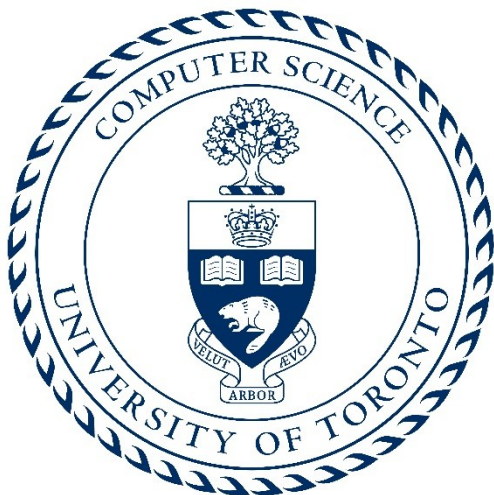# DOCTOR OF PHILOSOPHY PROGRAM

2019-20 GRADUATE HANDBOOK

Computer Science
UNIVERSITY OF TORONTO

Introduction

The main goal of a successful Ph.D. is not so much a thesis, but rather (and much more importantly), it is to train a researcher and prepare them for further professional development. One aspect of this training is to ensure that they have a broad and deep knowledge of Computer Science. The starting point for this aspect is the completion of the Ph.D. course and breadth requirements. However, course work is, by design, limited to relatively narrow and well-defined assignments, projects, and exams. To be a successful Ph.D. student, a candidate needs a much broader set of skills, including the maturity as a researcher to cope with significantly more uncertainty than is typically seen in course work. Additional skills include the abilities to evaluate the current literature, to select promising directions for future work, and to follow some of those directions through to the nuggets of new contributions. In our experience with our students we typically see these skills develop slowly, continuing through to their graduation from our Ph.D. program. However, our expectation is that the foundations for these skills should already be in place and evident by the beginning of the second year of Ph.D. studies.

Specific skills that we expect to be developed by a Ph.D. candidate include these:

a) The ability to **apply the basic tools of the field** in potentially new ways, along with the self-understanding of what they themselves know and what they have yet to learn.

b) The ability to **select significant research contribution**s from a larger set of published papers, and justify that selection (for example, on the basis of significance of the results or the novelty of the approach).

c) The ability to **relate the papers to one another**, and to other research in the literature.

d) The ability to **critique the research methods** used in these papers, including the strengths and weaknesses of these methods and likely threats to validity, whether these are acknowledged in the papers or not.

e) The ability to **identify limitations of the results** (and possibly errors) reported in the papers, along with their implications.

f) The ability to **suggest alternative approaches** to answering the research questions posed in these papers.

g) The ability to **identify and prioritize lines of investigation for further research**, based on an understanding of significant limitations of the research described in the papers and/or important open problems that the papers fail to answer, and also on the likelihood of being able to make progress on such issues.

This document describes the program requirements for the Ph.D. program in Computer Science. These requirements are meant to ensure that our students receive regular assessment and feedback on their progress toward these goals, and our graduates meet expectations.

Ph.D. Programs in Computer Science

The Department of Computer Science has three Ph.D. programs that are appropriate for students with different backgrounds. Students are assigned to one of these Ph.D. programs upon admission. The end result of these programs is the same, namely a Ph.D. in Computer Science.

1. **Ph.D.:** Students who entered the Ph.D. program after having completed their M.Sc. program in our department.

2. **Ph.D.-M:** Students who have completed the M.Sc. degree in Computer Science elsewhere and have now entered the Ph.D. program.

3. **Ph.D.-Direct:** Students who have completed a B.Sc. and have entered directly into the Ph.D. program. Also denoted as the **Ph.D.-U** program

As described below, the degree requirements vary across these three programs due to differences in the student's prior education.

Ph.D. Course Requirement

The **course requirement** covers the minimum number of courses required by a degree program. In order to obtain credit for a course, the student must obtain a mark of B– or higher. Students in the Ph.D. and Ph.D.-M programs are required to complete **four** graduate half-courses, while students in the Ph.D.-Direct program must complete **eight** graduate half-courses.

