

CS PhD Program

Overview of the new requirements

The main requirements and milestones along the path of a PhD student will be:

- Background Knowledge Requirement (new);
- Breadth Course Requirement (revised);
- Preliminary Oral Exam (revised);
- Thesis Proposal Exam (new)

Background Knowledge Requirement

The concepts covered here are considered to constitute a minimal core body of knowledge with which all PhD graduates of our department should be familiar. These concepts are required prerequisites for many of our graduate classes; students must know these concepts to succeed in these classes.

Background concepts

- **Machine Architecture and Organization.** Covers basic hardware/software components of a computer system, including data representation, machine-level programs, instruction set architecture, processor organization, memory hierarchy, virtual memory, compiling, and linking.
- **Theoretical Foundations.** Must cover *one of* the following two bodies of knowledge:
 - **Algorithms and Data Structures or Formal Languages and Automata Theory.**
 - **Algorithms and Data Structures.** Analysis, data structures, and algorithms, e.g.: basic algorithm analysis (recurrences, asymptotic notation), basic data structures (lists, stacks, queues, heaps, hash tables, (balanced) binary search trees), basic algorithms (sorting, searching, graph traversal, shortest paths, minimum spanning trees).
 - **Formal Languages and Automata Theory.** Logical/mathematical foundations of computer science. Specific topics include formal languages, their correspondence to machine models, lexical analysis, string matching, parsing, decidability, undecidability, limits of computability, and computational complexity.
- **Operating Systems.** Topics include processes/threads, process coordination, interprocess communication, asynchronous events, memory management/file systems.
- **Programming & Software Development.** Topics include: design and analysis of programs, software development tools and methods, debugging, I/O, state machines, exception handling, testing, coding standards, software lifecycle models, requirements analysis.

Satisfying the Background Knowledge Requirement

The Background Knowledge Requirement may be satisfied in five different ways:

1. By passing the GRE Computer Science subject exam with a score in the 90th percentile or higher.
2. By passing an appropriate undergraduate course with a grade of B+ or higher. The appropriate courses at The University of Minnesota are noted below. However, a student may take such courses anywhere, and simply needs to point out on their transcript any qualifying courses. The Director of Graduate Studies is responsible for approving the use of courses to satisfy the background requirement. The relevant UMN courses are:
 - **Machine Architecture and Organization** = CSCI 2021
 - **Theoretical Foundations:**
 - **Algorithms and Data Structures** = CSCI 4041
 - **Formal Languages and Automata Theory** = CSCI 4011
 - **Operating Systems** = CSCI 4061
 - **Programming & Software Development** = CSCI 3081
3. By passing the final exam for the appropriate UMN class with a grade of B+ or higher
4. By passing a graduate course with a grade of B+ or higher for which an appropriate undergraduate course is a clearly defined prerequisite. For example, at the University of Minnesota, CSCI 5421 "Advanced Algorithms and Data Structures" has CSCI 4041 "Algorithms and Data Structures" as a prerequisite. Thus, getting a B+ in 5421 is evidence that a student has adequate background in Algorithms and Data Structures. Students must check with the Director of Graduate Studies to verify that a specific graduate course demonstrates knowledge of a particular background area.
5. By petitioning the Director of Graduate Studies to accept some other experience as evidence of adequate background. For example, a student could have extensive industrial software development experience without having taken a course on software development.

Students must satisfy the background requirement within their first year in the PhD program. If they are not able to do so, they may – with the support of their advisor – petition the Director of Graduate Studies for an extension.

Prerequisite Table – Graduate courses for which background undergraduate courses are substantial prerequisites

CSci 2021	CSci 4041	CSci 4011	CSci 4061	CSci 3081
5204	5403	5106	5103	5106
	5421	5161	5105	5161
	5461		5211	5801
	5471			
	5481			
	5523			

Breadth Course Requirement

The purpose of the Breadth Course Requirement is to expose students to diverse Computer Science research topics and methods. PhD student must take a total of five (5) courses that satisfy the following requirements:

- Each of the five courses is in a different **sub-area**.
- The student must take at least one course in each different breadth **area**.
- The student **must** take one course in the Theoretical Foundations sub-area.

