CS PhD Program

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

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

PhD students must complete a minimum of 31 credits including the 5 breadth courses, 1 credit of Colloquium and 6 credits in a supporting program. The courses selected should be discussed with the advisor and form a cohesive program.

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

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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 with at least one course in each different breadth 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**

**Theory and Algorithms**

- 5302: Analysis of Numerical Algorithms
- 5304: Computational Aspects of Matrix Theory

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• 5403: Computational Complexity
• 5421: Advanced Algorithms & Data Structures
• 5525: Machine Learning

Architecture, Systems, and Software
• 5103: Operating Systems
• 5104: System Modeling and Performance Evaluation
• 5105: Introduction to Distributed Systems
• 5106: Programming Languages
• 5161: Introduction to Compilers
• 5204: Advanced Computer Architecture
• 5211: Data Communications and Computer Networks
• 5221: Foundations of Advanced Networking
• 5231: Wireless and Sensor Networks
• 5451: Introduction to Parallel Computing: Architectures, Algorithms, and Programming
• 5461: Functional Genomics, Systems Biology, and Bioinformatics
• 5708: Architecture and Implementation of Database Management Systems
• 5801: Software Engineering I
• 5802: Software Engineering II

Applications
• 5115: User Interface Design, Implementation and Evaluation
• 5125: Collaborative and Social Computing
• 5271: Introduction to Computer Security
• 5471: Modern Cryptography
• 5481: Computational Techniques for Genomics
• 5511: Artificial Intelligence I
• 5512: Artificial Intelligence II
• 5521: Pattern Recognition
• 5523: Introduction to Data Mining
• 5551: Introduction to Intelligent Robotic Systems
• 5561: Computer Vision
• 5607: Fundamentals of Computer Graphics I
• 5608: Fundamentals of Computer Graphics II
• 5609: Visualization
• 5611: Motion and Planning in Games
• 5619: Virtual Reality and 3D User Interaction
• 5707: Principles of Database Systems
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 serves 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. Since the written report serves as a test of the student's own research capabilities, which includes the ability to communicate clearly and effectively in written English, we require that the report wholly consists of material that is independently written by the student. (A research paper can be attached as an appendix but could be ignored by the committee.) The length of the report must be sufficient to demonstrate both the student's own research knowledge and their independent writing capabilities.

- **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

Graduate Education policy 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. Once the committee membership has been decided upon and all have agreed to serve, the student must then appoint his committee by submitting their names to this online form.

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 Student Services and Progress Office. 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.

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Thesis

Once you have completed your thesis, you may request your Graduation Packet. Included in the packet is your "Thesis Reviewer's Report Form" along with the Application for Degree. Please be sure that you have updated your committee membership indicating which of your members will be the three reviewers and which member will serve as chair since your advisor cannot be the chair for your final defense. Your advisor, co-advisor (if you have one) or one other CS member as well as the outside member must be designated reviewers.

Copies of your thesis should be given to all members of your committee. All members of the committee read the thesis, although only those designated as thesis reviewers sign the form indicating that the thesis is ready for defense. You must notify your advisor and the other members of your committee at least two weeks in advance that the thesis will be delivered on a particular date. All members of the examining committee must then have at least two weeks to read the thesis after it has been delivered. The thesis reviewers sign the Reviewer's Report form to certify that it is ready for defense. The Reviewer's Report form must be submitted back to the Graduate Student Services and Progress Office at least one week before the date of your final oral examination. The reviewers must decide unanimously that the thesis is ready for defense.

Final Oral

You are responsible for scheduling your thesis defense with the committee members and notifying the Graduate Student Services and Progress Office (Final Oral Examination Scheduling) at least one week in advance. The Graduate Student Services and Progress Office will send a "Final Oral Examination Report Doctoral Degree" form to the chair of your committee; this will not be your advisor. It is wise if you verify that this form was indeed received by the Chair of your committee. The Department of Computer Science requires all Ph.D. students to hold their final thesis defense within ninety days of obtaining the signatures of all assigned committee members on the "Reviewers Report on the Ph.D. Thesis" form which states that the thesis is ready for defense. Those who fail to take their thesis defense due to scheduling conflicts may take the exam only if they again obtain the signatures of all the committee members within ninety days. In other words, for each signed form, the candidate may have up to ninety days to take the final thesis defense. Graduate Education policy states that graduate programs require open public thesis defense for doctoral candidates. This means that your final oral examination is open to the public. To ensure complete openness the Computer Science Program has adopted somewhat more stringent requirements. Once the readers have approved your thesis, one copy must be made available for public perusal, preferably on-line. The availability of this copy, along with the time and place of your thesis defense must be announced in writing and via electronic mail to graduate faculty and students, at least one week in advance. This announcement must contain a one-page descriptive abstract of the thesis to be defended, the name of the advisor and the URL of your thesis.

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To schedule your final oral exam you must notify the Graduate Coordinator in the Computer Science Office. The Coordinator will answer any last minute questions you might have, and find a room for you in which to have the exam. It is important to note that you have only one chance to take the final oral. The committee of the final oral will complete the "Final Oral Examination Report" form and you must ensure that it goes directly to the Graduate Student Services and Progress Office. To be awarded the degree you must receive no more than one dissenting vote from the total examining committee. You must make all the necessary changes in the text of the thesis before it is bound. You must observe all requirements, including submitting one unbound copy of the thesis with the signature of your advisor to the Graduate Student Services and Progress Office, before your degree can be awarded. You must also supply the department with one bound copy of your thesis. Upon your departure, please remember to submit to the department a change of address, the name of your first employer (after graduation) and return keys you have for your office and/or the labs.