The only exception to this is for students who obtain a transfer credit for graduate courses that were completed but never used toward the requirements of another degree, diploma, certificate, or any other qualification (either at UofT or elsewhere), or as a Non-Degree Special Student. Students may transfer up to 1.0 Full Credit Equivalents (maximum two half-credit courses) to their current degree program.

For students who have completed the MSc program here in DCS, any graduate half-courses completed beyond the MSc course requirement (i.e., taken while the student is registered as an MSc student in DCS) can be used towards the Ph.D. course requirement.

Ph.D. Breadth Requirement

The breadth requirement for our degree programs ensures that students complete courses from a sufficiently wide range of topics within Computer Science. The Ph.D. program requires breadth in different **research areas** of Computer Science.

CS courses are classified into four methodologies and sixteen research areas based on their content. **Methodologies** are core problem-solving approaches and/or techniques and general tools emphasized in the course material, while **research areas** are aligned with the activities of the various research groups in the department. The methodologies and research areas are described in the next section below.

The list of courses in each of the four methodologies is available on the CS website. Courses that are not listed do not qualify for breadth credit, unless this has been approved and/or is explicitly noted in the course schedule posted by the Graduate Office.

The exact Ph.D. breadth requirement depends on whether the student is in the Ph.D., Ph.D.-M or Ph.D.-Direct program:

- **Ph.D.**: For the case of a Ph.D. student who is following on from an M.Sc. degree in our department, the eight graduate half-courses taken over their M.Sc.and Ph.D. must include courses from at least four different research areas and three methodologies. In this sense, courses taken during the student's M.Sc. are counted both for achieving methodological breadth and for research area breadth.

- **Ph.D.-M:** Students who completed a master's degree elsewhere are required to submit a Plan of Study and Breadth Assessment form at the beginning of their first term in order for the Associate Chair, Graduate Studies to assess which breadth credits can be transferred to their

Ph.D. program here. Including these breadth credits, these students must complete courses from at least four different research areas.

- **Ph.D.-Direct:** Ph.D. students who are entering the program directly from a bachelor's degree are required to take a total of eight graduate half-courses. These must include courses from at least four different research areas and three methodologies.

Graduate courses that were completed (either at UofT or elsewhere) **may qualify** for breadth credits. Students may request an assessment of breadth for courses from other departments by submitting evidence of the course content (e.g., a syllabus or copies of course notes) and the problem-solving approach or technique used in the course (e.g., copies of assignments or exams). Students in this situation should submit a Plan of Study and Breadth Assessment form to the Graduate Office to seek the necessary approvals. However, graduate courses taken in fulfillment of a bachelor degree's course requirement (even graduate courses from our department) **do not count** towards the breadth requirements.

The Four Methodologies

Methodology 1: Analysis and Computation in Discrete Models
The courses in this grouping focus on analysis of and algorithms for discrete mathematical structures, such as graphs, formal logic, and formal models of computation. The grouping includes courses that analyze computational limitations and discrete computation. These courses study and apply techniques from areas like probability, combinatorics, algebra, mathematical programming, and formal logic.

Methodology 2: Analysis and Computation in Continuous Models
The courses in this grouping focus on analysis of and algorithms for continuous mathematical models. Topics include the derivation of mathematical models, their properties, and computational techniques for approximating their solution. These courses study and apply techniques from areas like probability and statistics, computer graphics, computer vision, numerical analysis and machine learning.

Methodology 3: Building Software and Hardware Artifacts
This grouping includes courses that study the design and implementation of specific software or hardware artifacts. These courses expose students to the challenges in building artifacts such as computer-animated movies, computer aided design systems, databases, network protocols and devices, and simulations of large scale systems. Courses in this group typically have a significant project component where students build a substantial software or hardware artifact.

Methodology 4: Human-Centered and Interdisciplinary Computing
This grouping includes courses that study computational paradigms and methods within human-computer interaction and scientific domains outside traditional computational sciences. These courses typically have a cross-disciplinary component, involving fields such as the life sciences, linguistics, psychology, social sciences, and economics.