PhD students must have an average GPA of 3.45 or higher for the five courses they use to satisfy the Breadth Course Requirement. Students have three (3) years to satisfy this requirement. If students want to take a more advanced course in a sub-area than the listed options – typically, one for which one of the listed options is a prerequisite – they may petition the Director of Graduate Studies to use this course for satisfying the requirement. Students may petition the Director of Graduate Studies to transfer credit for up to two courses to use for satisfying the Breadth Course Requirement.

Master’s students (MS and MCS) are required to take three (3) courses, one from each of the areas. Students must maintain an overall GPA of 3.0 for MCS and 3.25 for MS candidates for all courses on their degree program, as well as those used to satisfy the breadth requirement. Substitutions are rarely permitted and transfer courses will not count towards the breadth requirement.

All courses must be taken for graduate credit and on the A-F grading basis.

Breadth Areas

There are three breadth areas:

- **Theory and Algorithms**
- **Architecture, Systems, and Software**
- **Applications**

Each area contains a number of sub-areas, and each sub-area contains a number of courses. Defining sub-areas within areas allows for clustering related courses and for increasing the diversity of the courses a student will take to satisfy the breadth requirement.

Theory and Algorithms

1. Theoretical Foundations (*note: all students **must** take one course in this sub-area*)
 - 5421: Advanced Algorithms & Data Structures
 - 5403: Computational Complexity
 - 5304: Computational Aspects of Matrix Theory
2. Applied Algorithms
 - 5302: Analysis of Numerical Algorithms
 - 5471: Modern Cryptography
 - 5481: Computational Techniques for Genomics
 - 5525: Machine Learning

Architecture, Systems, and Software

1. Programming, Software, Languages, Compilers
 - 5106: Programming Languages
 - 5161: Introduction to Compilers
 - 5801: Software Engineering I
2. Systems Software
 - 5103: Operating Systems
 - 5105: Foundations of Modern Operating Systems
 - 5451: Introduction to Parallel Computing: Architectures, Algorithms, and Programming
 - 5708: Architecture and Implementation of Database Management Systems
3. Architecture
 - 5204: Advanced Computer Architecture
4. Networking
 - 5211: Data Communications and Computer Networks
 - 5221: Foundations of Advanced Networking
 - 5231: Wireless and Sensor Networks

Applications

1. Intelligent Systems: AI, Robotics, Machine Learning, Vision
 - 5511: Artificial Intelligence
 - 5521: Pattern Recognition
 - 5551: Introduction to Intelligent Robotic Systems
 - 5561: Computer Vision
2. Data Mining and Bioinformatics
 - 5523: Introduction to Data Mining
 - 5461: Functional Genomics, Systems Biology, and Bioinformatics

3. Graphics, Visualization, Human-Computer Interaction, Social Computing
 - 5107: Fundamentals of Computer Graphics 1
 - 5109: Visualization
 - 5115: User Interface Design, Implementation and Evaluation
 - 5125: Collaborative and Social Computing
4. Security
 - 5271: Introduction to Computer Security

Preliminary Written and Oral Examinations

The goal of the Preliminary Examinations is to serve as an early test of a student's research abilities. Second year PhD students will meet with the Graduate Student Services Coordinator and go over the requirements including the WPE report, background knowledge requirements, breadth requirements, degree program form and committee membership. It is **not a thesis proposal**: a separate examination is being added to serve that purpose.

Timing issues

The preliminary exams should be taken as soon as the student is ready. Students **must take** the exam no later than their second year in the PhD program (however, with the support of their advisor, students may petition the Director of Graduate Studies for an extension). Students **must pass** the exams by the end of their third year. Students must first submit a written report to their examining committee. Once the committee approves that report, the student may schedule the Oral Prelim. Therefore, students should submit their written report to their examining committee at least two months before their preferred Oral Prelim date.

