MS Degree)

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 of a CE faculty 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 MS Thesis Research Advisor must be a member of the Northwestern University Graduate Faculty and must have an appointment in the ECE department. The MS Thesis Research Advisor may be different than the academic advisor assigned to the student upon matriculation. The process of changing advisors is detailed in Section 2.1.1.

Declaring a Thesis MS Degree Plan

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

a) 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.
b) The student selects the "*Thesis-based MS*" specialization in GSTS.
c) 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 (see Section 2.1.2)

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.

2.2.2 Plan B (Project MS Degree)
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 of a CE faculty 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 MS Project Advisor must be a member of the Northwestern University Graduate Faculty and must be either a Core Computer Engineering Faculty or an Affiliated Computer Engineering Faculty. The MS Project Advisor may be different than the academic advisor assigned to the student upon matriculation.

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

a) 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.
b) The student selects the "*Project-based MS*" specialization in GSTS.
c) 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 (see Section 2.1.2)

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).

2.2.3 Plan C (Course MS Degree)
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 (see Section 2.1.2)

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.

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).

Time Limits: 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.

2.2.4 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.

2.3 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.

2.4 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 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

2.5 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.

2.6 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.

2.7 Pursuing a PhD After Being Admitted to the MS Program

There is no guarantee for admission into the PhD program for students who are currently in the terminal MS program. However, successful students may be considered for a transfer. MS students are required to complete at

least 2 quarters in the terminal MS program before they can be considered for a transfer to the PhD program. If a student is planning to apply to continue with the PhD program, they should first contact the ECE Graduate Affairs Coordinator (catherine.healey@northwestern.edu). The proper process for application for a transfer will be advised. Each student's case will be evaluated subject to the same procedures that apply to external PhD applicants.

2.8 Probation, Exclusion, and Appeal Processes

Failure to meet academic integrity standards (e.g. cheating on coursework), failure to meet the requirements for academic progress (e.g. maintaining a 3.0 GPA or higher), failure to respond to the Director of Master's Studies or other ECE personnel, or failure to meet milestones related to project or thesis work (e.g. not submitting a project plan in the approved timeframe) may result in The Graduate School placing a student on probation. Students may petition The Graduate School for an extension of a milestone's deadline if a compelling reason and evidence are provided. Failure to remedy the missing requirements by the given due date may ultimately result in exclusion from The Graduate School and the respective program.

Once a MS student is placed on probation, the ECE department reserves the right to review the student's case and subject the student to additional penalties during probation as it relates to their standing in the ECE degree program, including, but not limited to, loss of funding and/or exclusion from the ECE graduate program. For more information on probation and appeal processes for probation, please refer to **The Graduate School's guidelines**: https://www.tgs.northwestern.edu/academic-policies-procedures/policies/satisfactory-academic-progress.html

3 PhD Program in Computer Engineering

This section describes the process and requirements for ECE doctorate (PhD) students that wish to obtain a PhD degree in Computer Engineering, and for CS doctorate students that wish to obtain a PhD degree in Computer Science through the Computer Engineering track.

3.1 TGS Requirements

All PhD students must satisfy The Graduate School's requirements for obtaining the PhD degree, as outlined at https://www.tgs.northwestern.edu/about/policies/phd-degree-requirements.html, and maintain Satisfactory Academic Progress throughout their PhD 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/.

3.2 CE Program Requirements and Milestones

PhD students in CE must meet a set of milestones to remain in good academic standing. Any student not meeting the milestones will be considered not in good standing, and therefore may 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 TGS and dismissed from the PhD program in CE.

Students may view these milestones and the deadlines for completion in GSTS. After logging into the GSTS Dashboard, the list of milestones can be viewed by navigating to "*Show Profile → Milestones*."

3.2.1 Advising Requirement

Upon matriculation, PhD 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 (see Sections 1.1.2–1.1.3), 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 PhD 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 PhD 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.

3.2.2 Course Requirements

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 PhD students, regardless of funding, complete both the web-based CITI training and the instructor-led RCR training **within their first year of PhD studies**.

PhD 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/.