The 16 Research Areas

1. Algorithms and Discrete Math

2. Complexity and Crypotography

3. Computational Biology

4. Computational Linguistics

5. Computer Graphics

6. Computer Systems and Networks

7. Computer Vision

8. Database Systems

9. Distributed Computing

10. Human-Computer Interaction

11. Knowledge Representation

12. Machine Learning

13. Scientific Computation and Numerical Analysis

14. Software Engineering

15. Interdisciplinary Computer Science

16. Robotics

Ph.D. Student Supervision

Every Ph.D. student will be assigned a supervisor(s) prior to registration. The supervisor advises on course selection and thesis topic selection, and provides continuing help during the conduct of research. All students are required to consult frequently with their supervisors throughout their graduate studies, to report on their progress, ask questions and to obtain advice regarding their research.

To be the primary or sole supervisor of a Ph.D. student, a faculty member must hold an associate or full membership in the School of Graduate Studies, with a specific graduate faculty appointment in the Department of Computer Science (i.e., a CS-SGS membership).

Faculty with an emeritus appointment in CS-SGS can also supervise Ph.D. students, with approval from the Graduate Office before taking on any new supervisory role. When a Ph.D. student is co-supervised, at least one of the co-supervisors must be identified as the primary supervisor (a.k.a. supervisor of record), and this faculty member must hold an associate, full, or emeritus membership in CS-SGS.

Occasionally the student–supervisor match is not productive. Any student who finds themselves in such a situation should discuss difficulties or concerns with their current supervisor. In many cases the reason is an issue which might be resolved by talking it out. If no resolution can be found, students who feel a need to change their supervisor are welcome to seek advice from the Associate Chair, Graduate Studies. However, the ability to switch supervisors depends on the availability of another faculty member to serve in this role. A Supervisory Committee Composition Form must be submitted to seek approval for change of supervision.

An excellent guide for making the most of the relationship between a student and their supervisor is provided by SGS. Take note of the checklists for both students and supervisors provided in Appendices 2 and 3 of the document. The Department of Computer Science supports the expectations stated in this guide and we encourage students to discuss these checklists with their supervisor.
http://www.sgs.utoronto.ca/Documents/Supervision+Guidelines.pdf

Ph.D. Supervisory Committee

The purpose of the student's Ph.D. supervisory committee is both to aid the student by providing timely advice and to evaluate the student's progress towards a Ph.D. thesis.

By the end of their **16th month** of program registration, each Ph.D. student must form a Ph.D. **supervisory committee** consisting of at least three members, including the supervisor and, if applicable, co-supervisor. Besides the supervisor, and possible co-supervisor, the other committee members must be associate or full members of SGS (although not necessarily in CS-SGS).

In addition, external experts can also serve on a supervisory committee as "advisors" (this term is **not** synonymous with "supervisor"). Advisors can take part in all the student's committee meetings with the following exceptions: a) they do not contribute to a quorum, and b) they cannot vote

in the student's Final Oral Examination (FOE), although they are permitted to attend the FOE.

The request for an external expert to serve as an advisor on a Ph.D. committee can be made by e-mail to the Associate Chair, Graduate Studies, gradchair@cs.toronto.edu, accompanied by a brief rationale and CV.

Students should notify the Graduate Office of the formation of the Ph.D. supervisory committee, and of any changes to that committee using the Supervisory Committee Composition form. Changes to the supervisory committee should only be made in consultation with the Grad Office and all changes must be reported immediately.

Legacy System for Ph.D. Supervisory Committee Meetings

Ph.D. students who enrolled in their program before 1 September 2015 and are maintaining regular meetings with their supervisory committees may continue with the previous Ph.D. checkpoint system. Alternatively, they may opt into the new system for supervisory committee meetings, as described above. However, if a student under the legacy checkpoint system fails to have a committee meeting for 18 months or more, they will be placed into the new system.

Ph.D. students who enrolled in their program before 1 September 2015 will be asked to complete progress monitoring reports prior to each checkpoint. These reports will be reviewed by the student's supervisory committee. This replaces the previous progress monitoring system.

Qualifying Oral Exam

The qualifying oral exam (also known as the litertaure review) must be held **within 16 months** of the start of the Ph.D. program. Note that the student must have formed the Ph.D. supervisory committee and have had it approved at least several weeks in advance of this exam.