Best Practices

The written report and oral exam must demonstrate the student's ability to do research. Different areas and different advisors use different methods and have different expectations of what a student must do to demonstrate research ability. Therefore, we cannot specify precisely what a student's report and oral presentation must include. However, we can offer a few "best practice" examples that would be acceptable in most or all research areas.

- **Completed research project.** A report on a research project **completed while a graduate student at the University of Minnesota**. Ideally, this project will have resulted in a published paper where the student is a major contributor.
- **Literature review.** A careful and insightful review of research in the student's specialty. This review should demonstrate a student's understanding of key research topics and methods in the area and show that he or she can identify interesting open research problems and appropriate means to address those problems.

Written Report

The report should be at least the length of a published conference paper, say 6000-8000 words, or 8-10 pages in the [ACM SIG Proceedings format](#).

The same committee will examine both the written report and the oral exam.

Exam Scope and Format

The student will present the material in the written report to their committee. The committee will question the student about that material and directly related material, such as the methods that were used and possible alternative methods, ideas for future work, potential problems and obstacles. The committee is encouraged to probe the student's understanding of *related* material and concepts.

Committee Composition

The Graduate School requires that the committee include three members from the Computer Science graduate faculty and one external member. The student in consultation with her/his advisor, will nominate three members, two internal (including the student's advisor) and one external. The DGS will approve these choices and will appoint one member of the committee from the department's Preliminary Oral Examination committee, selecting a person who is not in the student's research area.

Reminder: the same committee will examine both the written report and the oral exam.

Scheduling the Preliminary Oral Exam

An email will go out to the student's committee and the student once the members have approved the written report. The student must then schedule the exam with the committee members. Once a date and time have been set, the student must [schedule](#) the prelim oral exam with the Graduate School. They will then prepare the necessary document and it will be sent to the student's committee chair.

Possible outcomes of the exam

The committee may pass the student or fail the student. If the student fails, the committee may or may not choose to give the student another chance to pass the exam. A student can have at most two chances to pass the Oral Prelim. As stated above, students must pass the exam within three years of entry to the PhD program.

Relationship to a student's M.S. research (Plan A Thesis / Plan B Report)

The same piece of research can be used to satisfy both the MS (Plan A or B) and Oral Prelim requirements. If this is done, there are four possible outcomes of the exam:

- The student can pass both exams.
- The student can fail both exams.
- The student can pass the MS, fail the Oral Prelim, and be given the option to retake the Oral Prelim.
- The student can pass the MS, fail the Oral Prelim, and not be given the option to retake the Oral Prelim.

Thesis Credits

After successful completion of the preliminary oral exam, the student will be admitted to doctoral candidacy and will be able to register for thesis credits. A student is required to register for 24 thesis credits and it is recommended that these be completed within two semesters. Upon completion of all required course work and thesis credits, a student may then register for CSci 8444 FTE: Doctoral. This is a one credit course that gives a student full time status for holding an assistantship, maintaining a student visa or for any other purposes that require full time status. This also means that only this one credit is eligible for tuition reimbursement and any additional credits and the subsequent tuition is the responsibility of the individual student.

Thesis Proposal Examination

The Preliminary Oral Exam formerly was seen as a thesis proposal exam. However, under the new format, a separate exam will be required for this purpose. The thesis proposal examination should be taken within 1-2 years after passing the Preliminary Oral Examination. This examination should be organized around a presentation of your thesis proposal, but exam committee members are entitled to test the full range of your expertise to evaluate your preparation for your thesis research and the suitability of your thesis research plan. The committee members for the thesis proposal exam can be the same as the prelim oral exam although the departmental representative can be replaced. The student, in consultation with her/his advisor, should review the committee and notify the graduate student services coordinator of any changes. Committee members may vote to pass, pass with reservations, or fail. At least three passing votes are required to pass the exam. Students who fail the examination may be terminated, or may be allowed, upon unanimous recommendation of the committee, to retake the examination. No more than one reexamination is allowed and must consist of the same committee members. The thesis proposal examination is internally administered; students should obtain a Thesis Proposal Examination Report Form from the DGS assistant prior to the exam and must return the form with all signatures to the DGS assistant within 24 hours of the examination.