CE-Specific Course Requirements

To obtain a PhD 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 in Section 1.3).
- 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 PhD 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 PhD 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.
    - All **"CE Core Courses"** below are mandatory and count 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 PhD degree. Courses with grades of Pass (P) taken in the Spring 2020 quarter will count toward the course requirements of the PhD 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	PhD 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
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 offering: • Wearables and Physical Computing
COMP_SCI 397/497	Special Projects in Computer Science; only the following offerings: • Wireless Protocols for the Internet of Things • Wireless and Mobile Health
COMP_SCI 409	Swarms and Multi-Robot Systems
BME 353-0-01	Bioelectronics

3.2.3 Maintaining Student Status and Continuous Registration

PhD 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.

PhD 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 PhD students that are receiving funding and are doing primarily research during that quarter.

3.2.4 Professional Development

The PhD 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 PhD 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 PhD 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 PhD students who may not be eligible for most fellowships.

The CE PhD program expects that all PhD students will engage in such activities at some point in their PhD 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. PhD 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.

3.2.5 Annual Academic Standing Review

Students must maintain good academic standing throughout their studies. A student maintains good academic standing in the CE PhD program if the Core Computer Engineering Faculty determine that the student's progress in the Computer Engineering PhD 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 Section 4.6.

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.

3.2.6 Teaching Requirement

All students earning a PhD degree in CE must meet one of the following requirements:

- Serve as a full-time teaching assistant (20 hours per week) in an undergraduate course for at least one quarter.
- Serve as a Teacher Trainee (TT) for at least two quarters. First-time TT students should register for GEN_ENG 545 Teaching Experience; second-time TT students should register for GEN_ENG 546 Teaching Experience. These course registrations apply only to TT students (not to TAs).
- Meet a teaching requirement that has been approved by TGS and the CE program.

Teaching assistant (TA) positions must involve some direct contact with students (office hours, lab or problem session, lecturing) in addition to grading. TA appointments of international students whose primary language is not English require that the students fulfill TGS' English proficiency requirement (see https://www.tgs.northwestern.edu/funding/assistantships/graduate-and-teaching.html).

Teacher Trainee (TT) duties consist of 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. A PhD student cannot be both a teaching assistant and a TT in the same academic quarter.

3.2.7 Admission to PhD Candidacy

PhD students in Computer Engineering typically achieve PhD Candidacy through coursework.

Admission to PhD Candidacy through Coursework

PhD candidacy in Computer Engineering can be achieved through the demonstration of high performance in the PhD 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 PhD 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 PhD 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 PhD 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 PhD candidacy.

To apply for PhD candidacy, qualified students need to submit a *PhD 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 PhD Candidacy through Oral Qualifier Examination

If a PhD student fails to meet the criteria for admission to PhD 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 PhD 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 PhD 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.

3.2.8 PhD Prospectus

PhD 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 PhD Prospectus Committee. The student must invite faculty to serve on their PhD Prospectus Committee, in consultation with their permanent research advisor. The PhD Prospectus Committee is formed according to the following rules:

- The PhD 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 PhD Prospectus Committee members must be Core Computer Engineering Faculty that are members of the Northwestern University Graduate Faculty.
- The PhD 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 PhD Prospectus Committee Chair and the Director of Graduate Studies in Computer Engineering, the PhD 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 PhD Prospectus Committee must include the student's permanent research faculty advisor, who typically serves as the PhD Prospectus Committee Chair.
- Others may be invited to attend the PhD Prospectus Committee meetings as non-voting members.

The PhD Prospectus Committee must be formed no later than one week before the PhD 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 PhD Prospectus Committee may result in faculty declining to serve due to schedule constraints and time commitment to other responsibilities. Failure to secure a PhD Prospectus Committee may result in the student missing program milestones and completion deadlines, and may result in the student being placed on academic probation.

PhD Prospectus Examination (PhD Thesis Proposal)

A proposal of the PhD 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 PhD Prospectus Committee decides on approving the PhD Prospectus. The PhD Prospectus must be approved by the end of the 4th year of study (i.e., the last date of the 16th quarter of study). The written prospectus document must conform to The Graduate School's dissertation format guidelines at https://www.tgs.northwestern.edu/academic-policies-procedures/dissertation-publication/dissertation-formatting-requirements/. The oral presentation must conform to the format specified by the PhD Prospectus Committee. The prospectus document must be given to the committee **at least one week prior** to the oral presentation. All members of the PhD Prospectus Committee must attend the oral presentation of the prospectus, either physically, or via phone or video conferencing.