Working with their supervisor, the student should select 5–10 research papers to be emphasized at the qualifying oral. These should be important papers in one research area of relevance to CS. This research area need not correspond to the student's eventual choice of Ph.D. topic. Students do not have to be committed to a thesis topic prior to this committee meeting. In relation to the selected papers, the student will be examined on the points (a) through (e) listed in the introduction above. It is expected that students will have read and understood more than just the selected papers, but it is

not expected that the student master the majority of the relevant literature at the time of this exam.

In order to help focus the initial questioning, the student will prepare a short position paper (less than 10 pages, double spaced, in a reasonable font) on points c-e, as outlined in the introduction to this Handbook (page 1). If the student has begun to investigate this area themselves, then they are welcome to briefly describe their progress so far. In addition, it is the student's option to discuss the expected overall scope of the questioning with their supervisory committee several weeks prior to the exam.

At the beginning of the Qualifying Oral, the student will be asked to give a 15-minute talk to introduce their position on the research described in the selected papers. This will be followed by one or more rounds of questioning by the supervisory committee. During this questioning, it is critical that the student demonstrate an understanding of CS tools and techniques that are relevant to pursuing research in the area.

The supervisory committee will provide written feedback to the student (through the DCS Graduate Office), and the student will be invited by the Graduate Office to respond to this feedback. In addition, one of the following examination results will be provided:

1. Pass. A pass may be accompanied by constructive feedback and/or suggestions for activity in the next term(s).
2. Conditional Pass. The student is given one or more concrete tasks to complete by a specific deadline (no more than a year later). The tasks and the deadline are also communicated to the Graduate Office. The chair of the Qualifying Oral must report to the Graduate Office whether or not the student has cleared the conditions by the deadline. If the student fails to clear the conditions by the deadline, then they will be considered to be making unsatisfactory academic progress.
3. Fail (with the option to repeat). The student is considered to not be making satisfactory academic progress, and must retake the exam within 6 months.   The student will not be given a third chance to pass the exam.
4. Fail (no option to repeat). The student must either withdraw from the program or have their registration terminated. This result is possible only for students who were not considered to be making satisfactory academic progress at the time of the exam. The Associate Chair, Graduate Studies will review such a recommendation.

Candidacy

SGS requires that Ph.D. students achieve candidacy within the first 36 months of their program (48 months for Ph.D.-Direct students).

When ready to be considered for candidacy, Ph.D. students must arrange a committee meeting and contact the Graduate Office to at least two weeks prior to the meeting date.

Achieving candidacy involves:

a) completing all course and breadth work,
b) successfully passing the Qualifying Oral, and
c) having a thesis topic approved by one's Ph.D. supervisory committee.

Course and Breadth Requirements Completion

Students in the Ph.D. and Ph.D.-M programs are required to successfully complete four graduate half-courses, while students in the Ph.D.-Direct program are required to successfully complete eight graduate half-courses. The Ph.D. program requires breadth in four different Research Areas of Computer Science.

Thesis Topic Approval

We recommend that students have a thesis topic approved within 12 months of completing their Qualifying Oral (i.e., within 28 months of starting their Ph.D. or Ph.D.-M program, or 36 months for Ph.D.-Direct students. Delaying this step until the SGS deadline for candidacy will make it difficult to complete the thesis within the guaranteed funding period.

A thesis topic needs to be sufficiently broad to form the basis of the thesis, and it should be plausible that the student will be able to complete a thesis on this topic within two years. A student may still decide to switch thesis topics after achieving candidacy without affecting their candidacy; however, the student will need to clearly describe their new thesis topic to their committee members and have it approved during their next annual review.

To obtain thesis topic approval, the student should submit a written description of their thesis topic to their committee in advance of the meeting. This document should describe:

a) the scope of the proposed research,
b) explain its context with respect to the current literature (see items a–g in the Introduction to this document, page 1), and
c) provide an initial research plan.

Yearly Progress Review

Yearly progress reviews are for students who have passed their Qualifying Oral Exam, but are not yet ready for their Departmental Thesis Examination.

Timing: Yearly progress reviews must be held at least every 12 months following the successful completion of their Qualifying Oral Exam. If the student is expecting to schedule their Departmental Thesis Examination

shortly after this deadline has passed, then they can contact the Graduate Office to request a one-term extension.

Purpose: To assess the student's research progress since the previous committee meeting and to provide feedback on the student's research plans for the coming year.

Student preparation: The student should prepare a progress report to discuss with their committee. If approaching candidacy, the student should be prepared to have a Thesis Topic Approved. As the student prepares for the Departmental Thesis Exam, the student should prepare a **Thesis Proposal** (see below).

Committee recommendations: After a yearly progress review, the supervisory committee will provide written feedback to the student (through the Graduate Office) and the student will be invited by the Grad Office to respond to this feedback. In addition, the following examination results will be provided:

1. Pass. A pass may be accompanied by constructive feedback and/or suggestions for activity in the next term(s).
2. Conditional Pass. The student is given one or more concrete tasks to complete by a specific deadline (no more than a year later). The tasks and the deadline are also communicated to the Graduate Office. The meeting chair is responsible for reporting to the Graduate Office whether or not the student has cleared the conditions by the deadline. If the student fails to clear the conditions by the deadline, their progress will be considered unsatisfactory.
3. Fail (with the option to repeat). The student is not considered to be making satisfactory academic progress and must hold another Ph.D. supervisory committee meeting within 6 months.
4. Fail (no option to repeat). The student must either withdraw from the program or have their registration terminated. This result is possible only for students who were not considered to be making satisfactory academic progress at the time of the exam. The Associate Chair, Graduate Studies will review such a recommendation.

Thesis Proposal

The primary purpose of a **thesis proposal** is approval from the supervisory committee for the overall scope of the eventual thesis. In preparation, the student should submit a written proposal to the supervisory committee that:

a) outlines both the completed and anticipated the results of the thesis;

b) demonstrates that a substantial portion of research has been successfully completed; and

c) provides a clear plan for completing the remaining research.

Ideally, a thesis proposal is a draft of a substantial portion of the thesis itself, along with a clear description of the remaining work to be completed. The supervisory committee assesses the scope and relevance of the problems the student has to solve in the proposed Ph.D. thesis. The thesis proposal is typically completed six months to a year prior to the Departmental Thesis Examination.

Deadlines

Students who fail to meet the deadlines for the Qualifying Oral exam, or the Yearly Progress Review will not be considered to be making satisfactory academic progress. Details on those two milestones are provided in the sections below. Students who anticipate being unable to schedule a committee meeting before the deadline should contact the Graduate office as soon as possible. See also General Regulations, section 9.0 Graduate Student Supervision; Degree Regulations, section 13.0 Doctoral Degrees; and specific program requirements in the Programs by Graduate Unit section.

Students must notify the Graduate Office of all scheduled committee meetings **at least two weeks in advance** of the meeting.

Time Limit to Degree Completion

There are **two** program time limits. The **departmental** time limit refers to the amount of time a student can receive guaranteed funding from the department. **SGS** time limits refer to the amount of time a student can register in their program.

Program	Departmental guaranteed funding period	SGS time-limit for degree
Ph.D.	43 months	72 months
Ph.D.-M	48 months	72 months
Ph.D.-U	60 months	84 months

In exceptional circumstances, a Ph.D. student who does not complete all the requirements for the degree within the SGS time limit may be considered for a maximum of four one-year extensions, bringing the final limit to 10 years for the Ph.D. and Ph.D.-M programs and 11 years for the Ph.D.-U program.

Students who have serious health problems or personal circumstances that prevent them from making satisfactory progress are entitled to take a leave from graduate studies. Such a leave effectively stops the clock for funding and time to degree completion; on return, the student is entitled to resume

at the point where they left, without penalty.

Departmental Thesis Examination

The student defends the thesis before the supervisory committee. Outside members of the department are also invited. A draft of the thesis should be available to the committee members three to four weeks in advance of the departmental thesis examination. Each member of the committee is expected to read the thesis in sufficient detail to form a judgement about its acceptability. The committee may approve the thesis as is, or on condition that minor corrections be made under the supervisor's supervision, or require the student to repeat the Departmental Thesis Examination.