Upon formation of the PhD Prospectus Committee and agreeing on a PhD Prospectus Examination date, the student should submit the *PhD Prospectus* form through *TGS Forms* in GSTS. **At least two weeks** prior to the PhD 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 PhD candidate changes their advisor and/or research topic after completing the PhD Prospectus Examination, the student may be required to form a new PhD Prospectus Committee and successfully complete another PhD Prospectus Examination on the new research topic.

Students that fail the PhD 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).

3.2.9 PhD Dissertation and Oral Defense

Every PhD 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 PhD 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 PhD 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 PhD Final Exam. The date of the PhD Final Exam coincides with the date of the Oral Thesis Defense, as typically the PhD 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 PhD Thesis Committee are the same as the rules that govern the formation of the PhD Prospectus Committee. In the vast majority of cases, the PhD Prospectus Committee members continue on to serve as members of the PhD 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 PhD Thesis Committee **at least one week prior** to the Oral Thesis Defense.
- Within 2 weeks after the Oral Thesis Defense, the PhD 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 PhD 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 PhD Thesis Committee, physically, or via phone or video conferencing. Others may be invited to attend as non-voting members.
- The chair of the PhD 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 PhD 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 PhD 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 PhD Thesis Committee members participate. During the private segment the PhD Thesis Committee deliberates and determines whether the student has passed or failed the Oral Thesis Defense.

Upon formation of the PhD Thesis Committee and agreeing on an Oral Thesis Defense date, the student should submit the *PhD Final Exam* form through *TGS Forms* in GSTS. Moreover, **at least four weeks** before the PhD 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 PhD 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 PhD 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 PhD Final Exam and awarding of the PhD degree. This file is given to the student's advisor prior to the PhD Final Exam and must be in the examination room for reference.

Upon the conclusion of the PhD Final Exam, and after the dissertation is approved by all members of the PhD Thesis Committee, the student's file is signed by all members of the PhD Thesis Committee to denote their approval of the PhD 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.

3.3 PhD Degree Completion Procedure

To complete the PhD 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.

3.4 Additional Requirements for CS PhD 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 PhD degree in Computer Science. As of this writing the additional requirements are:

- CS PhD 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 PhD program.

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

4 Special Policies and Procedures

4.1 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.

PhD 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 PhD 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 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 participate in an internship must also apply for Curricular Practical Training (CPT) authorization for any off-campus internship opportunity. "Off-campus" is defined as any internship that takes place outside of Northwestern University. For more information on CPT, please visit https://www.northwestern.edu/international/living-working/student-employment/index.html.

4.2 Post-Graduation Employment

International MS and PhD 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.

4.3 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 PhD 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.

4.4 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/.

4.5 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.

4.6 Probation, Exclusion, and Appeal Process

If a student fails to remain in good academic standing at any point of time in the CE program, then the student is placed on probation. Failure to meet academic integrity standards (e.g., cheating on coursework, plagiarizing research), failure to meet any of the CE program's or TGS' requirements for the PhD degree (e.g., not making satisfactory progress in thesis research, not having a permanent research advisor at any point in the program), may result in the student considered as not making satisfactory academic progress. Students who fail to make satisfactory academic progress in a given quarter will be placed on probation by The Graduate School for the following quarter. Once a graduate student is placed on probation, the CE program reserves the right to review the student's case and subject the student to additional penalties and requirements beyond the ones mandated by TGS.

The student must use the probationary quarter to meet all the requirements imposed by the program and TGS during probation, and seek an alternate advisor or improve their performance to receive a report of satisfactory progress with their current advisor. At the end of the probationary quarter, if the student has secured an advisor who can report satisfactory progress, the student will be removed from probationary status. Otherwise, the program reserves the right to stop funding the student from departmental or advisor funds after the end of the probationary quarter, and may make a recommendation of exclusion (dismissal) of the student to The Graduate School.

In cases of missing a milestone deadline, students may petition The Graduate School for an extension of the milestone's deadline, if a compelling reason and sufficient evidence are provided. If the petition is approved, the student will be given an extended milestone due date and the requirements that must be completed by that deadline. Failure to remedy the missing requirements by the extended due date may ultimately result in the exclusion of the student from The Graduate School and the respective CE graduate program. More information on probation and appeal processes for probation can be found at TGS' website at https://www.tgs.northwestern.edu/academic-policies-procedures/policies/satisfactory-academic-progress.html.