Final Oral Exam at the School of Graduate Studies

Upon the successful defence of the thesis at the Departmental Thesis Examination, the candidate will be ready to go forward to the Final Oral Examination (FOE). Eight weeks prior to the proposed date of the examination the student should notify the Graduate Office of the intention to book an FOE. All forms and instructions are available on the DCS internal web page or from the Graduate Office. Full FOE details and regulations can be found on the SGS website.

It is important to allow yourself and the Graduate Office plenty of time to organize the necessary steps and follow the required procedures in setting up your Ph.D. Final Oral Examination.   The School of Graduate studies is under no obligation to find an FOE chair if a minimum of six weeks' notice is not provided.

Graduation

Following the completion of the Final Oral Exam and the submission of the final thesis, SGS will submit a Recommendation for Degree and the student's name will be added to the convocation roster.

A graduation package will be sent to the student from the Convocation Office regarding convocation dates, tickets, etc.

Timeline

Months in program	Program progress Note that this time-line reflects progress through your program within the period of guaranteed funding.
1 to 2 months (The Grad Office will announce the submission deadline at the start of each term for newly admitted students).	Submit **Breadth Evaluation and Plan of Study Form** to Department Graduate Office outlining: 1. Intended course enrollment and the breadth areas these course will satisfy. 2. Any requests for transfer of breadth credits from a University of Toronto program or program elsewhere. *Note:* If approved, a transfer of breadth credit does not reduce the program's course requirement. 3. Requests for transfer of course credits (that reduce the number of courses you are required to take for your program) should be included on your Plan of Study form; however, the official request must be submitted using the SGS transfer credit request form obtained from the SGS website. This document must be signed by you and your supervisor or faculty group representative.
16 months	Form **Ph.D. supervisory committee. Qualifying Oral Examination.**
At least annually following formation of supervisory committee	**Yearly progress review** in a Ph.D. supervisory committee meeting.
12 months following completion of Qualifying Oral Exam	**Achieve candidacy:** • Complete all required course work, including breadth requirements. • Hold supervisory committee approval of the thesis topic.
40 months for Ph.D. 45 months for Ph.D.-M 57 months for Ph.D.-U	**Departmental Thesis Examination** A minimum of 8 weeks is suggested between the passing of the Departmental Thesis Exam and the FOE.
42 months for Ph.D. 47 months for Ph.D.-M 59 months for Ph.D.-U	**Final Oral Examination** at the School of Graduate Studies Students are required to be registered until the submission of the final and corrected thesis is submitted. Students will receive 1 month to submit Minor Modifications and up to 3 months to submit Major Modifications following the FOE.

43 months for Ph.D. 48 months for Ph.D. -M 60 months for Ph.D. -U	Final thesis submitted where Minor Modifications are required.

Unsatisfactory Academic Progress

The status of being considered to be making unsatisfactory academic progress can have serious consequences. For example, if a student fails a subsequent qualifying oral or supervisory committee meeting while they have this status, or if the student misses a second consecutive deadline, then they will be offered the option to either withdraw from the program or have their registration terminated. (see http://www.sgs.utoronto.ca/facultyandstaff/Pages/Termination-Student-Info.aspx).

Dropping down to the M.Sc. program from a Ph.D. program

Students in the Ph.D.-Direct program may choose to drop down to the MSc program, in which case they are required to complete the standard M.Sc. program requirements (namely, the M.Sc. course breadth requirements along with the M.Sc. research paper). Similarly, students in the Ph.D. program who do not have a previous M.Sc. degree in Computer Science can drop down to our M.Sc. program. In either case, the student's guaranteed funding period will be reduced to 17 months, the limit for the M.Sc. program. If the student has been funded for more than 17 months, their funding will be terminated. A Program Transfer form must be submitted to make the switchover official.

Appeals

Graduate students may appeal the decisions made by their Ph.D. supervisory committee, or by a course instructor. The procedures for such an appeal are described in the SGS Calendar (see SGS Academic Appeals Policy).